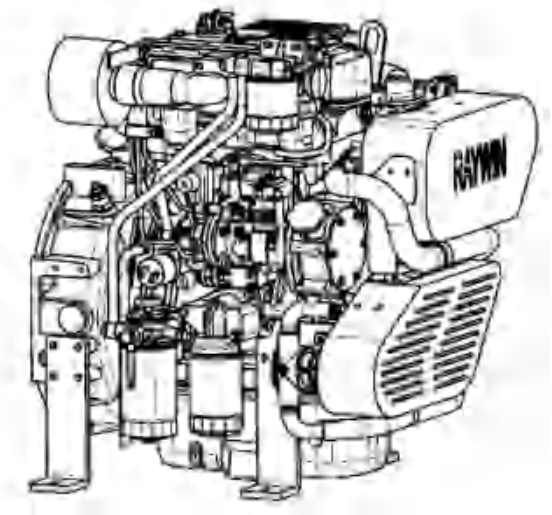
RAYWIN

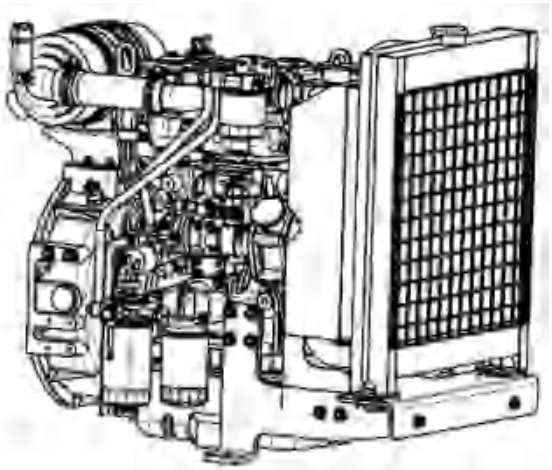
RM703-4003108

3M16 Series Diesel Engine

Operation & Maintenance Manual

Please read this manual carefully before using the engine.





Raywin Powertrain Technology Co., Ltd.

March, 2023

Preface

3M16 series off-highway diesel engines are developed by RAYWIN POWERTRAIN TECHNOLOGY CO., LTD. with international engine R&D institutions together. Adopted tunnel block, rotary fuel pump, turbocharged/naturally aspirated and 2-valve technologies, 3M16 series engines are with reliable, fuel-efficient, and strong power characters. It could be applied for agriculture & garden fields, construction equipment, power generation, marine and industrial equipment.

This manual contains some operation and maintenance instructions for 3M16 series diesel engines, and some usual failure removal methods as well. Please know well about the structure, operation and maintenance instruction of this engine. It helps prolong the engine lifetime if the users could make well maintenance.

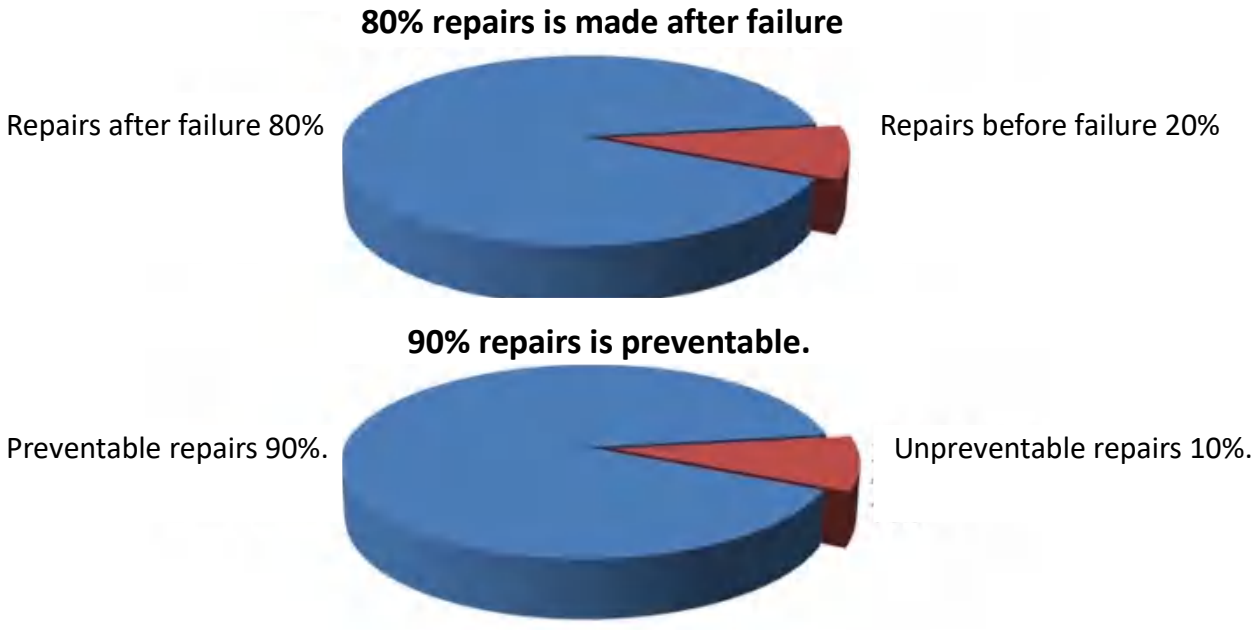
Further improvement and advancement of product design may cause changes which are not included in this manual.

The interpretation of this manual owned by Raywin Powertrain Technology Co., Ltd.

CONTENT

1. Foreword

The relating statistic data shows:



Preventive maintenance is simple and lower cost, please make the maintenance according to the maintenance instructions in this manual, and make regular preventative maintenance records.

Please utilize the fuel, oil and coolant correctly as per the instructions in this manual, and do not mix the fuel and oil together for the engines with after-treatment equipment.

Attention

When welding on the machinery, please remove the battery positive and negative pole cables from the battery, and dismantle all plugs on the ECU as per the procedure to prevent from ECU damage, do not connect or dismantle ECU plugs with electrification, also do not perform welding operations on the engine or on the engine mounting parts, otherwise the engine or components may be damaged.

The meaning of the safety alert symbols is listed as follows:

Warning

If do not follow this instruction, it will cause serious personal injury or substantial property damage

Attention

If do not follow this instruction, it will cause personal injury or parts, assembly, engine damages.

Illustration description: Some illustrations in this manual are schematic, it may be different from the engines or parts that you use actually.

1.1 General Safety Rules

Warning

Incorrect procedures, carelessness or neglect of warning instructions may cause burns, cuts, body mutilation, asphyxiation or other injury or even death.

Before maintenance, please read and understand all the security measures instructions and warnings carefully. The following pages contain a general security measures to ensure personal safety that you should follow.

Maintenance The area around the maintenance work area should be dry, bright, well ventilated, free of sundries, scattered tools, parts, fire sources and other dangerous goods. Be aware of possible dangerous situations. When you remove any fuel system component for maintenance (such as replacing the fuel filter), please place the special fuel container under the component to collect the residual fuel. The rag after wiping the residual fuel is flammable and explosive, so please avoid using it.Due to the pressure in the oil circuit, fuel injection may occur when removing parts of the fuel system. Please wear goggles and protective equipment to avoid personal injury.

Do not touch rotating parts, because the rotating parts may cause lacerations, physical disability, even death.

Do not rotate the crankshaft by leveraging the fan. This approach may cause serious personal injury, property damage, or damage the fan blades, causing premature failure of the fan.

If the engine has been running for a while, and the coolant is hot, the engine should be gradually cooled firstly, then loosen the filling port cap slowly to release pressure in the cooling system, or else it could cause scald and other personal injury.

Corrosion inhibitor (coolant additives and ingredients in oil) contains alkali. Do not make these substances into the eyes. Avoid skin touch with it time and again. Do not swallow it. In case of contact, please wash the skin with soap immediately. If it enters eyes, please rinse with plenty of water for fifteen minutes at least, and go to hospital at once. Put it where children can not touch.

In order to reduce the possibility of burns, do not touch the hot parts, exhaust pipeline, hot liquid and engine cabin while the engine is stopped. When replace the fasteners, please use the fasteners with the same part number (or equivalent). Do not use the poor quality fasteners.

Avoid inhalation oil vapors, do not swallow, or contact used oil for a long time.

Do not connect starting cable or battery charging cable with any ignition or speed control cable, or else it may cause ignition and governor damage.

Please tighten fasteners and fuel connectors according to the technical specifications. It may cause leakage if the fastener or connector is too tight or loose.

The smell of leaking fuel will weaken gradually, therefore, test whether there is fuel leakage in accordance with the testing methods as instructions.

The coolant is toxic, please make treatment in accordance with relating environmental regulations if you do not continue to use it.

1.2 General operating specification

This manual specifies the proper use of the machine in the operation and maintenance of the 3M16 engine, otherwise it may damage the machine, personal property and/or the environment or lead to improper operation of the equipment.

●Please use the diesel grade recommended by RAYWIN to achieve the best engine performance and prevent engine damage.

●Please use clean and pollution-free diesel fuel. Do not remove the main filter from the fuel tank filling port, otherwise dirt and debris may enter the fuel system and cause it to clog.

●Use RAYWIN recommended oil grades for optimal engine performance to prevent premature engine wear. It is strictly prohibited

●Mix different types of engine oils. This may adversely affect the lubrication performance of the engine oil. Keep the oil filling volume at the oil level between the oil scale and the oil scale. Do not overfill the engine oil.

●Use the coolant recommended by RAYWIN. Other engine coolants may cause internal rust and scale buildup and/or shorten engine life.

●Please use the battery capacity recommended by RAYWIN; otherwise, the engine will not start normally.

●Do not keep the starting switch for more than 15 seconds when starting the engine, otherwise it will lead to overheating of the starter. After the engine starts successfully, please release the starting switch immediately. Do not connect the starting switch when the engine is running, otherwise it will lead to the starter.

●When new engine starting for the first time, should let the engine idle speed for about 15 minutes, check the oil pressure at the same time, diesel oil leakage, oil leakage, cooling fluid leakage, and the indicator and/or instrument is normal operation, in the early operation, carefully observe the engine oil pressure and water temperature, and the coolant fluid level is as air discharge needs to supply cooling fluid.

●Do not attempt to adjust low or high idle limit screws. This can compromise the safety and performance of the machine and shorten its service life. Contact your local RAYWIN dealer or distributor for adjustments.

●Ensure that the engine is mounted on a level surface. The engine is running at an Angle less than 25° in any direction, or the engine is running at an Angle greater than (IDI=30°, DI=35°) in any direction for a short time (less than three minutes), otherwise

the oil may enter the combustion chamber, resulting in excessive engine speed and white exhaust. This can cause serious engine damage.

● In order to maintain the engine performance, please avoid the following operating environment to avoid premature engine wear and take protective measures; Avoid operating in extremely dusty conditions;

● Avoid operating in the presence of chemical gases or fumes.

● Avoid operating in corrosive environments, such as saltwater spray.

● Avoid exposing the engine to rain.

● The operating environment temperature exceeds -25°C to 45°C.

● U If the engine is operating in the above environment, measures must be taken to protect the engine, otherwise the engine will be damaged prematurely;

● Please refer to the requirements in this manual for regular engine maintenance. Failure to comply with these guidelines will compromise the safety and performance characteristics of the engine, shorten the life of the engine, and may affect the warranty coverage of your engine.

● When you start the engine for the first time after replacing the fuel line, you need to empty the fuel line again. You can use the hand-pressure pump provided by the engine (if any), and loosen the fuel line at the highest position of the fuel line to empty the fuel line until no air bubbles appear in the oil line visually.

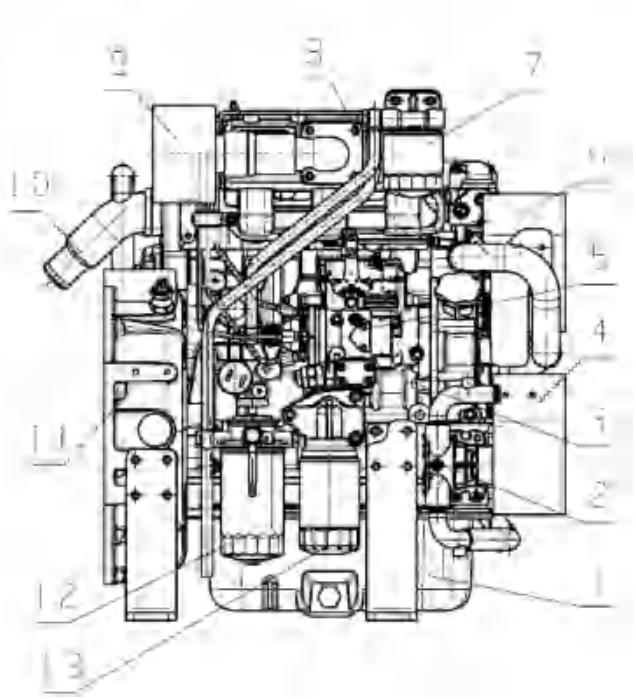
● If the height of the fuel tank is lower than that of the engine fuel injection pump, please maintain the proper height; otherwise, the fuel cannot be normally absorbed. Without the fuel electronic lifting pump: ≤0.5m; with the fuel electronic lifting pump: ≤1m.

● If the engine parts need to be removed, the gaskets must be replaced when some parts equipped with gaskets are replaced, otherwise the engine seal problems will cause leakage;

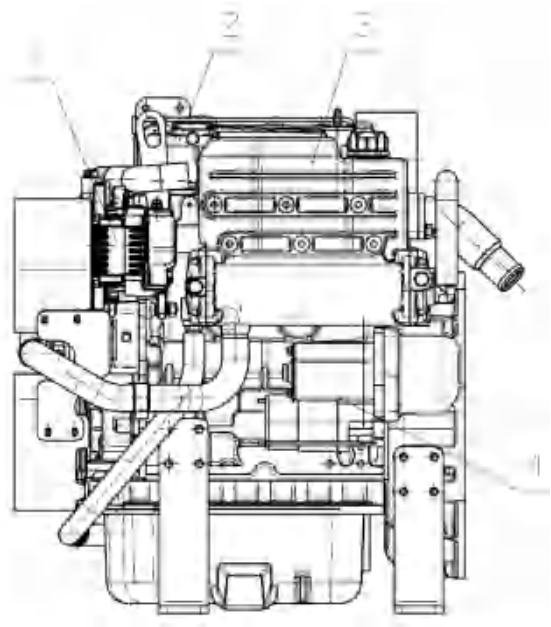
2. Overview

2.1 General Purpose Machinery engine

2.1.1 Marine Engine schematic diagram

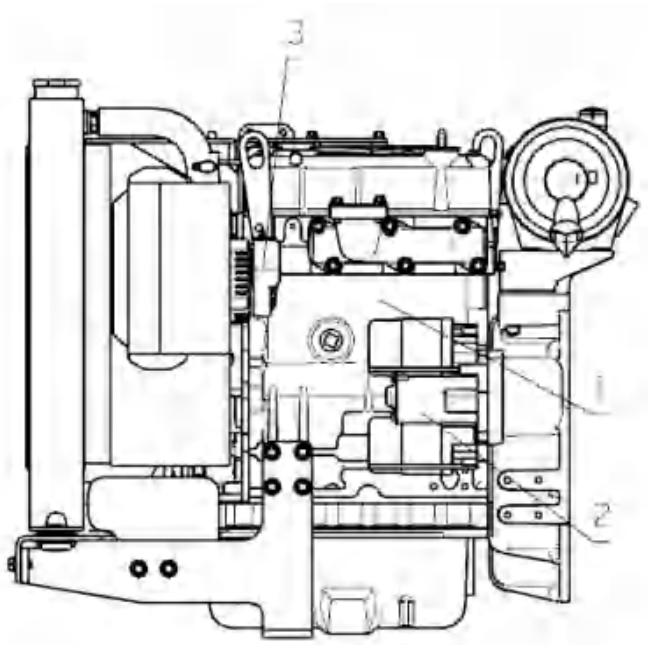


1.Oil sump
2.Sea water pump
3.Cylinder block
4.Sea pump belt cover
5.Fuel injection pump
6.V belt cover
7. Fuel fine filter
8.Intake manifold
9.Air filter
10. Sea water Exhaust manifold
11. Flywheel housing
12. Fuel filter
13.Oil filter

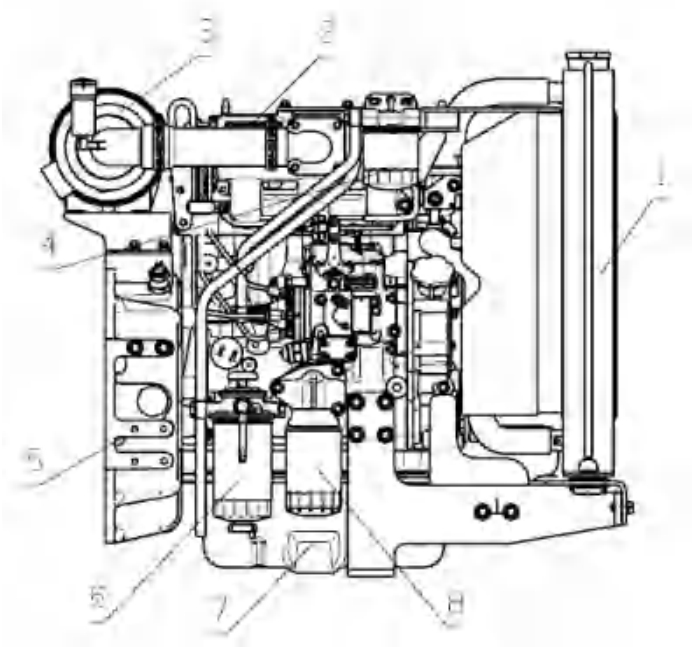


1. Alternator
2.Cylinder head cover
3.Exhaust manifold
4.Starter

2.1.2 G-Drive Engine schematic diagram



1.Alternator 2.Starter motor 3.Cylinder block



1. Radiator 2.Intake manifold 3.Air filter 4.Fuel filter 5.Flywheel housing 6.Fuel prefilter 7.Oil sump 8.Oil filter

2.1.3 Model characters explanation

The following is an explanation of the Engine Family designation:

3M16：

3-----3 cylinders **M---- series code**

16—1.6 liters displacement

2.1.4 Main Applications and Working Environment

3M16 series diesel engines can be applied for agriculture & garden fields, construction equipment, power generation, marine and industrial equipment.

Engine can work properly with ambient temperature of -25 ℃ ~ 40 ℃, it prohibits from running under the environment of water leaching and fire. When the ambient temperature is below -25 ℃ or higher than 40 ℃ or altitude over 1000 meters, please consult with our technology or service department and take effective measures or use the special engine to ensure that the engine could work properly.

2.1.5 Engine Data & Specifications

Table 2-1 3M16 Series Diesel Engine Technical Parameters

S/N	Items	Specifications		
1	engine model	3M16G3/F	3M16G1/F	3M16O2/F
2	engine type	In line, 3 cylinders, 4 stroke, water cooled		
3	Intake air system	NA		
4	combustion type	DI		
5	Cylinders Bore×Stroke(mm)	3-88×90		
6	valve per cylinder	2		
7	Displacement (L)	1.64		
8	Compression ratio	18.2：1		
9	Dry weight kg（Includes air filter and radiator）	220±10	220±10	220±10
10	Dimensions （L×W×H）mm	817×520×724（G-Drive Engine） 664×535×675（Marine Engine）		664×535×675
11	Lubricating system	pressure and splash lubrication		
12	Start type	Electric starting (Starter motor12V -1.8kw)		
13	Alternator	14V 40A		
14	FIE system	Mechanical rotary pump（STANADYNE）		

15	Oil capacity L	6.5		
16	Coolant capacity L	7.5		
17	Preheating system	air intake preheating		
18	Fire order	1—3—2		
19	Crank Rotation	CCW (view from flywheel)		
20	Rate power (kW)/speed(r/min)	15/1500	24/3000	24/3000
21	Max torque (N.m)/speed(r/min)	93N.m/2200		
22	External minimum fuel consumption rate(g/kW·h)	≤245		
23	Minimum oil consumption rate(g/kW·h)	≤0.2		
24	Minimum adjustable no-load speed(r/min)	1000		
25	Fuel NO	summer: GB 252-2000 No 0#、10#, winter: GB 252-2000 No 0#、-10#、-20#、-35#		
26	Oil NO	Recommend the use of quality grade CF-4 special engine oil.		
27	Max.duty intake resistance kPa	2.1		
28	Max.duty outlet resistance kPa	7.2		
29	Smoke intensity FSN	≤3.5		
30	System voltage V	12		
31	Apply laws	/		

2.2 Agriculture & Construction & Marine Applications

3M16 series diesel engines have been widely applied to agriculture sector, construction sector, marine sector, can supply reliable power for harvester, tractor, picking machine, excavator, boat, yacht and other farm machinery and engineering machinery.

2.2.1 Typical application samples

Marine Gen-set Light Tower Air Compressor Aerial work Platform Sweeper

Harvester Excavator Loader Forklift Tractor Water Pump

3. Fuel, oil, antifreeze and auxiliary battery

3.1 Fuel

Fuel quality and composition is very important. Poor quality fuel reduces engine performance and durability

In order to make the diesel engine has higher reliability and lower fuel consumption, we recommend using the diesel complied with relating national standard or international standard.

For more details of the fuel standards, please refer to the technical specifications of the respective country.

Users must select suitable diesel at different ambient temperature as follows:

Table 3- 1

Diesel Grade	Ambient Temperature
0#	Above 4℃
-10#	Above -5℃
-20#	Above -14℃
-35#	Above -29℃
-50#	Above -44℃

Warning

Do not mix gasoline, alcohol or alcohol-gasoline mixture in diesel, otherwise it will cause explosion.

△ **Attention**

Because the tolerance of diesel injection system is extremely precise, it's very important to keep the fuel clean and no dirt or water. If there is water or dirt in the fuel system, it may severely damage the fuel pump and injectors.

RAYWIN requires the user to use recommended fuel.

3.2 Oil

The precision of 3M16 series engine parts is very high, hence the oil selection requirements is strict. Above CF-4 level engine oil must be used, engine oil CF4 15W-40 (quality grade of CF-4, viscosity grade of 15W-40) is recommended.

The oil with suitable grade should be selected according to the local season and temperature, and must pay attention to two indicators, namely the oil quality level

(Performance Level) and viscosity grade as below:

Table 3-2

Grade	CF-4	CH-4	CI-4	CI-4+	CJ
Available emission level	**Chinese Non-road Stage III** Tier2				

Table 3-3

Type	Mineral oil type					Synthetic oil type	
viscosity grade	30	20W-50	15W-50	10W-40	5W-50	5W-50	10W-40
	40	20W-40	15W-40	10W-30	5W-30	5W-30	10W-30
Available ambient temperature ℃	10～50	-15～30	-20～50	-25～30	-30～30	-35～40	-30～40

Oil pressure of this engine is (0.3 ~ 0.6) MPa at rated speed, and not less than 0.1MPa at idle speed.

RAYWIN engine requires multi-grade viscosity oil, because the suitable temperature operating range of multi-grade viscosity oil is wide, which can meet the requirement of the engine works properly with temperature varied by a wide margin in the morning and evening, or works across different temperature regions, or works during long time season. Furthermore, the consumption of single-grade viscosity oil is about 30 percent higher than the multi-grade viscosity oil.

Oil grade represents the level of engine oil additives, for heavy duty engine, the oil additives is the main protective matters. The additives will be consumed over time gradually, that's why the adequate grade oil should be chosen for ensuring the engine to be well protected throughout the oil change interval.

Please fill the oil according to the circumstances after replacing the oil filter. After filling the oil, run the engine for 2 minutes then make it be still for 15 minutes, check the oil sump level, the oil level should be in the place between 1/2 of lower/upper limit and upper limit. （the upper limited of the oil pan is 6.5L）

RAYWIN recommended to use the engine oil designated by Raywin Powertrain technology Co., Ltd. or the engine oil that meets the emission requirements of stage iiia and Tier2.

oil for 3M16 is listed below:

Table 3-4

Name	Grade	Package	Available emission level
Hanhu Chinese Non-road Stage III oil	CF-4/SL 10W-30 CF-4/SL 15W-40 CF-4/SL 20W-50	4L 16L 18L 170Kg	

The user can use higher grade oil instead of low-grade oil, oil and fuel ratio should be complied with relating national or international standard.

Other rule:

- When the total alkalinity (TBN) of the engine oil drops to 1.0, it must be replaced. TBN（mgKOH/g）tested standard: as per JIS K-2501-5.2-2（HCl），or ASTMD4739(HCl)
- Standard engine oil replacement interval is 250 hours or 12 months.
- Do not add any additives in the engine oil.
- Do not blend different types, and/or brands oil.

3.3 Antifreeze

△ Attention

When the engine stops working and no insulation measures is took below 0 ℃, the water in the cooling system will freeze, and the volume expands which causes block, radiator, cylinder head, water pump and other cooling system components cracked, therefore, antifreeze must be filled into the cooling system.

For a longer lifetime, we suggest to use RAYWIN recommended antifreeze.

△ Attention

Fresh water is not suitable for the engine coolant, because the thermal conductivity of fresh water is very poor, which can lead to inadequate cooling and make engine internal component damaged.

Water preparation required for engine coolant

When available, please buy the antifreeze specified by RAYWIN POWERTRAIN TECHNOLOGY CO., LTD. If the appropriate antifreeze can not be got, ethylene glycol and soft water are allowed to be blended, and the relationship of the boiling point and pour point of this antifreeze is listed below:

Pour point and Boiling point		
Glycol and soft water volume ratio	Pour point	Boiling point
	℃	℃
40	-24	106
50	-35	108
60	-52	111

Pressurized cooling system can increase its boiling point, radiator pressure cap can help keep the system pressure, in order to ensure good water quality, we recommend using our specified or international famous brands and grades of antifreeze.

3.3.1 RAYWIN antifreeze brand and model information

Table 3-5

Brand	Model	Spec.	Freezing Point	Available min. ambient temperature (℃)
HANHU	YCF4—8	4kg	-8℃	2
	YCF4—25		-25℃	-15
	YCF4—30		-30℃	-20
	YCF4—35		-35℃	-25
	YCF4—40		-40℃	-30
	YCF4—45		-45℃	-35
	YCF9—8	9kg	-8℃	2
	YCF9—25		-25℃	-15
	YCF9—30		-30℃	-20
	YCF9—35		-35℃	-25
	YCF9—40		-40℃	-30
	YCF9—45		-45℃	-35
	YCF10—8	10kg	-8℃	2
	YCF10—25		-25℃	-15
	YCF10—30		-30℃	-20
	YCF10—35		-35℃	-25
	YCF10—40		-40℃	-30
	YCF10—45		-45℃	-35
	YCF18—8	18kg	-8℃	2
	YCF18—25		-25℃	-15
	YCF18—30		-30℃	-20
	YCF18—35		-35℃	-25
	YCF18—40		-40℃	-30
	YCF18—45		-45℃	-35
	YCF200—8	200kg	-8℃	2
	YCF200—25		-25℃	-15
	YCF200—30		-30℃	-20
	YCF200—35		-35℃	-25
	YCF200—40		-40℃	-30
	YCF200—45		-45℃	-35

Usually, choose the freezing point as 10℃ lower than the lowest temperature of the equipment running area. For example: Suppose the minimum temperature in some area is -15 ℃, then select antifreeze with type of -25.

3.3.2 Note for using antifreeze

a) Please clean the engine cooling system with water before antifreeze is filled, it's better to clean it with decriminalize or deionized water.

b) Pay attention to checking the antifreeze level and the tightness of cooling

system. Do not fill up antifreeze fully if the machinery has no overflow tank, but 95% volume or so; If there is an overflow tank on the machinery, fill antifreeze to the specified scale firstly, then run the engine for a few minutes, and continue to fill antifreeze to the required scale;

c) The antifreeze from different manufacturers or with different types cannot be mixed, or else the antifreeze performance would be reduced, even it causes engine damage.

d) If the level is below required scale, please fill to a required scale. The filled antifreeze must be same type from same manufacturers as the existing antifreeze in the engine.

e) The glycol is toxic, please clean it with water immediately if the glycol is contacted with skin; Glycol will burn in case of fire, so do not weld or make fire near the engine with antifreeze leakage; The boiling point of glycol is 197.4 ℃, so it's easy to evaporate for the water in antifreeze, please make up water after the antifreeze works for some time.

3.3.3 Replace antifreeze regularly.

a) Light duty antifreeze/inorganic antifreeze replacement cycle is 24 months.

b) Heavy duty antifreeze/organic antifreeze, replacement cycle is 36 months.

c) The technical requirements of light duty antifreeze/inorganic antifreeze or heavy duty antifreeze/organic antifreeze should meet the petrochemical industry standards or RAYWIN Q /YC 908 "engine coolant technical conditions" requirement.

3.4 Battery selection

With the machinery electricity consumption is increasing in plateau or alpine regions in the winter (-15 ℃ or less), to ensure and improve engine cold starting performance, the machinery should be equipped with same capacity low temperature batteries.

Table 3-6 Battery Selection Table

Common region		**Plateau or alpine region**	
Battery capacity Ah)	Cold starting current (A)	Battery capacity Ah)	Cold starting current (A)
≥120（165）	570	≥180（195）	622
Note	It's better to select the battery type in the brackets for the engine that runs in plateau region.		

4. Engine Operation & Maintenance

4.1 Engine Operation

4.1.1 Before starting

a) Check the oil level in the oil sump. The level should be within the upper and lower scale limits of the oil dipstick. If the oil volume is not enough, fill some oil as required after checking the accordance of oil grade with temperature.

b) Check the coolant level, add some coolant if necessary, and the accordance of coolant type with temperature should be checked before filling.

c) Check and exhaust the air in the fuel pipeline, and drain the water from the fuel filter.

d) Check the fuel tank. If the fuel is insufficient, refuel it after checking the accordance of fuel grade with temperature.

e) Check the electrical system (including connecting wires, switches, electrolyte, fill enough electrolyte if it's insufficient.)

f) Check the tension of the driving belt， the tension should be moderate as required.

4.1.2 Start

Warning

Do not start the engine in the environment where may be flammable gases, that could be drawn into the engine through the intake system, resulting in engine acceleration and over-speed, which could cause fire, explosion and property damage. Engine manufacturer can't know how the user operates the engine. Engine user and operator are fully responsible for operating the engine safely under harsh environments.

Attention

The engine cannot be started unless the preparations have been completed and confirmed to comply with requirements. (The engine could be started after warmed in cold winter). The continuous starting time can't be over 10 seconds, the next starting time interval is should not be less than 1 minute, if it can't be started after three times trial in succession, user should check the reasons and restart it after the malfunction is removed.

△ Attention

Check the oil pressure: it should not be lower than 0.1MPa at idle speed. If the low oil pressure indicator still flash within 15 seconds or the oil gauge displays no oil pressure, please shut down the engine immediately to prevent engine from damage.

Check whether the water pump operates properly and whether the coolant runs into water jacket of the diesel engine. Check the leakage of oil, fuel and water, and shoot the trouble if there is leakage. Check if there is abnormal noise. Check and confirm all monitor work well. Please stop the engine immediately and check the reason if there is abnormal status, and send the engine to service center if necessary.

Cold start: Under the cold environment, it's the same as conventional starting operations. If there is preheating during start, please start the engine after the preheating indicator is turned off or flashing.

Starting steps after long time no running or oil replacement

To start the engine as per the normal steps stated in this chapter. The engine could not be started if the ECU detects that the oil pressure does not meet the minimum pressure of motor starting value. It will take a longer time to start the engine if it is no running for a long time or with replacement of oil.

4.1.3 Running

When the diesel engine is started, it should keep running at low and medium revolution speed in sequence with no load, the engine could not run at high speed with full load unless the coolant temperature is higher than 60℃ and oil temperature higher than 45℃. Pay attention to the following instructions:

△ Attention

Do not idle for long time, or else it may reduce engine performance. The oil pressure should be not less than 0.1MPa

Observe the meters reading frequently during engine operation, ensure the oil pressure, oil temperature and water temperature to be in normal range.

If there is alarm from meter, or engine abnormal sound or abnormal vibration, please stop the engine and check it as soon as possible.

Pay attention to the sealing of every water passage and the fuel pipe. If there is leakage, remedy it immediately.

△ Attention

The new engine or overhauled engine is not allowed running at high-speed or with heavy load. In order to ensure a good break-in, the load should not exceed 65% within the first 40 hours.

4.1.4 Stopping the diesel engine

Do not stop the engine sharply unless there is an emergency. Keeps the engine running at low revolution speed for 3 to 5 minutes before stopping it in order to make the engine cool down, and keep idling for 2 to 3 minutes in order that the oil could be carried to each part of the engine, then stop the diesel engine.

When the ambient temperature is below 5℃ and the coolant is not sure to be anti-freezing, discharge all the coolant liquid after stopping the engine to avoid engine damage by frost crack.

When the temperature is below -30 ℃, the battery should be disassembled and moved to warm space, otherwise it would be hard to start the engine.

4.1.5 Routine Operating Notes:

Comparing to the traditional mechanic fuel system, electric control fuel pump requires higher fuel cleanliness.

Please fill cleaning fuel with regular stations.

Do not make the filled fuel contaminated.

When the fuel pipeline needs to be removed, the tools and hands must be cleaning to avoid the pipeline to be contaminated.

The malfunction indicator is on the control panel, if there is no malfunction, the indicator shall flash once then be turned off while the engine is electrified. If there is malfunction, the indicator will be turned on automatically and the malfunction reminder will be displayed, please turn off the ignition switch, and check the engine fuel pipeline, air system and electric circuit carefully to find whether there is obvious fuel leakage, air leakage or connectors fallen off.

In principle, when the malfunction indicator is turned on, the user check and find there is obvious fuel pipeline, air system or electric circuit malfunction, the user may solve it by himself.

4.1.6 Refilling method after the fuel consumed up.

If there is air in the fuel pipeline when the fuel is consumed up or the fuel filter/fuel pipeline needs to be replaced, it must evacuate all air from the fuel pipeline as follows:

Release the air discharging screw on the top of fuel filter, deaerate the air with hand priming pump till the fuel filter is full of fuel, and tighten the air discharging screw after there is no any air bubble arising from the fuel.

Release the fuel return pipe from fuel pump, deaerate the air with hand priming pump till the fuel pump is full of fuel, and tighten the air discharging screw after there is no any air bubble arising from the fuel.

Release the connectors between fuel pipe and fuel injector for each cylinder, deaerate the air from fuel pipes by hand priming pump, and tighten the connectors till the fuel comes out from the pipes.

Wipe off all fuel on the surface of engine or surroundings after deaerating all air.

Avoid the fuel spilled on the exhaust pipe, starter, wiring harness (especially connectors) during deaerating, please wipe off the fuel that's spilled on the parts if any.

Ensure fuel cleaning from contamination during deaerating.

4.2 Maintenance of diesel engine

- The initial maintenance should be made and recorded according to the warranty manual.
- During the use of diesel engines, the following requirements should also be carried out for routine maintenance, daily maintenance by the user own, other levels of maintenance by professional maintenance person；
- Air filter is a key component to ensure the diesel engine clean air inhaled, to always check the air intake system and maintenance, to replace the air filter, ensure that the diesel engine does not appear early wear.

4.2.1 Diesel engine breaking-in

The new diesel engine need to have breaking-in period (starting 50h), in order to make the match performance of each moving parts to further improve, ensure the working reliability and service life of the diesel engine：

1) After starting the diesel engine in low speed to warm up for at least 5 minutes;

2) After starting, the load cannot be increased sharply, it needs to slowly increase;

3) Diesel engine idle speed or full load running not more than 5 minutes;

4) Often observe the oil, water temperature meter, to ensure the normal working status of the diesel engine;

The overhauled diesel engine, also need to have breaking-in period (refer to new machine breaking-in), to ensure of the friction pairs matching effect. After the end of the breaking-in period oil should be replaced, and replace the oil filter element. No idle running, which resulting in early wear and tear.

4.2.2 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:

4.2.2.1 Maintenance cycle of the table below**:**

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 is necessary to shorten the replacement cycle of engine oil.

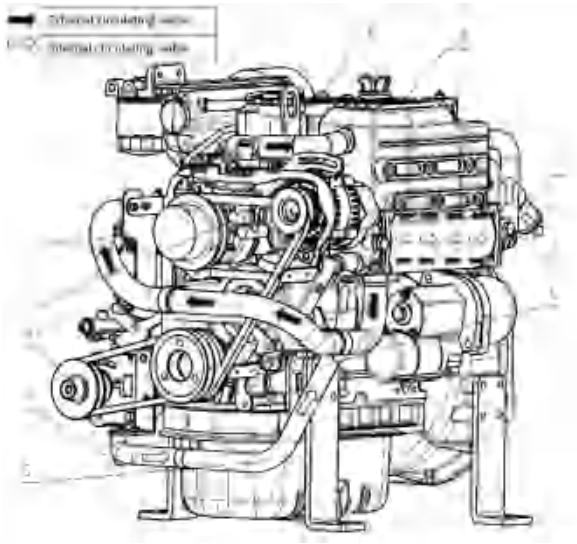
Engine maintenance cycle time

Item	Maintenance cycle time											
	50 hrs	100 hrs	200 hrs	250 hrs	400 hrs	500 hrs	1 or 2 months	1 year	800 hrs	1500 hrs	3000 hrs	2 years
Check fuel tube and clip	☆											
※Change oil	★											
Clean core of air filter		☆										
Check position of battery electrolyte		☆										
Check fan belt tension and damage		☆										
Check radiator hose and hose clamp		☆										
※Change oil filter	★			☆								
Check intake valve				☆								
Change fuel 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)												☆

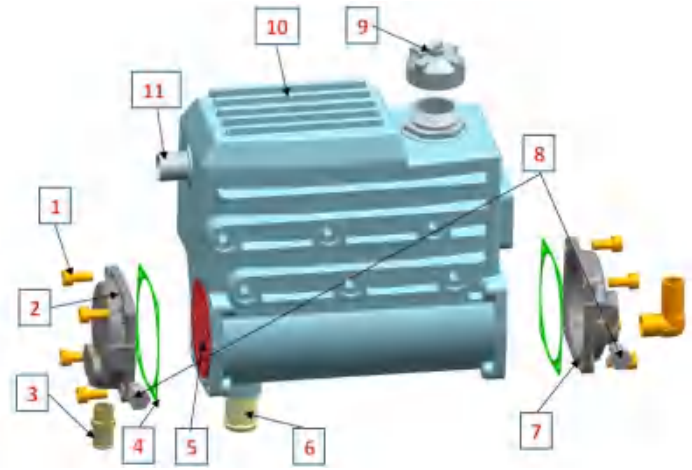
Note: After running 50 hours, please change oil and oil filter
According U.S. EPA off road emission standard, above items listed as the important items by our company

4.3 Marine Diesel engine daily maintenance and operation instructions

4.3.1Marine Diesel engine heat exchanger system



1.Fresh water circulation circuit 2.Fresh water pump 3.Sea water pump 4.Seawater drain valve 5.Sea water circulation circuit 6.Fresh water drain valve 7.Plug 8.Smoke and water mixer 9.Heat exchanger 10.Fresh water circulation circuit



1.Bolt M8×20 2.Inlet cover 3.Sea water inlet 4.Cover gasket 5.Heat dissipation core 6.Fresh water return joint 7.outlet cover 8.Plug 9.Add water cover 10.Case 11.Water return joint

4.3.1 Heat exchanger

1. Under the pressure of the sea water pump the sea water high speed flows in the tube of heat exchanger radiator .The coolant of engine through the cylinder and cover, Water sleeve water cooled drainage pipe then enters the heat exchanger.And the coolant flows outside the radiator pipe along the guide plate,and dissipate the heat of the cylinder casing water through heat exchanger .The end cover equipped with zinc bar,which can slows corrosion of seawater to heat exchanger components.After a period of time to use,the surface of zinc bar will have a layer of scale,should be cleaned it.otherwise it will lose the anti-corrosion effect.If the zinc bar corroded,should be to change it.We suggest change the zinc bar every three months.
2. Owing to the sea water is corrosiveness it will broke the surface of protective layer and make the tube corroded and form dirt,which will reduce the flow area of sea water lead to reduce cooling effect.Therefore,it should be cleaned regular.Remove the heat exchanger and inlet and outlet caps,And remove the cooling bar make it bathed in water containing scale remover.By using the Non-metal brush to clean the inside of radiator tube.After removing the scale 15 min,removethe water pipe and it thoroughly with water,and check the corrosion of the inlet and outlet and caps and zinc bar.All sealing rings and gasket must be replaced

4.3.2Sea water pump

High bending performance rubber impeller is installed in the sea water pump.Please use and maintain the sea water pump correctly,otherwise will make the sea water pump pumping ability decreased or damage it

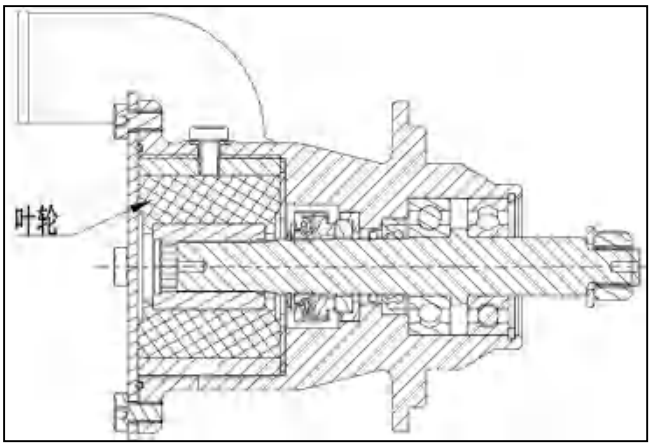
Maintenance precautions：

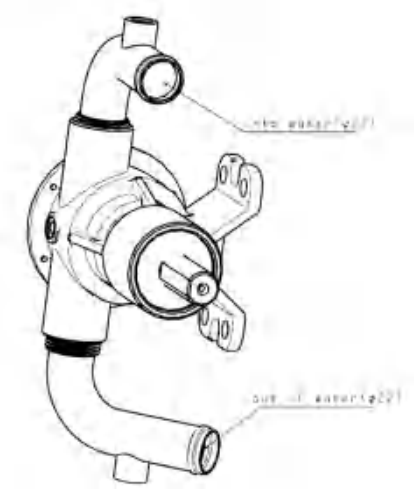
1.The sea water pump cant be idling,otherwise the impeller will be seiously wear or even scrapped

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.The impeller need to change regular which make sure the ability pumping of the sea pump ,otherwise the engine causes poor cooling.When replacing the impeller,remove the end cover first,and then remove the rubber impeller.Check the impeller replacement cycle once at 500h and be replace once at 800h.

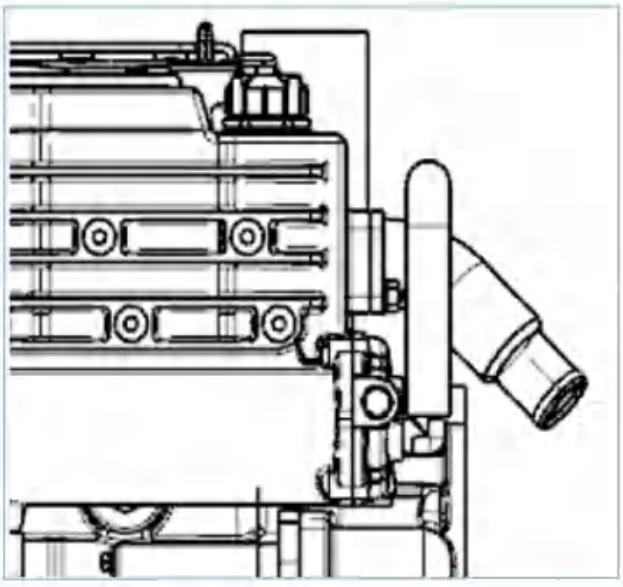
4.When the engine is not used for a long time, the sea pump and pipeline seawater should be discharged, and the residual water should be dried with compressed air





4.3.3Water and smoke mixer

The smoke-water mixer (vortex rear cooling pipe) is an anti-corrosion stainless steel double-layer structure, which can effectively avoid seawater from entering the supercharger. Do not modify the original structure to avoid damage to the engine.



4.3.4The Marine maintenance cycle

Maintenance items	Maintenance cycle time												
	50	100	200	250	400	500	1 or 2 month	3 months	one year	800	1500	3000	2 years
Check fuel tube and clip	☆												
Change oil	★												
Clean core of air filter				☆									
Clean the fuel filter element				☆									
Check position of battery electrolyte				☆									
Check fan belt tension and damage		☆											
Check radiator hose and hose clamp			☆										
Change oil filter	★												
Change fuel filter（Coarse and fine filtration）				☆									
Clean inner of fuel tank						☆							
Clean inside the water jacket and the radiator						☆							
Heat exchanger end cover gasket						☆							
Check air intake pipeline			☆										
Change drive belt													
Recharge battery							☆						
Replace the air filter element									☆				
Check valve clearance										☆			
Check injector											☆		
Check turbocharge（if have）												☆	
Replace intake tube													☆
Replace battery													☆
Replace fuel hose and clamp													☆
Replace radiator coolant（L.L.C）													☆
Check the seawater pump impeller						☆							
Replace the seawater pump impeller										☆			
Zinc bar assembly								☆					

Note: harsh use conditions (the minimum temperature is lower than-20℃, or the highest temperature is higher than 35℃, or the environmental dust content is high in desert, mining areas, construction site, coal yard, etc., the oil replacement cycle should be shortened).

★：The first maintenance cycle；

□ ：Cyclic maintenance cycle (if every 100 hours run)；

4.3.5 Maintenance instructions**:**

- Change the oil filter

The first engine oil and filter replacement of the new engine is very important. RAYWIN recommends a first replacement period of 50h. Note: If a different oil pan is used, the release plug may be elsewhere. Drain the engine oil as follows:

1.Make sure that the engine fluid level is even.

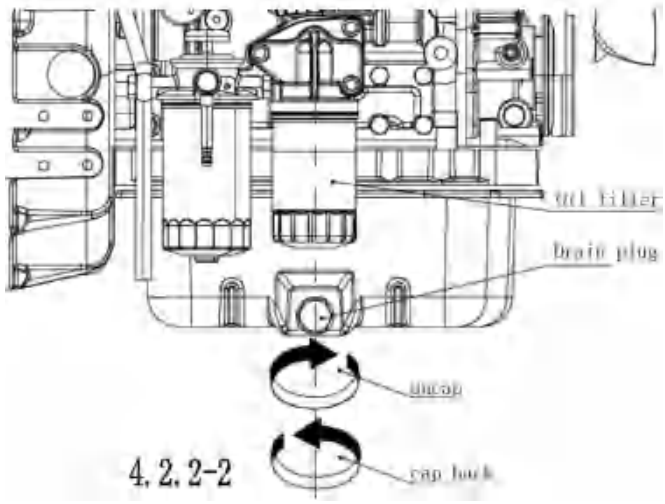
2.When changing the oil, it is recommended that the oil temperature is about 60~80℃, and it is more conducive to the oil discharge,

3.Remove one filling cap, as FIG. 4.2.2-1: to allow the engine oil easier to removal.

4.place a pan under the engine to collect waste oil.

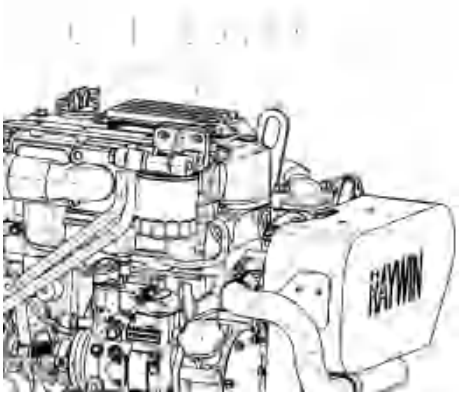
5. Remove plug from engine oil pan (see Figure 4.2.2-2 for plug position). Let the oil out.

6. After draining all engine oil, reinstall drain plugs and tighten to（50 N・m5.5-6.5kgf・m）;



7. Using the filter wrench, turn the engine oil filter counterclockwise. Clean the mounting surface of the engine oil filter. (Figure 4.2.2-2)

8. Gently apply the engine oil to the gasket on the new oil filter. Manually install the



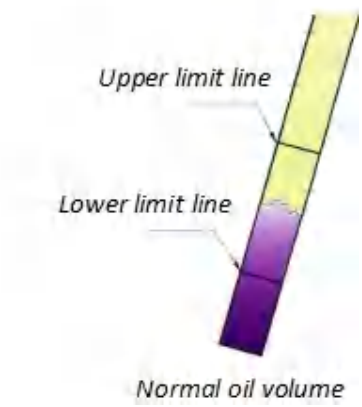
new oil filter by rotating clockwise until it touches the mounting surface. Use the filter wrench to tighten to（20 N·m；2.0-2.4kgf·m）；

9. Add new engine oil to the engine as recommended by the RAYWIN.

Note: Do not overfill the engine oil. Always keep the upper and lower markers of the oil stick.

10. Preheat the engine for 5 minutes and check for any oil leaks.

11. Turn off the engine and wait for 5 to 10 minutes.



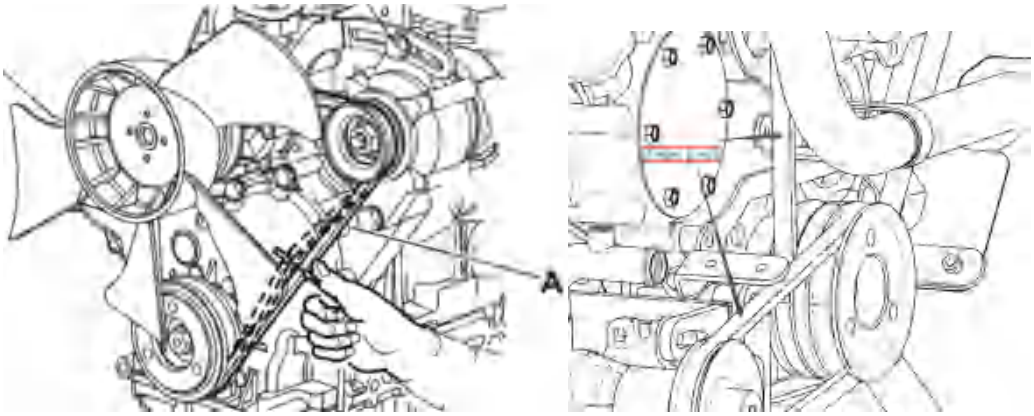
12. Re-check the engine oil level. Add oil filling according to the upper and lower limit mark of the oil level on the oil gauge.

13. Reinstall the refueling oil cover.

● Check and adjust the cooling fan V belt

RAYWIN recommended check and adjust the cooling fan V belt regularly as follows:

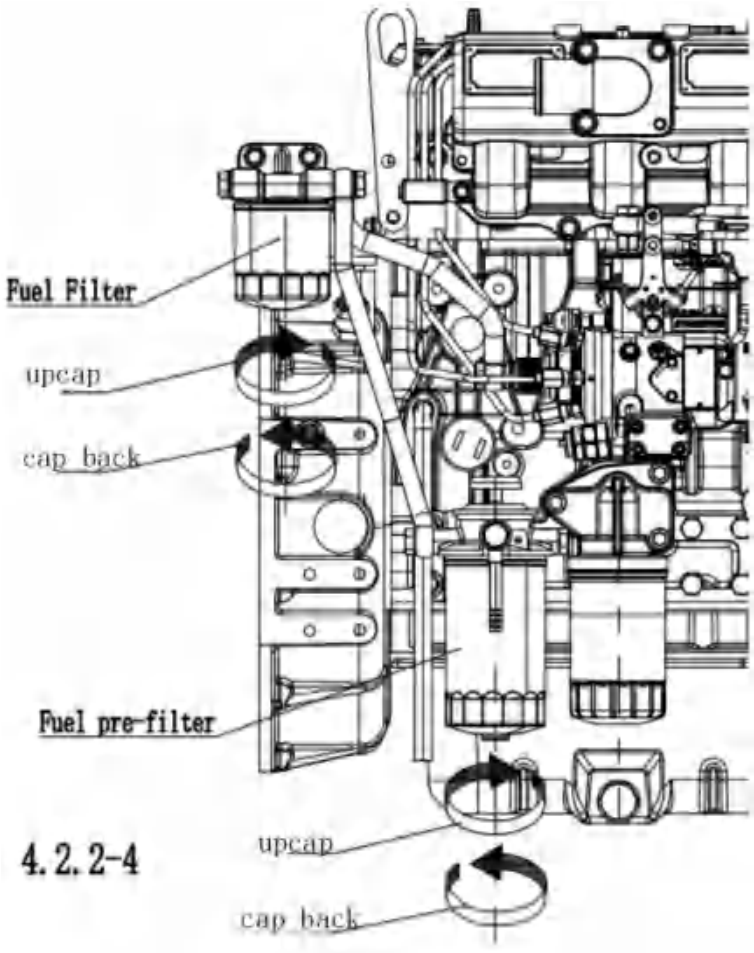
1. Press the v-type belt with about 22 ft (98 N m; 10 gf), thumb k gf. There are three positions to check the V-band tension, position A in the figure below. Qualified belt offset in the range of 9 to 14:



If beyond the recommended range value, adjust the tension of the V belt.

● Change the fuel filter

1. Engine handling at room temperature。
2. Turn off rotary plug for the fuel filter / water separator.
3. Use the filter wrench to remove the fuel filter and take care to prevent fuel overflow when removed. Wipe off all the spilled fuel oil. Clean the filter mounting surface and apply small amounts of diesel fuel to the gasket of the new fuel filter.as illustrated in following figure（4.2.2-4）



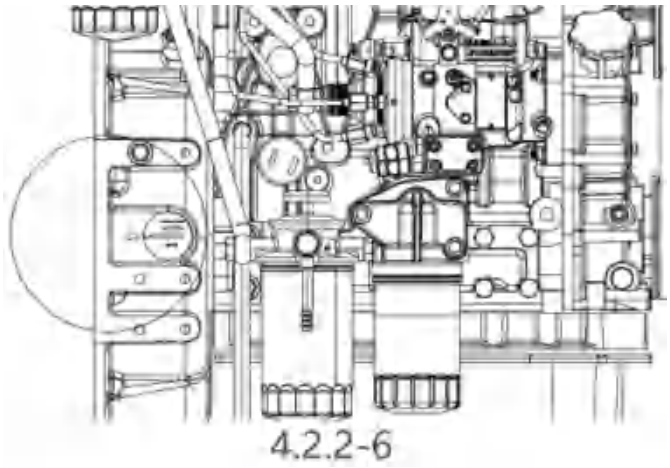
4.2.2-4

4. Install a new fuel filter.
5. The diesel prefilter element is replaced in the same way as the filter ；

● Adjust the gap of valve：

To ensure the normal working condition of the diesel engine, users shall regularly check and adjust the valve clearance as required. In the cold state, the clearance of the intake valve is 0.14~0.2, and the clearance of the exhaust valve is 0.14~0.2. The method are as follows:

1. Turn the crankshaft to the first cylinder piston compression upper stop position (TDC), and the first cylinder is located at the flywheel end of the engine with an

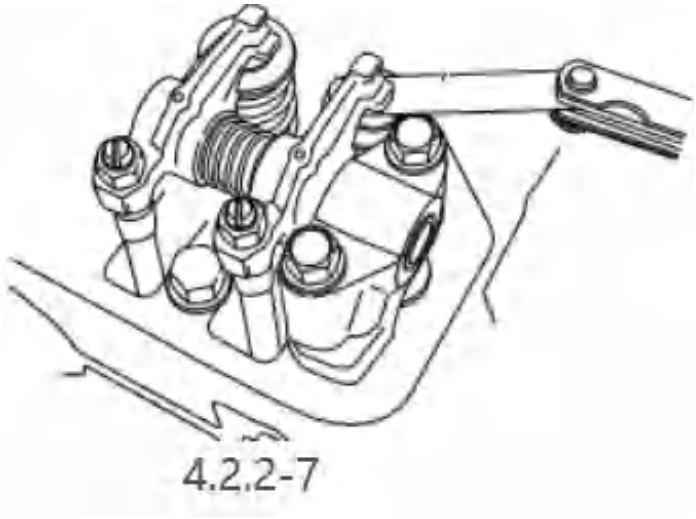


4.2.2-6

ignition order of 1-3-2.

2. Turn the crankshaft to mark the mark "NO.1 TDC" mark on the main flywheel and the timing window mark of the flywheel housing, as shown in the following figure; then the inlet and exhaust doors of the first cylinder shall be closed, and check the gap of the inlet and exhaust valve;

3. Check the valve gap with a special tool (Figure 4.2.2-7). If the range value is exceeded, readjust the engine;



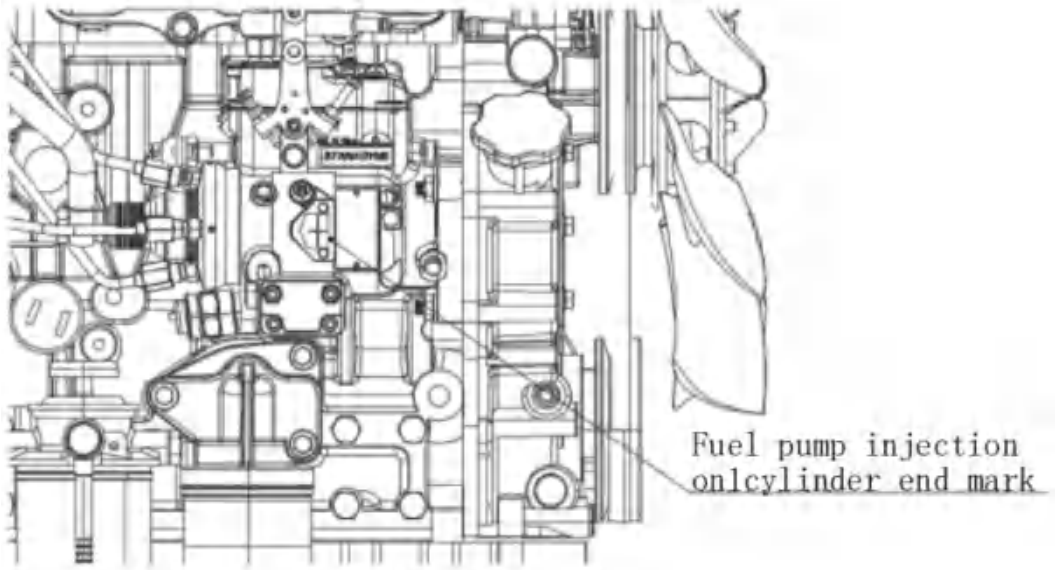
4.2.2-7

4.Adjust the valve clearance in the following order; when the first cylinder piston is in the compression stroke TDC (both valves closed), the valves shown at the top of the chart can be adjusted without rotating the crankshaft. To adjust the remaining two valves, turn the crankshaft 360 from the normal direction of rotation of the engine until the exhaust stroke of the No.1 piston is TDC (only opened by the exhaust valve)

Cylinder No.	1		2		3	
Valve	Intake	Exhaust	Intake	Exhaust	Intake	Exhaust
No. 1 cylinder at TDC compression	●	●	●			●
No. 1 cylinder at TDC exhaust				●	●	

- Check and adjust the fuel injection’s advance angle

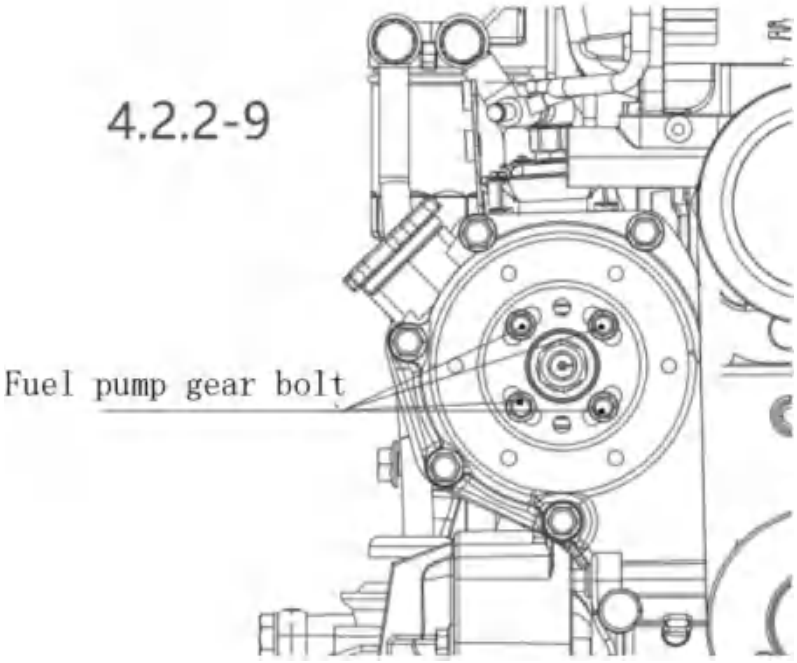
1. Turn the crankshaft to the first cylinder piston compression (TDC) in Fig. 4.2.2-6; remove the fuel injection pump timing window cover as shown below; and turn the crankshaft again, make the two lines even on the fuel injection pump；



4.2.2-8

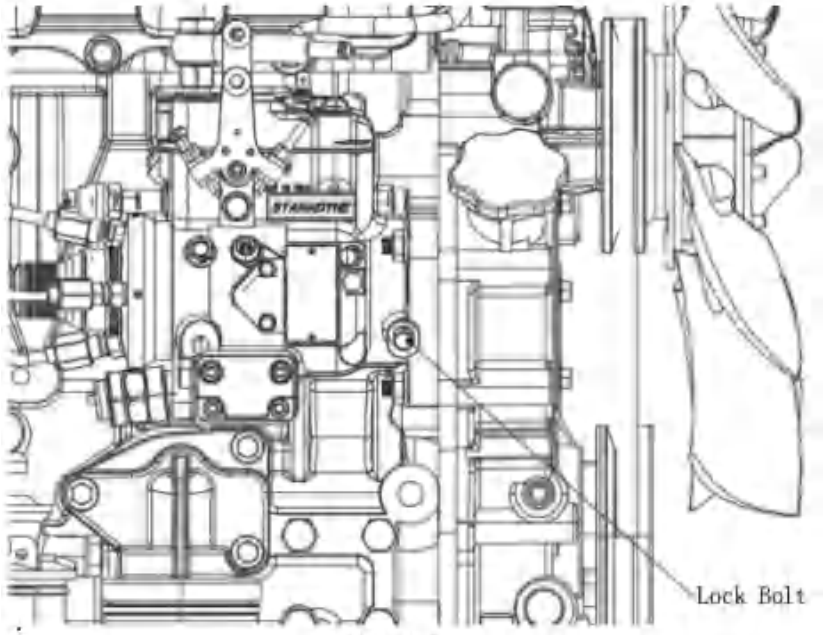
2. Check whether the angle cutting mark of the timing window hole arrow mark on the front flywheel (Figure 4.2.2-6) is consistent with the recommended value of the RAYWIN 3M16 engine; if not, adjust by the following methods；

1.Remove the gear cover of the oil injection pump, and remove the 4 oil injection pump drive gear bolts, as shown in the figure below；



4.2.2-9

2. In FIG. 4.2.2-10, unlock the bolt (Fig. 4.2.2-10), spin out about 3mm, push the limit gasket under the lock bolt up to expose the upper half of the waist hole, and lock the bolt again to unlock the fuel injection pump timing；



4.2.2-10

3.Remove the timing window cover of the fuel injection pump, turn the drive shaft and align the two engraved lines; rotate the crankshaft; align the fuel injection pump timing mark, adjust the limit gasket under the lock bolt; again check whether the crankshaft timing mark and the fuel injection pump timing mark are in the positive position (Figure 4.2.2-10)；

4.Turn the crankshaft and mark the timing window hole arrow of the flywheel shell at the RAYWIN recommended value (Figure 4.2.2-6); Note: when turning the crankshaft, the fuel injection pump drive shaft does not rotate. Again, recheck whether the fuel injection pump timing mark is correct；

5.After confirmation, install the rear fuel injection pump drive gear bolt, fuel injection pump gear cover (Figure 4.2.2-9), fuel injection pump timing window cover plate and flywheel housing timing window block plug;

5. Diesel engine daily maintenance instructions

Good maintenance from day to day of diesel engine and its system are beginning to understand, starting diesel engine before check the oil level and coolant level, check whether there is：

- leakage
- The loose and damaged parts
- The belt is worn or damaged
- Any change in the appearance of the diesel engine
- No fuel smell

At the same time need to see if there is no fault lights on, if there is a fault then need to identify, if it is historical failure, can be cleared.

This section describes the daily maintenance instructions of some of diesel engine system and parts.

5.1 Coolant level check of cooling system

Coolant level check

Warning

Do not open the radiator pressure cap from the hot diesel engine, should wait for coolant temperature below 50℃ to open the pressure cap, otherwise high temperature coolant or steam spray may cause personal injury.

Warning

Coolant is poisonous to avoid contact with kids or pets. If it is not be used anymore, it should be treated according to the local environmental regulations.

Warning

Do not use corrosive cleaning agents in the cooling system, otherwise it will damage the aluminum parts**.**

Attention

Do not use the seal additive to solve the cooling system leakage problem. This will cause the cooling system block and the coolant flow is not smooth, thus causes the engine overheat.

The coolant level must be checked every day.

Attention

Do not add a cold coolant to the hot diesel engine, otherwise it will damage the Diesel Engine Castings, wait until the diesel engine temperature below 50 ℃, then add coolant**.**

Adding coolant to the diesel engine must be mixed with the correct proportion of antifreeze, auxiliary coolant additives and water to prevent damage to the diesel engine.

Fill the coolant to the bottom of filler, of the radiator or expansion tank.

Warning

DO not rotate the diesel engine by pulling or prying fan. Otherwise, it will damage the fan blade, resulting in fan fault and caused personal injury or property loss, should use accessory drive shaft and the crankshaft turning tool to rotate the crankshaft.

Warning

Do not attempt to bend the blades of the fan or continue to use the damaged fan, bending or damaged fan blades cannot work properly, and will result in personal injury or property damage.

5.2 Fuel filter

Warning

Discharge the water in the fuel filter (pre filter) to the container, and handle it in accordance with local environmental regulations.

RAYWIN required the user to install the fuel filter (pre filter and fine filter) or fuel-water separator, daily discharge water of fuel filter (pre filter) or water in oil-water separator and sediment in the fuel supply system.

Attention

Close the discharge valve, the valve will not be overdone, excessive tightening will damage the thread**.**

5.3 Check oil level

User should check the oil level before each starting.

Attention

It is strictly prohibited to running the engine in oil level below or above the oil limit marks, which can lead to diesel engine performance degradation and damage of diesel engine**.**

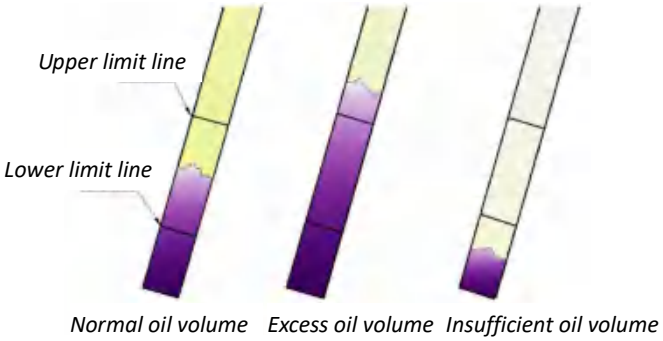


Fig. 5-1 Schematic diagram of oil dipstick

The precise reading can be measured after diesel engine shutdown. At least until diesel engine downtime longer than 15 minutes, then began to check the oil level. This period of time can let the oil back to the bottom of oil pan.

Warning

Used oil has a carcinogenic effect, and may produce reproductive disease, should avoid the inhalation of oil vapor, do not swallow and prolonged contact with the used oil, if no longer use should be handled in accordance with local environmental regulations

Warning

In order to reduce the possibility of personal injury, should avoid the skin direct contact with hot oil.

5.4 Air filter

Users can observe the air resistance indicator to judge the air cleaner clogging which installed on the intake pipe of the air filter, when air resistance indicator changed from normal green to red, it indicates that the air intake filter resistance exceeds the limit value, and air filter need to be cleaned or replaced.

Attention

The engine is absolutely forbidden to work in case of air filter failure or without air filter. The intake air must be pre-filtered to prevent dust and impurities, otherwise caused engine early damage.

6.Common trouble of diesel engine and removal methods

Note: This manual describes some typical engine operation problems, the reasons and the solutions.

Warning

Implementation of this chapter of the fault diagnosis and elimination steps may result in machinery damage or personal injury or even death. It must be by trained technicians implement fault diagnosis and troubleshooting work. For not listed in this chapter the diagnosis and exclude steps and symptoms, please contact Raywin.

To make a fault diagnosis, please follow the following recommendations：

※Careful analysis of the problem before action；

※Start with the most easy and obvious place；

※Find the root causes and eliminate the problem.

6.1 Quick Reference Table for Troubleshooting

\Trouble Symptom / Cause		Starting failure				Engine stall after start			Insufficient engine output		Noise/vibration				Lubricating oil				Cooling water		Air Intake		Exhaust				Fuel			Corrective Action
		Starter not rotate	Starter rotates			Exhaust fume			Exhaust color														At work							
		The indicator light does not light up after power on	Engine not start (not even Initial combustion)	Engine not start (stall after serial combustion)	Engine starts later then ever	None	Little	much	When	back	Knocking noise at combustion toa high	Combustion noise uneven	Noise other than combustion from engine	Engine vibration too big	Lubricant consumption too much	Lubricant diluted with fuel	Lubricant mixed with water	Oil pressure too low (oil pressure lamp on)	Overheated (water temperature lamp on)	Water temperature too low	Pressure down (air cleaner lamp on)	Pressure up	White exhaust color	Black exhaust color	Blow-by too much	Exhaust temperature up	Fuel consumption too much	Fuel mixed with water (oil-water separator lamp on)	Fuel filter contaminated too early	
Engine system	Intake/exhaust valve clearance Incorrect		√			√							√								√					√				Valve clearance adjustment
	Compression failure at valve seat		√							√			√								√			√	√	√	√			Valve seat facing
	Intake/exhaust valve seizure		√					√		√			√	√		√					√			√	√					Correction or replacement of Intake/exhaust valve
	Cylinder head gasket blow-out																√		√											Gasket replacement
	Piston ring sticking or breakage		√					√	√				√	√	√	√			√				√		√	√				Piston ring replacement
	Wear of piston ring, piston or cylinder		√					√	√						√	√							√		√					Honing work and usage of over-sized parts
	Seizure of crank pin metal or bearing parts		√			√							√	√											√					Repair or replacement
	Closed gap position fault of piston ring					√			√						√										√					Correction of closed gap position
	Reverse assembling of piston ring								√						√								√		√					Correction of assembling
	Wear of crank pin metal and journal metal												√	√				√												Measurement and replacement
	Connecting rod bolt loose												√	√				√												Tightening at specified torque
	Foreign material entered into combustion chamber		√										√		√										√					Disassembling and repair
	Gear backlash too big												√																	Gear mesh adjustment
	Wear of intake/exhaust valve guide								√						√										√					Measurement and replacement
	Open/close timing failure of Intake/exhaust valve		√						√	√			√										√	√						Valve clearance adjustment
	Engine vibration isolating support loose, damage												√	√																Repair or replacement of faulty parts
Cooling water system	Radiator super cooled																			√			√				√			Thermostat replacement
	Insufficient radiator cooling									√									√							√				Thermostat replacement or check for fan belt loose
	Insufficient cooling water quantity									√									√							√				Water leak inspection of coaling water system
	Water jacket cracks																√	√	√											Repair ar replacement

ng water s	Fan belt elongation									√								√							√			Adjustment of belt tension
	Thermostat fault									√								√	√			√						Inspection or replacement
Lubricant system	Incorrect lubricant		√			√									√			√							√			Usage of correct lubricant
	Lubricant system leakage														√			√										Repair
	Insufficient discharge rate of trochoid pump																	√										Inspection and repair
	Lubricant filter clogged																	√							√			Cleaning or replacement
	Regulator valve fault																	√										Cleaning, adjustment or replacement
	Insufficient lubricant quantity					√												√										Replenishment of correct lubricant
	Excess filling into crankcase														√			√					√					Engine oil check
Fuel system	Fuel injection pump with injection timing excessively advanced										√			√									√	√				Inspection and adjustment
	Fuel Injection pump with injection timing excessively retarded								√	√													√	√		√	√		Inspection and adjustment
	Incorrect fuel								√	√		√											√	√			√	√	Usage of correct fuel
	Water entered into fuel system		√	√				√	√			√											√				√		Drainage of fuel filter
	Fuel filter clogged		√		√	√																							Cleaning or replacement
	Air entered into fuel system		√	√		√																							Bleeding
	Fuel pipe clogged, cracked		√			√																							Cleaning or replacement
	Insufficient fuel feeding to fuel injection pump		√	√		√																							Check of fuel tank cock, fuel filter, fuel pipe, fuel feed pump
	Uneven injection quantity of fuel Injection pimp								√	√		√		√									√	√		√			Inspection and adjustment
	Fuel injection quantity too much														√			√			√			√	√	√			Inspection and adjustment
	Defective spray of fuel injection nozzle								√	√		√		√									√	√			√		Inspection and adjustment
	Priming not available		√																										Valve In priming pump pinched dust (disassembled cleaning)
	Strainer at feed pump Inlet clogged				√																								Cleaning of strainer
	Operation defect of CSD valve		√		√						√																		Replacing the pump Replacement of CSD valve
	Sealing defect of fuel tank																										√	√	Check of fuel tank and cap, as well as Installation of genuine parts
	Air filter clogged							√		√		√			√					√			√		√				Cleaning of air filter
	Engine operatlon at high temperature or high land									√								√		√			√			√			Consideration of matching output reduction with load
	Exhaust pipe clogged						√			√		√											√		√				Cleaning of exhaust pipe
Electric system	Starter fault		√																										Repair or replacement of starter
	Alternator fault		√																										Repair or replacement of alternator
	Wiring disconnection	√	√			√																							Repair or replacement of harness disconnection
	Wiring short-circuit (insulator broken), electric power load of added device too big	√																											Inspection, repair or replacement of harnesses Review of added devices
	Battery voltage descent		√																										Inspection and charging of battery
	switch fault, disconnection	√				√																							Repair or replacement of harness Key switch replacement

Electric system	Instantaneous interruption of key switch			√		√																								Key switch replacement
	Failure, disconnection, short-circuit of starter relay																													Repair or replacement of harness Replacement of starter relay
	Disconnection /short-circuit of water temperature sensor																													Repair or replacement of harness Replacement of water temperature sensor
	Disconn ection/short-circuit of accelerator sensor																													Repair ar replacement of harness Replacement of accelerator sensor
	Speed sensor signal error			√		√																								Repair ar replacement of harness Repair or replacement of fuel Injection pump
	Rack position sensor signal error																													Repair or replacement of harness Repair or replacement of fuel Injection pump
	Operation defect of rack actuator					√																								Repair or replacement of harness Repair ar replacement of fuel injection pump
	Engine over speed					√																								Check operating machine's driving. Check speed sensor signal.
	Fuel injection pump solenoid valve disconnected/shorted		√		√																									Repair or replacement of harness Replacement of valve solenoid
	Disconnection/short-circuit of start assist relay	√			√																			√						Repair or replacement of harness Relay replacement
	Disconnection/short-circuit of rack actuator relay																													Repair ar replacement of harness Relay replacement

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