

Operational Manual for WD Series Diesel Engines

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FOREWORD

WD series diesel engines are newly-developed products based on original 135 series diesel engines of my company. During the process of continuous development and improvement, domestic and overseas advanced internal combustion engine technologies are introduced. Compared with original 135 series diesel engines, its power performance is strengthened a lot and its economic performance is better. Meanwhile its overall structure keeps crossing-over with original ones, so its components have a good capacity of general service. It also has some advantages like compact structure, small contour dimensions, light weight, high power and good performance etc.

The edition of this manual places emphasis on the use and maintenance for customers as well as main faults and remedies during normal use. Therefore, customer must read this manual carefully before using. If it's a turbocharged-diesel engine, customer must also read the attachment manual: 《The operation manual for turbocharger》. In this way, the diesel engine can be properly used and maintained. Contact special manufacturers if you want to know detailed technical parameters, specification and structure.

We may make some necessary amendments at appropriate time with continuous innovation of our products without impartation in advance.

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SECTION I. SUMMARY

1. STRUCTURE, MODEL AND APPLICATION

WD series diesel engines are high speed, four strokes, direct injection and water-cooled model. They are divided into model in-line 6 cylinder and model 12V according to cylinder arrangement, aspirated, turbo-charged and inter-cooled According to air intake way. 140 stroke, 150 stroke, 160 stroke according to the stroke of piston. 135 series, 138 series, 140 series according to cylinder bore. Our engines are widely used in the field of generating-set, agricultural irrigation, construction machinery, emergency fire protection pump and other industry. It can also be used as light railway locomotive power and auxiliary power of marine application.

Model in-line 6 cylinder diesel engine use integral crankshaft and gantry cylinder block while model 12V diesel engine uses combined crankshaft and tunnel cylinder block. Power is output from the flywheel end. Therefore, suitable power take-offs and necessary accessories must be attached to the engine before it can be properly used. Connection of the output end is SAE type and can also be modified to resilient coupling. Cylinder number designation of model 12V diesel engine: Viewed from the flywheel end, the right hand bank is the first bank and the left hand bank is the second bank; counted from free end, the first bank is cylinder numbers 1-6, the second bank is cylinder numbers 7-12. Our product is designed in the principle of series, standard, general, so that the main components can be exchanged.

2. Explanation of power rating

The power rating of WD series diesel engine is the permissible effective power output for the engine with the air cleaner, but without other accessories which will not affect its running such as fan, muffler, sea water pump, and gear box etc. to operate under the atmospheric condition of 100 kPa (750mm Hg) barometric pressure, 25°C ambient temperature and 30% relative humidity. The engine can also be overloaded at 110% of the 12 hour power rating for a short period of not over 1 hour discontinuously or continuously during each 12 hour operation. If the engine is required to operate continuously over 12 hours, it should run at 90% of the 12 hour power rating (continuously power rating).

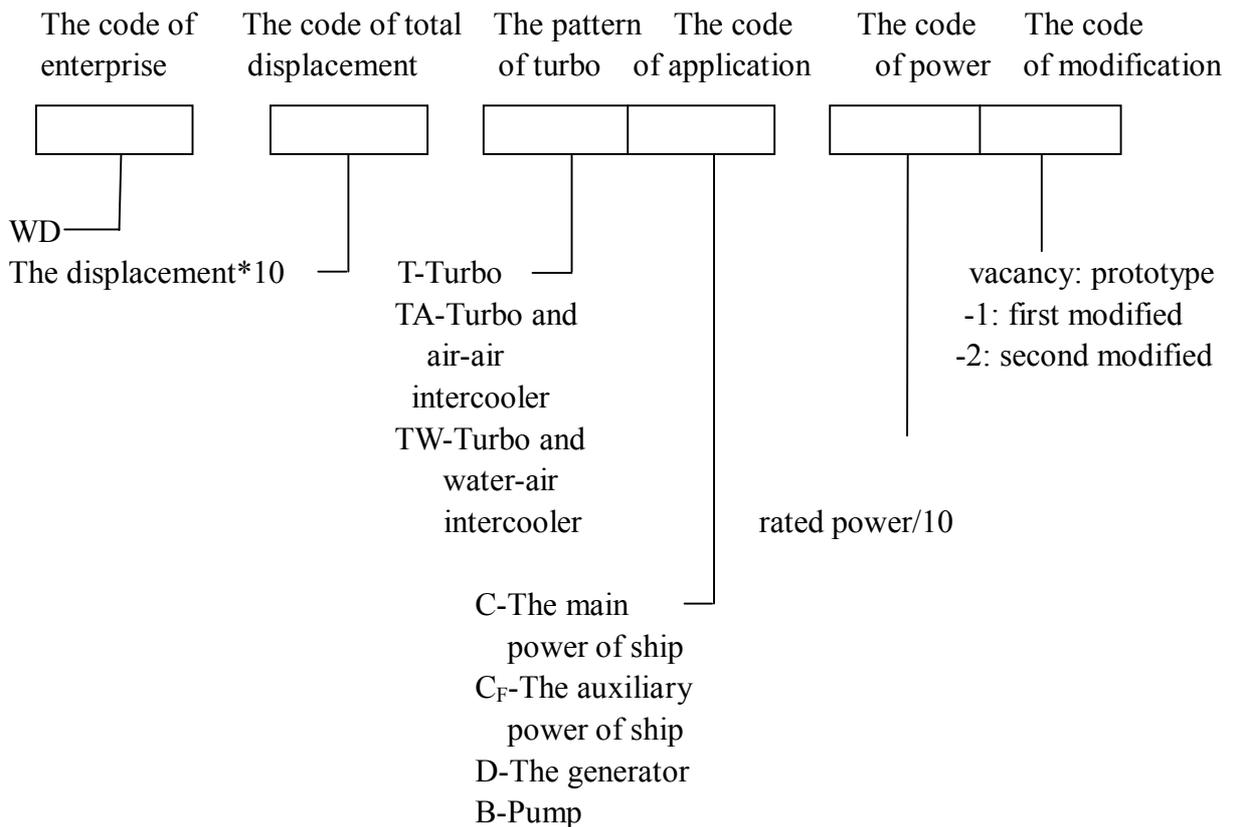
The value of the output power on the nameplate contains the power consumption of the fan so the net output power of the engine (effective power) should deduct the power consumption of the fan.

Since the output power will decrease with the increasing of altitude, ambient temperature and relative humidity, so the customer should modify the rated power according to the correcting method of standard GB/T1105 (see Appendix) when the barometric pressure, ambient temperature or relative humidity is different from the above stated standard atmospheric condition. The allowable power output should be calculated according to the power

correction table included in Appendix.

3. Introduction to model naming

WD series diesel engines are named according to the following diagram



For example: WD269TAD38 –Wandi brand, the total displacement is 26.9L, turbocharged, air-air intercooling, for generator, the rated power is 382 kW.

SECTION II. OPERATION AND ADJUSTMENT

1. Selection of fuel oil, lubricating oil and coolant

1) Diesel oil

Customer should select proper diesel oil according to the environment temperature. In the south areas where climate is hot, fuel oil high condensation point should be selected while in the north area where climate is cold, fuel oil with low condensation point should be selected, for example, grade “-35” or lower condensation point fuel oil for the north area. While in the south area where climate is relatively hot, grade “10” can be selected. While under ordinary climatic conditions, use grade “0” or grade “10” light diesel oil.

Water and mechanical particles in the diesel fuel oil should be as little as possible. Such diesel oil as mixed with water, kerosene or gasoline is strictly forbidden to use. Otherwise, the fuel filter elements may be blocked and injection pump choked etc.

The fuel oil must be clean. Before using, settle the fuel oil for at least 7 days so that the mechanical impurities within it can deposit to the bottom of the storage tank, or filter the fuel oil through silk filters so as to get rid of the mechanical particles. Otherwise, it will cause fuel system accidents by choking plunger coupling.

2) Lubricating oil

CD grade lubricating oil specified in GB11122 should be selected for the diesel engine. In non-cold climate areas, grade 40 lubricating oil can be selected in any season. It is very useful in prolonging the life of engine's components, reducing wear and improving lubrication condition.

In cold climate areas, use lower freezing point lubricating oil. Commendatory grade:

15W/40 grade lubricating oil is recommended when lowest ambient temperature is – 10°C.

10W/30 grade lubricating oil is recommended when lowest ambient temperature is – 15°C.

5W/30 grade lubricating oil is recommended when lowest ambient temperature is – 20°C.

For new engines or those after overhauling, the first oil change should be carried out after 60 hours of running-in operation finished. Thereafter, it should be changed every 200-250 hours of operation under ordinary operating conditions. During oil change, if the oil is rather clean and still useable, the change period can be prolonged to 300-350 hours. Drain out the oil while it is still hot, for example do that immediately after the engine has stopped.

For those highly-strengthened turbocharged engines, it is not permitted to use lubricating oil lower than CD grade. Mixing of different grade lubricating oil is not permitted either.

3) Coolant

It is recommended to use soft water such as rain water, city supply water or clean river water for engine cooling. Because well water contains too many kinds of minerals and forms scale in the engine water jacket which would affect proper cooling efficiency, so such kind of water is unsuitable for engine cooling directly.

When the engine is operated below 0°C, strict precautions should be taken against freezing that can lead to cracking of the engine parts. Therefore, drain out the cooling liquid completely after the engine stops. Proper freezing point antifreeze agent can be added to the cooling system according to local lowest ambient temperature. Antifreeze agent compounding used widely is described in the following table:

Antifreeze agent compounding

Name	component %				unit	Solidifying point °C ≤
	glycol	alcohol	glycerin	water		
Glycol antifreeze agent	65			40	Volume ratio	-55
	55			45		-40
	50			50		-32
	40			60		-22
Alcohol and glycerin antifreeze agent		30	10	60	Weight ratio	-18
		40	15	45		-26
		42	15	43		-32

100% antifreeze agent is strictly prohibited to use as coolant!

Sea water is absolutely prohibited to cool the engine directly.

If there is too much scale and dirt in cooling system and cooling effect has been affected, clean the cooling system with washing liquid. Washing liquid consists of water, soda (Na_2CO_3) and water-glass (Na_2SiO_3). Add 40g soda and 10g water-glass to one liter of water. Put washing liquid into cooling water chamber to clean the engine, then run the engine until outlet water temperature over 60°C, go on running for about 2 hours before stopping and then drain out the washing liquid. After the engine cooling, clean it twice with clean fresh water. Then add cooling water and run the engine till outlet water temperature over 75°C. Drain out the water completely again after stopping. Finally it is all right to add new cooling water.

4) Grease

Lithium base grease (GB5671-85) can be adopted for fresh water pump, fan belt pulley and rolling bearings. Before the engine leaving factory, lubricating cavity should be full of grease. When maintained, check it in time to avoid bearing damage caused by leakage of grease after a long period of running.

2. Starting the engine

(1) Preparations before starting

Before using the diesel engine, customers should know the basic knowledge about engines as following.

Governor system

Reliability of the fuel system and governor directly affects the operating characteristics of the engine. Therefore during dismantling, repairing, reassembling, adjusting and testing of the

fuel system and governor, it is important to keep all parts clear. Remember, cleanliness is of primary importance to quality and reliability.

When the governor of the diesel engine is of mechanics, there is a maximum speed limiting screw in the control mechanism. When the engine is tested in the factory, the maximum speed limiting screw has been set and lead sealed. Don't alter it unless absolutely necessary. Otherwise, the product would not be placed into the quality assurance service extent. There is an engine stop handle on the governor front housing, when it is necessary to stop the engine immediately in case of emergency, pull this handle.

On the rear of the governor housing, there is a low speed stabilizer to keep engine speed fluctuation at a minimum when the engine runs at low speeds. If the engine hunts at low speeds, turn the stabilizer screw slowly into the governor until engine speed is steady. (A speed fluctuation of $\pm 25\text{r/min}$ at minimum speed is permissible.) The low speed stabilizer has been adjusted in the factory. Don't readjust it unless necessary. If the injection pump and governor have been dismantled for repair or the engine speed fluctuates too much at low speed after reassembly, the low speed stabilizer can be readjusted. But be careful not to screw the stabilizer screw into the governor too much. Otherwise, the engine may overspeed when the load is suddenly taken off.

When the governor of the diesel engine is of electric, it consists of speed sensor, electromagnetic performer, speed controller, control switch and connecting cable etc. Speed sensor has been installed on the flywheel housing of the diesel engine. Speed signal would come out from flywheel ring gear of the diesel engine. Electromagnetic performer has been installed in the back of the fuel pump. Speed controller, and connecting cable has been placed or installed in the monitoring instrument of the engine. High-low speed alter switch and stop switch (power switch) would be supplied with the engine. The power of the electronic governor is 24V battery which is used to start the engine (two 6-Q-195 type). Users can refer to the operation manual for electronic governor during operation and maintenance of the electronic governor. If a diesel engine used for generating-set adopts electronic governor, its governing performance is obviously improved. The ratio of steady-state governing is no more than 3%. The speed fluctuation is so low that it would satisfy completely the technical requirement of matching for generator.

When the engine is tested in the factory, each parameter of speed controller has been set and lead sealed. Don't adjust it without permission of the specialist of manufacturer. Otherwise, the product would not be placed into the quality assurance service extent. If you want to adjust the engine's starting speed in special condition, you may adjust the remote control potentiometer. If you want to shut down the engine in an emergency, you can shut down the power of the electric governing by shutting down the power switch (stop switch of the diesel engine) of electric governing.

In order to ensure the reliability of transmission agent , WD series diesel engines all adopt steel plate coupling between high-pressure fuel pump and transmission shaft of gear chamber .

The fitting relation of steel plate coupling and transmission shaft and jointing tray of fuel pump is shown in figure 1.

In order to ensure the reliability of steel plate coupling and avoid outbreak accident of steel plate in the coupling caused by mal-installation and mal-operation, users must pay attention to the following items especially while the steel plate coupling parts are replaced:

At first, install the steel plate coupling on the transmission shaft of injection pump and

make sure it can be moved along axial direction. Then loose bolts D (2 pieces) and tighten the back-end steel plates (4 pieces) of steel plate coupling on the jointing tray of injection pump with bolts A (2 pieces), the tighten moment of bolt A is 40NM. The next is that tighten the bolts D (2 pieces) on the steel plate coupling, tighten moment is 40NM too. Then, adjust the axial location of steel plate coupling and ensure the steel plates are no deflection, tight bolt B (1 piece) and the moment is 40-50NM and make the steel plate coupling fixed with the transmission shaft of injection pump reliability. At last, loose bolts C (2 pieces) and adjust the fuel supply advance angle to specified range, then tighten the bolts C (2 pieces) to 40NM. Thus, the installation of steel plate is finished.

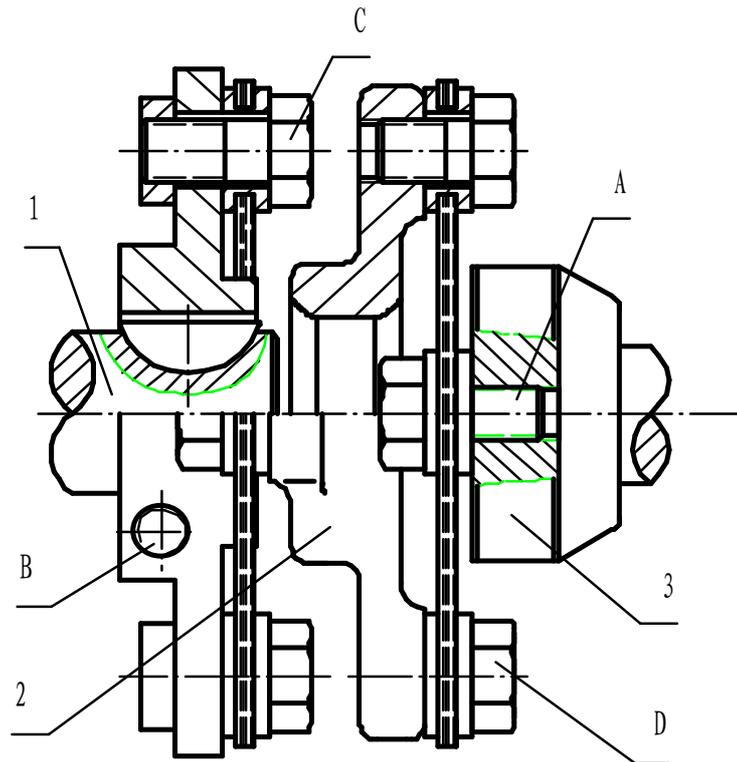


Fig.1 Assembly parts of steel plate coupling

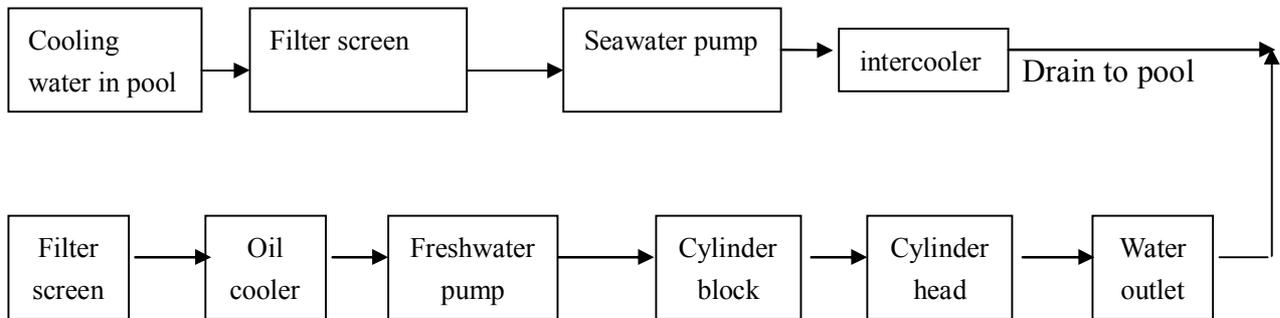
1. Transmission shaft of injection pump
2. Steel plate coupling
3. Jointing tray of injection pump
4. Shaft of injection pump

Cooling System

There are two types of cooling system used on WD series turbocharged diesel engines: the open type and the close type. Air-air inter-cooled diesel engine is applied. The close type cycle cooling system only. The open type is introduced as following.

The open type cooling system mainly consists of fresh water pump, thermostat, water tank and piping etc. The cooling water in water tank is sucked into oil cooler by freshwater pump of diesel engine to cool the lubricating oil first, then it is pressurized to cylinder block to cool cylinder liner and cylinder head. Flow from cylinder head, it is pressurized to thermostat and main collecting drainage pipe. At last, the cooling water is pressurized to open water tank and

begins the next cooling circulation. Water-air inter-cooling diesel engine is added one route of cooling water for intercoolers to cool intake air. The cooling water circulating route is shown in following figure. In the circulating system of intercoolers, the cooling water in water tank is sucked into sea water pump and is pressurized to left and right intercoolers. In intercooler, the cooling water cool the high-temperature air from turbocharger, then the cooling water in intercooler is combined and pressurized to open type pool and enter the next circulation.



The water level in the tank should be higher than that of the diesel engine to ensure uninterrupted water supply to related parts of the engine. Water temperature of the tank should be kept higher than 40°C and less than 60°C . Therefore, cold water must be added to the tank continuously (or cool it by other means) so as to maintain water temperature within this range which is recommended for normal operation of the engine. In order to ensure the cooling effect, the pool must have enough capacity, recommendatory capacity is 6m^3 . The water tank may be laid in front of the diesel engine and its water level should be higher than center of fresh water pump. In the water tank of water-air inter-cooled diesel engine, cooling water of intercooler should be separated from cooling water of diesel engine. In order to control water temperature, when diesel engine is running continuously, the water supply facilities and overflow pipe should be installed for water tank, so as to adjust the water level and water temperature within above regulated range.

When dismantling and checking the water pump, knocking, inclined and surface bruising are forbidden. After finishing working in winter when the temperature is below 0°C , must unscrew the drain cock and drain out the remained water in pump body to avoid frost crack of pump.

The function of thermostat is to regulate cooling water temperature of the engine. When cooling water temperature is low, the water outlet port of the thermostat is closed. Water flowing out of the cylinder head is by-passed to the fresh water pump inlet through the by-pass port of the thermostat. When cylinder head outlet water temperature reaches $72\pm 2^{\circ}\text{C}$, the water outlet port of the thermostat starts to open. A part of the outlet water is directed to the engine water outlet piping (open circuit cooling) and the rest is by-passed to the fresh water pump to recirculation. As the cylinder head water outlet temperature reaches 84°C , the outlet port of the thermostat is completely open, and the by-passed port is completely closed. All cylinder head outlet water is directed to the engine water outlet piping or to the radiator.

To check whether the thermostat is operating accordingly, place it in water and heat the water up slowly. When the water temperature reaches $72\pm 2^{\circ}\text{C}$, its outlet port should start opening and when it reaches 84°C , it should be fully open. Maintenance of the thermostat

should be done with care. To keep it in proper condition, don't harm it or let anything which may impair its normal operation get on it. If the engine operates without the thermostat, cooling water temperature would be too low which is undesirable for normal operation of the engine. Therefore a damaged thermostat should be promptly repaired or renewed. It not should be canceled never.

Starting system

Starting system mainly consists of battery, starting motor, charging alternator and some accessory wire.

Some basic wiring diagrams of starting system are shown in following figures.

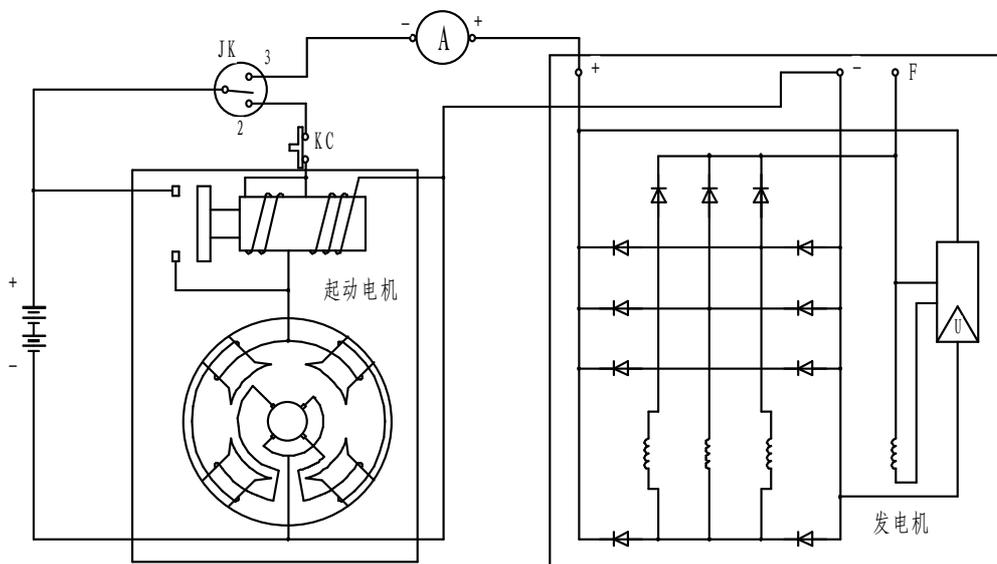


Fig.2 wiring diagram of starting system of V-shape, 12-cylinder non-supercharged engines

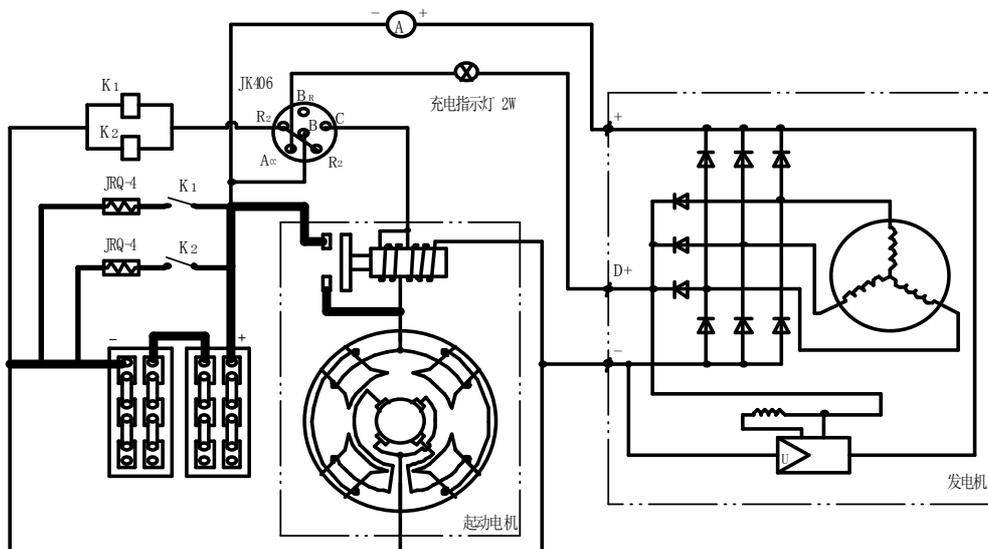


Fig.3 wiring diagram of starting system of 12V turbocharged engines

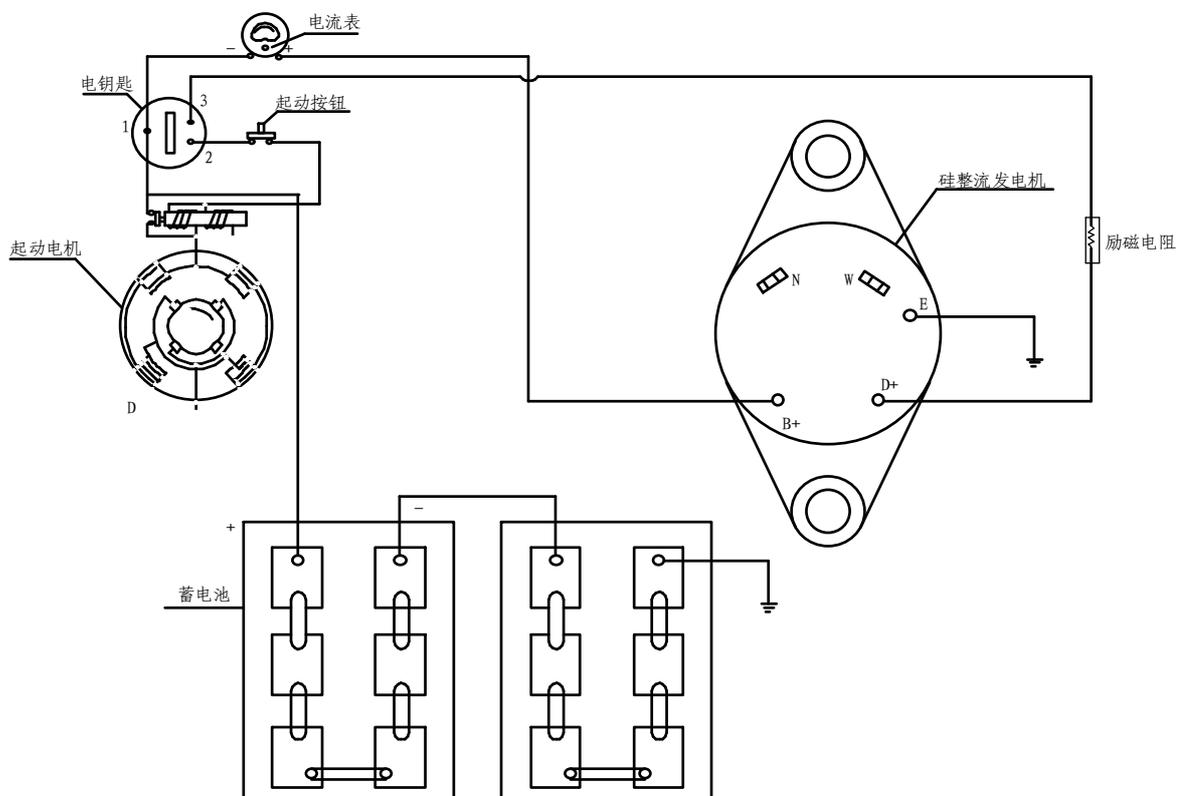


Fig.4 wiring diagram of starting system of 6-cylinder engines

Note: Specification of connecting wire from battery to starting motor: QVR133/0.68

Specification of connecting wire from air-heater to battery: QVR49/0.52

Other: QVR19/0.64

Pay attention to voltage of the battery and specific gravity of the battery acid at any moment when the engine is running. The specific gravity of the battery acid should be within 1.28-1.29 (at ambient temperature of 15°C) and should not be lower than 1.27. Under ordinary conditions, the charging alternator can maintain the batteries fully charged. But under special conditions such as when the engine has been idled for a long time, the batteries may be insufficiently charged. If so, the batteries should be charged by other means.

Check frequently the tightness of the starting motor fasteners and the firmness of the wiring contacts. Clean off the dirt on the starting motor and the wiring contacts. Smear some protective grease on all expose metallic parts to protect them from rusting.

The silicon rectified alternator must be used in conjunction with the designated type of battery and connected according to the wire diagrams. All wirings and cables must be firmly and correctly connected, especially the positive and negative poles which should not be mixed up, otherwise, it will cause serious damages to the alternator. A ball bearing is fitted at each end of the alternator, enclosed in the front and rear cover respectively. These bearings should be lubricated by calcium base complex grease which should be renewed after approximately every

1000 operating hours. When filling these bearings with grease, don't fill them up too full. If too full, grease will leak out and drop on the slip rings which would affect the performance of the alternator. The construction of the silicon rectified alternator is rather simple and it does not need any special maintenance. Usually, it is only necessary to blow off the dirt gathered within the alternator so as to keep the air ducts clear; check the contact of the brushes with the slip rings and the wear of the brushes and tightness of the fasteners.

After understanding the knowledge described above, pay attention to the following items before starting the engine:

(1) Check all parts to see whether they are in proper order. Check the accessories to see whether they are firmly and reliably connected.

(2) Check the cooling system to see whether it is full.

(3) Check oil level in the engine oil sump to see whether it is sufficient.

(4) Check the fuel tank to see whether there is enough fuel for the run.

(5) Check all electrical wiring connections of the starting system to see whether they are correctly and firmly connected. Check the batteries to see whether they are fully charged.

(6) Use hand pump on the fuel feed pump in order to deliver fuel to fuel system. Loosen the vent bolt of injection pump or loosen the vent screw on the fuel filter in order to vent the air in fuel system. Tighten the vent bolt or screw till fuel flowing out of the high pressure piping without any air bubbles. Then go on pumping oil, tighten the hand pump till there is oil in the return piping.

(7) For a new engine or an engine idled for 5 days without operation, rotate the crankshaft 3-5 turn before starting.

(8) For an emergency engine, it should be operated once every 3-5 days during the storage period until the water temperature and oil temperature exceed 60°C in order to be started immediately when required.

(9) For an emergency engine, ensure the temperature in the storage room is within 10~15 °C

(2) Starting the engine

After completing the above checks, turn on the key-switch and press the starting press button. As soon as the starting press button is pressed, the pinion of the starting motor comes into mesh with the starting ring gear on the flywheel and starts cranking the engine crankshaft. Under ordinary conditions, the engine can be started with on starting operation, if the first starting operation fails, wait for at least 2 minutes before starting the engine again. The continuous time for pressing down the starting press button should not exceed 5 seconds. It is forbidden to press the starting press button while the starting motor or the engine crankshaft is still turning. Otherwise, the starting motor pinion will ramp the starting ring gear and cause serious damages.

For those engines with preheat facilities, the cold start system can be used when ambient temperature is lower than 10°C. Turn on the "preheat" key for 20-40 seconds and ensure the air heater is electrified and give off heat. Then start the engine immediately. In order to preheat inlet air during the course of engine warming, user may preheat air 20-40 seconds continuously. (This can reduce white smoke emits when starting and wear of moving parts). In addition, users

can spray low temperature starting liquid to inlet of turbocharger to start the engine at the same time when it fails because of faults using cold start facilities above. It can start quickly at low temperature too.

After the engine has started, run it at 600-750 r/min for a while. Right after engine has started, pay close attention to the reading of the gauges (especially the oil pressure gauge). Then, check all parts to see whether there are any faults. All faults should be promptly remedied.

The user must also pay attention to the following questions when using the starting system of this engine:

regard as using this starting system:

1) This engine adopts silicon rectified alternator and voltage regulator installed in the alternator. Indicated lamp not for charging on the table should be out when silicon rectified alternator is working. Not only magnetizing to coil resistance of magnet field, but also the charging indicated lamp turn on at the time that engine doesn't work and starting system doesn't cut through charging indicted lamp and "D+" connector.

2) Add grease to bearing of starting motor and gear surface periodically.

3) Starting motor and battery should be parallel connection. Whether the charging alternator is working normally can be judged by the indication of the electric current meter on the meter board. Connecting "+" and "-" poles with metal or screwdriver is not permitted in order to avoid damaging components .

3、 Operation and running in

(1) Preheat

Warm the engine and let it speed up from 700 to 1000-1200 r/min. The engine can be fully loaded only after cooling water temperature has reached 55°C and lubricating oil temperature has reached 45°C.

(2) Running in

A new or overhauled engine must undergo a run in period before formal operation. Since there are incisions of different sizes on the surface of parts after being machined, which will lead to excessive wear of parts and have an influence on the service life of diesel engine or go wrong up to damaged if they don't undergo a certain extent running in and brought into load operation immediately.

Running in the diesel engine according to the procedures in the following list (totalled 60h)

No.	Rotation speed (r/min)	Load (percent of rated power)	Run in time (h)	Add up time (h)
1	700~1500	0	0.25	0.25
2	1500	0	0.25	0.50
3	1500	25%	0.25	0.75
4	1500	50%	1.75	2.5
5	1500	75%	45	47.5
6	1500	90%	5.0	52.5
7	1500	100%	3.0	55.5
8	1500	75%	3.0	58.5

9	1500	50%	1.0	59.5
10	1500	25%	0.5	60

Note:

1. Pay attention to the exhaust smoke, sound and thermal conditions of diesel engine at any moment during running in period and remedy the abnormalities.
2. Pay attention to that oil pressure, oil temperature and outlet cooling water temperature are all in their given range in instruction manual during running in period and make them neither too high nor too low.
3. Pay attention to the state of instrument regularity during running in period.
4. Renew the lubricating oil after running in period.

(3) Power output of the diesel engine

For WD series diesels, the power is output from flywheel end. It is forbidden to install belt pulleys on the flywheel end directly and drive machinery laterally because this kind of power output can easily cause damages to crankshaft and main bearings. When adopting coupling connection, the center line of machines and the center line of crankshaft should be aligned. If it is elastic coupling, its misalignment should be within $\Phi 0.30\text{mm}$. If it is rigid coupling, its misalignment should be within $\Phi 0.10\text{mm}$.

Part power of the engine can be output from the engine's front end of crankshaft. The maximum power output should be lower than 50kW if the bearings and clutch are installed between the front shaft and driven machinery. If dragged laterally directly, it is absolutely not permitted to exceed 11kW in order to avoid damaging the front shaft, the main bearings and the driven gears. For these engines with a fan, it is absolutely prohibited to drive working machinery directly any more.

Note: It is prohibited to start the engine with load. Therefore, a clutch must be fixed between the engine and driven machinery. Start the engine as the clutch is separated.

4、 Operation of turbocharged diesel engines

After a diesel engine has started, it should run at low speed for a period of time before speeding up. Otherwise, it is easy to burn out the bearing on turbocharger. Especially for an engine in which the lubricating oil has been changed, the turbocharger and filter cleaned or the filter element replaced, or which has stopped for more than one week. After starting the engine, loosen the oil inlet joint on oil filter of turbocharger (or oil inlet joint of turbocharger) for a little, tight the joint after lubricating oil flow out. Let the engine rotate at an idling mode for several minutes before load are added.

For a new engine or an engine with a newly replaced turbocharger, remember to dismantle the oil inlet connector of the turbocharger and then add 50-60ml lubricating oil into the oil inlet to prevent the bearings of turbocharger from being burned out due to shortage of oil during engine starting.

The diesel engine should not run at idling speed or the load is lower than half of its rated power for a long time, otherwise it can easily make the oil in turbocharger leak into compressor housing and lead to oil spout out of exhaust pipe.

Run the diesel engine at idling speed for 2~3 minutes before stopping. The engine should not be stopped suddenly unless it is really urgent, otherwise the turbocharger will get overheated which will cause its bearings to seize up.

Listen to see whether there is sound of collision between impeller and housing of turbocharger at the moment of stopping. If so, disassemble the turbocharger to inspect the bearing clearance.

The intake and exhaust manifold of turbocharged diesel engine must be kept sealing, or it will affect the performance of the engine. Check the tightness of the connecting nuts or bolts, bust of rubber hose and sealing washer for air leakage regularly.

The load power for turbocharged diesel engine should be reasonable when matching with working machinery. It is strictly forbidden that the load power is too high or too low for turbocharged diesel engine. If the diesel engine is running under over load condition for a long time, it will cause failures and lower the reliability of diesel engine. However, if the load power is too low, the diesel engine can not make full use of its power ability and may easily cause flee oil.

5、 Check and adjustment

(1) Adjustment of injection timing

To ensure normal operation of the engine and to obtain the best economical fuel consumption and good combustion, injection timing should be checked and readjusted after every 500 operating hours and whenever the engine has been dismantled and reassembled.

To adjust injection timing, remove the high pressure fuel piping of the first cylinder and turn the crankshaft until the piston of the first cylinder is at the beginning of its expansion stroke. (To determine whether it is at the beginning of its expansion stroke, turn the crankshaft slightly and observe the movement of the valves. If the valves remain still when the crankshaft is slightly turned, it indicates that the first cylinder is at the beginning of its expansion stroke.) Check the timing pointer on the flywheel housing which should point at the “0” mark on the rim of the flywheel. At this position, the plunger spring of the first pump element of the injection pump should be compressed. (This can be checked by removing the B-type injection pump inspection door cover.) Then turn the crankshaft in the direction opposite to that of its rotation about 40° . After this, turn the crankshaft slowly and smoothly in the direction of its rotation and observe the fuel level in the fuel outlet of the delivery valve holder of the first pump element at the same time. When this fuel level just starts to rise, stop turning the crankshaft immediately. This is the beginning of injection of the first cylinder whose angle can be read out from the degree marking on the flywheel rim at which the timing pointer points. The angle at which injection begins should be at the range of technical parameter of the relevant model diesel engine. If it is not within this limit, it can be adjusted by loosening the two screws (Fig.1 item C) on the injection pump coupling and turn the crankshaft till the coupling has turned the required angle. After adjustment, tighten the two screws and check the injection timing again.

Another way to adjust the injection timing is to turn the injection pump coupling. Turn the crankshaft until the piston of the first cylinder is at the beginning of its expansion stroke. Then

turn the crankshaft in the direction opposite to that of its rotation till the timing pointer on the flywheel housing is relevant mark. Remove the injection pump inspection door cover and loosen the two screws on the injection pump coupling. Turn the injection pump camshaft in the direction of its rotation till fuel level in fuel outlet of the delivery valve holder of the first pump element just starts to rise. Then tighten the coupling screws and check the beginning of injection again. The beginning of injection should also be within the range of technical parameter of the relevant model diesel engine.

(2) Adjustment of valve lash

Before adjusting the valve timing, attach a degree plate with 360° marks to the free end of the crankshaft and mount an adjustable pointer onto the timing gear case cover as a reference pointer when the crankshaft is turned.

① Adjustment of 12V model diesel engine

Remove the cylinder head cover and turn the crankshaft until the timing pointer on the flywheel housing is pointing at the “0” mark on the rim of the flywheel. (Note: There are two punched marks on the timing mark inspection window of the flywheel housing for locating the timing pointer. For correct indication of timing, the timing pointer can not be distorted and its two sides must be located within these two punched marks.) With the crankshaft at this position, adjust the adjustable pointer mounted on the timing gear case cover to point at the “0” mark on the degree plate.

This indicates that the piston of the first and the sixth cylinders of the engine are at their top dead center position. To determine whether the first cylinder is at the beginning of its expansion stroke, remove the injection pump inspection door cover and check whether the plunger spring of the first pump elements is compressed or slightly bar the crankshaft and observe whether the intake and exhaust valves move. If the plunger spring of the first pump elements is compressed or if the intake and exhaust valves remain still when the crankshaft is slightly barred, it means the first cylinder is at the beginning of is expansion stroke. Then, adjust the valve lash. With the crankshaft at this position, valve lash of the valve listed in the following table can be adjusted:

Table.1 When the 1st cylinder of the 12V model engine are at the beginning of their expansion stroke, valve lash of the following valves can be adjusted.

Cyl. No.	1	2	3	4	5	6
Valves can be adjusted	intake, exhaust	intake	exhaust	intake	exhaust	

Turn the crankshaft 75° in direction of its rotation and let the twelfth cylinder at the beginning of the expansion stroke. Valve lash of the following can be adjusted.

Table.2 When the 12th cylinder of the 12-cylinder engine are at the beginning of their expansion stroke, valve lash of the following valves can be adjusted.

Cyl. No.	7	8	9	10	11	12
Valves can be adjusted		exhaust	intake	exhaust	intake	exhaust, intake

Using the same method, make the 6th cylinder and the 7th cylinder at the beginning of

their expansion stroke, At this time, intake and exhaust valve lash in table.3 and table.4 can be adjusted.

Table.3 When the 6th cylinder of the 12V-cylinder engine is at the beginning of their expansion stroke, valve lash of the following valves can be adjusted.

Cyl. No.	1	2	3	4	5	6
Valves can be adjusted		exhaust	intake	exhaust	intake	exhaust, intake

Table.4 When the 7th cylinder of the 12V-cylinder engine is at the beginning of their expansion stroke, valve lash of the following valves can be adjusted.

Cyl. No.	7	8	9	10	11	12
Valves can be adjusted	exhaust, intake	intake	exhaust	intake	exhaust	

② Adjustment of 6-cylinder diesel engine

Remove the cylinder head cover and turn the crankshaft until the timing pointer on the flywheel housing is pointing at the “0” mark on the rim of the flywheel. This indicates that the piston of the 1st and the 6th cylinders of the engine are at their top dead center position. To determine whether the 1st cylinder is at the beginning of its expansion stroke, remove the injection pump inspection door cover and check whether the plunger spring of the 1st pump elements is compressed or slightly bar the crankshaft and observe whether the intake and exhaust valves move. If the plunger spring of the first pump elements is compressed or if the intake and exhaust valves remain still when the crankshaft is slightly barred, it means the first cylinder is at the beginning of is expansion stroke.

After ensuring the beginning of the expansion stroke.

When the 1st cylinder of the 6-cylinder engine is at the beginning of their expansion stroke, valve lash of the following valves can be adjusted.

Intake valves: 1–2–4

exhaust valves: 1–3–5

When the 6th cylinder of the 6-cylinder engine is at the beginning of their expansion stroke, valve lash of the following valves can be adjusted.

Intake valves: 3–5–6

exhaust valves: 2–4–6

To adjust valve lash, loosen the lock nut and valve lash adjusting screw on the rocker arm by means of a wrench and screw driver. Slip a feeler gauge between the rocker arm and the tip of the valve stem. Adjust the adjusting screw till the rocker arm just presses the feeler gauge against the valve stem tip and the feeler gauge can just be withdrawn by a slight pull. Then lock the adjusting screw with the lock nut, and check the valve lash again.

(3) Check of valve timing

After adjusting valve lash, valve timing can be checked. Usually, it is unnecessary to do. If necessary, begin with the 1st cylinder. While barring the crankshaft over, feel the movement of the push rod by turning it with fingers. As long as there is clearance between the rocker arm and

the tip of the valve stem, the push rod for that valve is free to rotate. Thus, while the crankshaft is slowly bared in the direction of its rotation, the moment at which the push rod can just not be turned by hand is the moment at which the valve starts opening. Stop barring the crankshaft immediately and note the reading on the degree plate indicated by the reference pointer at the free end of the engine. This is the opening angle of that valve.

After taking the angle of opening, turn the crankshaft in the same direction until the push rod for that valve can just be rotated with fingers. This is the angle at which the valve just closes. Note the reading indicated by the reference pointer. Valve timing can thus be checked according to the ignition order of the engine. The specified valve timing is accordance with the range in technical parameter. If valve timing is incorrect due to wear of parts, it can be slightly compensated by varying the valve lash. Reducing the valve lash enables the valve to be opened earlier and closed latter. Increasing the valve lash gives the opposite results. But when doing such compensating adjustments, the valve lash must still be within the specified range.

(4) Adjustment of lubricating oil pressure

After diesel engine starts, the oil pressure should be higher than 49kPa at about 600r/min while it should be 245~392kPa at rated speed. If the oil pressure doesn't conform to above regulation, adjust it in time. When adjusting, unscrew the oil sealing nut on the pressure regulating valve, loosen the lock nut, and then turn the adjusting bolt with a screwdriver. Screwing the adjusting bolt in or out will raise or lower the oil pressure respectively. After adjusting, the lock nut and oil sealing nut should be tightened in sequence.

(5) Adjustment of V-belt tension

During engine operation, the rubber V-belt must be kept at a proper tension. In the normal case, the V-belt can be pressed down 10~20mm when a 29~49N is applied to the midway of the V-belt. If the belt is too tight, it will cause excessive wear of the bearings on the charging alternator, fan and water pump. But if the belt is too loose, it will cause the speed of the driven accessories to be lower than required, lowering the voltage of the charging alternator, cooling efficiency of the fan and flow rate of water pump. Then it will affect normal operation of the engine. So the tension of the V-belt should be checked and adjusted periodically..

For 12V model engine, the tension of rubber V-belt is adjusted by changing the position of the shaft with the adjusting bolt of the fan rack.

For in-line 6 cylinder model engine, the tension of rubber V-belt is adjusted by changing the position of the alternator bracket. Fix the bracket again after it has been adjusted to a proper tension.

It is useful to prolong the V-belt's service life if used correctly and tightened properly. They must be renewed immediately when stratified or can not be tightened to required tension because of excessive extension.

When purchasing or replacing the V-belt, make sure that the type and length of the new ones should be same as those of the original ones. If a group of two or more V-belts are used, these belts should approximately have the same length., otherwise the tensions of these belts will be unequal to each other and cause quick damage.

SECTION III MAINTENANCE

Correct maintenance of diesel engine, especially preventive maintenance, though it is the easiest and most economical, it is the key of prolonging service life of diesel engine and decreasing its operation cost. First of all, daily records for the engine operation should be well done so that necessary adjustments and regulation can be performed accordingly. In addition to the daily records, users should refer to the instructions in this section and work out their own particular maintenance schedule in terms of their specific operating condition and experience.

Generally, the contents of daily records include:

Date, beginning and end time of every shift; routine record of readings on all meters; load of the engine; leakage and excessive consumption of fuel, lubricating oil and cooling water; exhaust color and abnormal noise; problems and solutions.

A. Main items of maintenance

For reliable engine operation, all maintenance work must be carried out promptly, carefully and correctly. Always remember that cleanliness is of prime importance to quality and reliability.

There are the following kinds of maintenances:

Daily maintenance (after every work-shift)

First order maintenance (after every 100 accumulated operating hours).

Second order maintenance (after every 500 accumulated operating hours)

Third order maintenance (after every 1000-1500 accumulated operating hours or every 2 years).

No matter what kind of maintenance is carried out, the dismantling, checking and reassembling should always be done in a planned and sequential way. Be sure to use suitable tools and exert proper strength. After dismantling, the surfaces exposed must be kept clean and coated with anti-rusting oil or grease to prevent them from rusting. Take care of the relative positions of the detectable parts, the structural features of the parts which can not be dismantled, the fit clearances and the adjusting methods. At the same time, keep the engine and its accessories clean and complete.

1. Daily maintenance

1. Check lubricating oil level in engine sump. Oil level should meet the marks indicated on the oil level scale. If insufficient, replenish to the specified limit.

2. Check oil, water and gas leakage.

3. Check rigidity and reliability of all components attached to the engine. Check rigidity and reliability of engine foundation bolts and the connection between the engine and the driven machinery.

4. Check all the meters to see whether the readings are normal. If abnormal, replace or repair it.

5. Check injection pump connecting plate. If there is any alteration of injection timing or

the joint bolts are loose, check the injection timing and tighten the bolts.

6. Check the connecting screw between turbocharger and its bracket and bust of connection between turbocharger and air inlet pipe to see whether they are loose.

7. Clean the engine and the surface of the attachment. Oil, water and dust gathered on the engine surface, turbocharger, cylinder head cover and air filter can be wiped clean with a dry rag or cloth dipped in a bit of diesel. Clean off the dust gathered on the charging alternator, radiator, intercooler and fan by wiping or blowing with compressed air.

2. First order maintenance

Besides the maintenance work given in “Daily maintenance”, add the following items:

(1) Check the voltage of the battery and specific gravity of the battery acid. The specific gravity of the battery acid should be within 1.28-1.29 (at ambient temperature of 15°C) and should not be lower than 1.27. Check the level of the battery acid which should be 10-15 mm above the pole plates. If insufficient, add distilled water to required level.

(2) Open the crankcase inspection door covers and dismantle the lubricating oil suction strainer. Clean it in fuel oil.

The lubricating oil filters should be cleaned every 200 operating hours. Lubricating oil change should be carried out then. (If the oil is rather clean, its change period can be prolonged.)

(3) Check lubricating oil in injection pump and governor as using B-type injection pump. Add lubricating oil if insufficient.

(4) Fill all grease nipples with the proper grade of grease and fill all oil cups with lubricating oil.

(5) Clean air filter and get rid of the dirt in the collector. Take out the filter-element and clean off the dirt by vibrating or blowing with compressed air (its pressure is 98~147kPa) from the center to the outside.

The air filter consists of rain-hat, cyclone blade and paper made filter-elements. The air is sucked into the filter canister from the rain-hat and passes through cyclone blade ring in canister. In the filter, most of the dust particles in the air are gathered into dust collecting tray which is located on the rear of filter canister by centrifugal force and inertia force while smaller dust particles are filtrated by paper made filter elements. Then the filtrated air is sucked into the diesel engine by the turbocharger. For the convenience of cleaning, maintenance and replacement, the outside shell, filter-elements and dust collector of filter are detachable. Dirt gathered in the dust collector can be cleaned by dust removing facilities. Figure 5 is a brief diagram of the structure of the air filter.

Maintenance about the air filter should be done regularly as following requirements:

- ① Open the back cover and clean dust gathered in dust collector for an interval of every 50-100 operation hours (determined by working condition of diesel engine).
- ② Take out the filter-element and clean it by vibrating or blowing with compressed air (pressure is 98~147kPa) from the center to the outside for every 100~200 operation hours.
- ③ Renew the filter-element for an interval of 500~1000 operation hours or the exhaust smoke is over-rich and exhaust temperature is over-high caused by filter-element choked.

- ④ Keep the filter-element dry and renew it while the filter-element is perforated and polluted by water or oil.
- ⑤ Strictly forbidden to clean the filter-element with any kind of oil and water.
- ⑥ This air filter is equipped with a maintenance indicator. The “RED” signal appears on the maintenance indicator means that the filter-elements in air filter have already been choked. Maintain it as methods mentioned above. After finishing maintenance, press the rubber cover on the top of the indicator and make the indicating hole on indicator come back to GREEN which means the air filter can work normally.

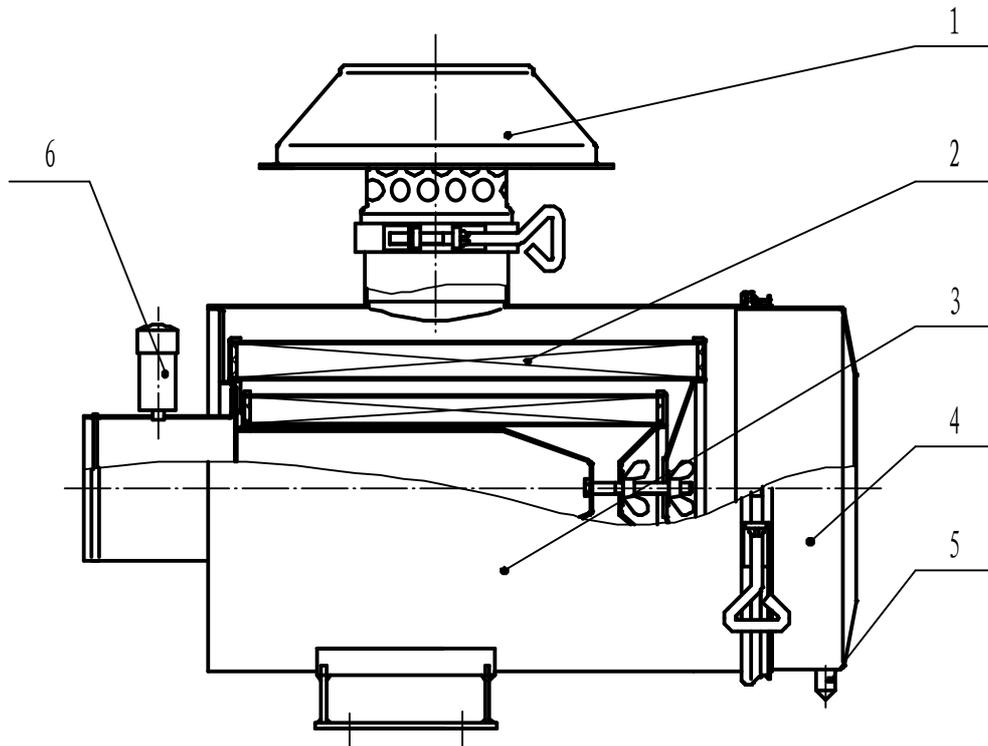


Fig. 5 Air filter

- 1. Rainhat 2. Filter-elements 3. Filter shell
- 4. Back cover 5. Dust removing plant 6. indicator

(6) Dismantle the elements and the shell of the fuel filter every 200 operating hours. Replace it or clean the elements in diesel oil or kerosene. The fuel filter must be replaced every 250 operating hours to ensure that cleanliness of fuel coming into the high pressure injection pump can meet the operating requirements when using rotary fuel filter. Rotate the elements with its shell out of filter seat to renew a new filter elements assembly. In order to ensure seal, smear some lubricating oil on the surface of seal ring as installing. In order to prevent the coarse strainer from being choked which can affect the fuel supply from the fuel feed pump, the inlet piping connector of fuel feed pump should be dismantled and the coarse strainer should be cleaned in fuel oil at the same time before being installed in fuel feed pump again.

(7) Clean oil filter for turbocharger every 200 operating hours. Clean the elements and

piping in fuel oil or kerosene, then blow them dry in order to avoid being polluted by dirt and impurities. Turn the handle to clean off the oil dirt on elements surface or brush it in fuel oil.

(8) Move the turbocharger rotor with hand. If the rotor can not rotate freely and smoothly or stop rotating soon, this means that the bearings may be worn excessively or there occur collision or jam between rotor and its mountings or there may be severe carbon deposit on the air sealing plate of turbo back. In such a case, disassemble the turbocharger and check radial clearance and axial move of rotor to analyze probable causes and remedy them.

(9) Check the tightness of bolts of busts on connection between turbine case and middle case and tighten them if loose.

(10) Disassemble the compressor housing and clean impeller and passage of compressor housing.

3. Second order maintenance

Apart from the items stated in “First order maintenance”, add the following:

- (1) Check the injection pressure and spray pattern of the injectors. If necessary, dismantle the injector, clean the parts and adjust. (injection pressure of 437 injector is 18.6MPa, injection pressure of 532 injector is 23.5Mpa.)
- (2) Check the calibration of the injection pump. If necessary, recalibrate it.
- (3) Check valve timing and injection timing. If necessary, adjust these timings.
- (4) Dismantle cylinder head. Check seal and wear of valves. Repair if necessary.
- (5) Check leakage of fresh water pump. Repair or replace if necessary.
- (6) Open the crankcase inspection door covers and check the cylinder liners for water leakage. If the liner skirt shows signs of water leakage, the liner rubber seal rings should be renewed.
- (7) Remove the timing gear case cover and check the oil nozzle on the main bearing front cover. If the nozzle hole is blocked, probe it with a wire of proper size.
- (8) Check the lubricating oil cooler and radiator for oil and water leakage. If necessary, repair.
- (9) Check the tightness of the connecting rod bolts, crankshaft bolts and nuts, and cylinder head studs and nuts.
- (10) Check the wiring contacts of the electric system. Burnt marks should be removed.
- (11) Clean piping of lubricating oil and fuel oil system including oil sump, lubricating oil piping, lubricating oil cooler, fuel case and fuel piping. Clean off the dirt and blow them dry.
- (12) Clean the cooling system. Compounding and method is described in SECTION III.
- (13) Whether it is necessary to disassemble the turbocharger or not can be judged by the running condition of the engine. If necessary, disassemble the turbocharger and do the following work: clean air seal ring and air seal plate of turbo end, clean the dirt and carbon deposits of turbo impeller and inlet shell, clean oil reservoir of middle shell, check the wear of float bearing. Replace the parts if it is seriously worn. Check the wear of oil seal ring and see whether it is distorted and sintered, replace the parts if so.

4. Third order maintenance

Apart from the items stated in “Second order maintenance”, add the following:

- (1) Check cylinder head assembly. Check wear of valves, valve seats, valve guides, valve

springs, as well as fitting surfaces between push rods and rocker arms. If necessary, repair or replace worn parts.

(2) Check piston and connecting rod assembly. Check wear of piston ring, cylinder liners, and connecting rod bearing and bushing. If necessary, replace worn parts.

(3) Check the crankshaft assembly. Check wear of thrust bearing and thrust plate, and check whether there is any rotation of inner and outer races of main roller bearing. If necessary, replace worn parts.

(4) Check drive mechanism and valve timing. Check wear of tooth surfaces of drive gears and measure their backlashes. If necessary, repair or replace worn parts.

(5) Check injector. Check spray pattern of injectors. If necessary, repair or replace worn parts.

(6) Check injection pump and mechanical governor. Check plunger couple for leakage and flyweight pin for wear. If necessary, replace.

(7) Check lubricating oil pump and fresh water pump. Check and measure parts which are liable to wear. If necessary, readjust.

(8) Check gaskets of cylinder head and intake and exhaust manifolds. Any gasket damaged or has lost its sealing effect should be replaced.

(9) Check charging alternator and starting motor. Clean all parts and bearings, blow them dry and fill with new grease, check wear condition of starting motor pinion and see whether transmission mechanism is running freely.

B. Fit clearance and wear limits of main parts (unit: mm)

No.	Description	Nominal dimensions (mm)	Fitting mode	Value of initial clearance	Repair or change when exceeding the following clearance
1	Crank pin and connecting rod large end bearing	$\Phi 95_{-0.08}^{-0.06}$ $\Phi 95_{+0.020}^{+0.071}$	Clearance	0.10~0.151	0.25
2	Connecting rod large end and crank fillet surface	$2 \times 45_{-0.142}^{-0.080}$ 开挡 $90_{+0.12}^{+0.34}$	Axial clearance	0.28~0.624	0.90
3	Connecting rod small end bushing and connecting rod small end bore	$\Phi 58_{+0.08}^{+0.10}$ $\Phi 58_0^{+0.03}$	interference	0.05~0.10	
4	Piston pin and connecting rod small end bushing	$\Phi 52_0^{-0.014}$ $\Phi 52_{+0.035}^{+0.05}$	Clearance	0.035~0.064	0.15
5	Crankshaft journal and inner race of main roller bearing	$\Phi 185_{+0.06}^{+0.08}$ $\Phi 185_0^{-0.025}$	interference	0.06~0.105	
6	Crankshaft thrust surface and thrust		Axial clearance	0.130~0.370	0.70

	bearing surface				
7	Front extension shaft journal and thrust bearing bore	$\Phi 72_{-0.060}^{-0.030}$ $\Phi 72_{+0.220}^{+0.260}$	Clearance	0.250~0.320	0.45
8	Crankshaft rear flange and flywheel housing oil seal hole	$\Phi 225_{-0.029}^0$ $\Phi 225_{+0.53}^{+0.63}$	Clearance	0.530~0.659	
9	Camshaft journal and camshaft bushing bore	$\Phi 60_{-0.08}^{-0.05}$ $\Phi 60_0^{+0.03}$	Clearance	0.05~0.110	0.25
10	Camshaft and camshaft thrust bearing hole	$\Phi 42_{-0.050}^{-0.025}$ $\Phi 42_{+0.025}^{+0.050}$	Clearance	0.050~0.100	0.25
11	Camshaft thrust collar and camshaft thrust bearing surface		Clearance	0.20~0.57	1.00
12	Piston pin and bore in piston	$\Phi 52_{-0.012}^0$ $\Phi 52_{-0.017}^{-0.002}$	intermediate	+0.01~-0.017	
13	Ring gap of first compression ring	0.6~0.8	Ring gap	0.60~0.80	2.00
14	Ring gap of second and third compression rings	0.5~0.7	Ring gap	0.50~0.70	2.00
15	Ring gap of fourth oil ring	0.4~0.6	Ring gap	0.40~0.60	2.00
16	Valve tappet and cylinder block	$\Phi 38_{-0.089}^{-0.050}$ $\Phi 38_0^{+0.039}$	Clearance	0.050~0.128	0.25
17	Backlash of crankshaft main timing gear and idle gear		Gear back lash	0.120~0.350	0.50
18	Backlash of idle gear and injection pump driven gear		Gear back lash	0.120~0.350	0.50
19	Backlash of idle gear and camshaft driven gear		Gear back lash	0.120~0.350	0.50

C. Tightening torque of bolts and nuts.

No.	Name	Tightening torque N • m
1	Cylinder head bolts screwed into cylinder block.	39~49
2	Cylinder head nuts	274~294
3	Crank connecting bolts M18 × 1.5 M20 × 1.5 M22 × 1.5	226~255 254~284 294~323
4	Connecting rod bolts	274~294
5	12V model diesel engine flywheel bolts M18 × 1.5 M20 × 1.5	235~255 274~294
6	6-cylinder diesel engine flywheel bolts	255~284
7	Drive gear locknuts	255~274
8	Delivery valve seat of injection pump	39~68
9	Injector cap nuts	59~78
10	main bearing bolts of 6-cylinder	300~320
11	injector studs	20~25
12	Common bolts and nuts M8	22~30
13	Common bolts and nuts M10	45~59
14	Common bolts and nuts M12	78~104
15	Common bolts and nuts M14	124~165

Note : The above torque is the reference for the ordinary bolts and nuts of engine except the torque of special bolts and nuts.

D. Engine main technical data

(1) Various temperature range at rated power

The temperature at inlet of turbocharger $\leq 600\sim 650^{\circ}\text{C}$

Maximum temperature in oil sump $\leq 100^{\circ}\text{C}$ (close type)

$\leq 95^{\circ}\text{C}$

Maximum outlet temperature of cooler $\leq 95^{\circ}\text{C}$ (close type)

$\leq 90^{\circ}\text{C}$

(2) Oil pressure at rated power

12V model diesel engine 245~392 kPa

6-cylinder model engine 343~441 kPa

(3) Valve lash (under cold condition)

intake valve lash 0.30~0.35mm

exhaust valve lash 0.35~0.40mm

SECTION IV MAIN FAULTS AND REMEDIES

A、 Engine can not start

Probable causes	Remedies
<p>1. Fault in fuel system:</p> <p>(1) Air trapped in fuel system</p> <p>(2) Fuel piping blocked</p> <p>(3) Fuel filter choked</p> <p>(4) Feed pump supplies fuel irregularly</p> <p>(5) Fuel injected too little or no fuel at all. Fuel spray not atomized.</p>	<p>(1) Check fuel piping connections. If loose, tighten it. Loose the vent screw on the injection pump and fuel filter, work the hand priming pump till fuel flowing out of the vent screws is without air bubbles, tighten the vent screws and the hand pump knob. Loose the injector high pressure piping connector and actuate the injection pump plunger by means of a screw driver till fuel flowing out of the high pressure piping is without air bubbles. Tighten the connector and pump plunger another few strokes so that the injector is filled with fuel oil.</p> <p>(2) Check and clean.</p> <p>(3) Clean or renew element</p> <p>(4) Check the inlet piping for leakage. If the fuel inlet pipe and its connections are normal, dismantle the feed pump for check and repair.</p> <p>(5) Take the injector out of the cylinder head. Connect it with high pressure fuel piping to observe its spray. Actuate the injection pump plunger and check weather its spray is normal.</p>
<p>2. Fault in starting system:</p> <p>(1) Wires not correctly connected or not in firm contact.</p> <p>(2) Battery not charged</p> <p>(3) Bad contact between the brushes and commutator of the starting motor</p>	<p>(1) Check and correct</p> <p>(2) Use fully charged batteries or temporarily series connect another battery for starting.</p> <p>(3) Repair or renew the brushes. Polish the commutator surface with sand paper and blow clean.</p>
<p>3. Compression pressure insufficient:</p> <p>(1) Piston rings worn</p> <p>(2) Valves leaked</p>	<p>(1) Renew. If the liner is also worn, renew it at the same time.</p> <p>(2) Check valve lash, valves springs, valve guide and sealing of the valves with their seats. If the valve seating line is not continuous, lap the valve with its respective seat until a bright, even, continuous band is obtained.</p>

B、 Engine power suddenly drops

Probable causes	Remedies
1. Valve springs damaged	Check and renew
2. Valve timing and injection timing incorrect	Check and adjust. Check tightness of injection pump coupling screws. If loose, tighten them.
3. Valve lash incorrect	Check and adjust to specified value.
4. Compression pressure insufficient. Piston or valve movement sluggish.	Clean and repair.

5. Engine overheated, (Fault in cooling water or lubricating system causing water temperature too high)	Check cooling water and lubricating system. Clean scale in water jacket. Clean lubricating oil cooler.
6. Serious carbon deposits.	Dismantle the cylinder head and clean off the carbon deposits. Find its causes.
7. Air cleaner choked.	Clean or renew the filter element.
8. Exhaust manifold blocked.	Check and clean.
9. Air in fuel system.	Vent. (refer to directions given in paragraph A.1.(1) of this section.
10. Injection pump out of order	Check or repair. Renew plunger and barrel couples if necessary.
11. Injector out of order	Check or repair. Renew nozzle couple if necessary.
12. Gas leakage in injector hole of cylinder head (1) Nozzle cap nut copper washer damaged. (2) Dirt on injector seating surface. (3) Leakage in nozzle and nozzle holder contact surface.	(1) Renew. (2) Remove. Clean the surface. (3) Tighten the nozzle cap nut. Lap the contact surface if necessary.
13. Gas leakage in cylinder head gasket (1) Cylinder head nuts loose. (2) Cylinder head gasket damaged	(1) Tighten to specified torque. (2) Check contact surface of cylinder head and cylinder block. Repair if necessary. (Don't try to repair the damaged gasket.)
14. The connecting rod bearing shell and the crankshaft's connecting rod surface bite together, with some unordinary noise and the dropping of oil pressure.	Dismantle the side cover of the diesel engine, check the clearance of the large end of connecting rod and check the moving. If the large end can not move, it means there is biting between them, repair the crankshaft and replace the shell.

C、Unordinary noise

Characteristic of trouble	Probable causes	Remedies
1. Clear rhythmic metallic pounding noise from cylinder	Injection timing too early	Readjust injection timing
2. Low dull pounding noise from cylinder.	Injection timing too late.	Readjust injection timing
3. Light clear noise which is especially clear when engine idles.	Clearance between piston pin and connecting rod small end bushing too large.	Renew connecting rod small end bushing.
4. Pounding noise from cylinder right after engine is started. This noise reduces as engine warm up.	Clearance between piston and liner too large.	Renew piston rings. If the liner has worn beyond the specified limit, renew it too.
5. When engine runs at 1500 rpm, the crankcase emits a pounding noise which becomes a dull forceful noise as engine speed suddenly drops.	Connecting rod large end bearing clearance too large.	Check. Renew bearings if necessary.
6. Main roller bearing noise (1) An especially clear ear paining	Fitting of main roller bearing too tight.	Check. Renew the noisy bearings.

noise from crankcase. This noise becomes clearer as fuel is increased. (2) Bearing rattle.	Fitting of main roller bearing too loose.	
7. When engine idles, the crankshaft float back and force with a pounding noise.	Crankshaft thrust bearing worn.	Check. Readjust thrust bearing clearance by shims. If the bearing is seriously worn, renew it.
8. A light rhythmic clicking noise from cylinder head.	Valve spring broken, or valve push rod bent, or tappet worn.	Renew the worn and damaged parts. Adjust valve lash to the specified limit.
9. A dull, even, rhythmic clicking noise from cylinder head. With fingers touching the cylinder head cover crown nut, valve pounding the piston can be felt.	Valve pounding the piston.	Remove cylinder head cover and check which valve pounds the piston. Adjust valve lash. If necessary, replace cylinder head gasket with a thicker one (0.20-0.40mm thicker than standard gaskets can be supplied), or machine down the valve cavity on the piston.
10. Unordinary noise from timing gear case cover. When engine speed suddenly drops, gear pounding noise can be heard.	Gear backlash too large or gears seriously worn	Adjust gear backlash. Renew the gear if it is seriously worn.
11. Dry metallic rubbing noise from cylinder head.	No oil between rocker arm and valve tip.	Add oil.

D、 Abnormal exhaust color

When the engine is operating under load, the exhaust usually is of greyish color. At high loads, it may be of deep grey. (It is permitted to operate with such exhaust for short durations.) Exhaust color is considered abnormal when the engine emits black smoke, or when its color becomes blue or white. Ordinarily, engine emits black smoke is due to incomplete combustion. When it emits blue smoke, lubricating oil may have entered into the combustion chamber and when it is white, fuel injected into the combustion chamber may be not fully ignited. The causes and remedies of these faults are given below:

Characteristic of trouble	Probable causes	Remedies
Black smoke	(1) Engine over-load. (2) Uneven delivery of injection pump elements. (3) Valve lash incorrect, or valves leaked. (4) Injection timing too late. Part of the fuel burns in exhaust manifold. (5) Air intake insufficient.	(1) Reduce the load. (2) Recalibrate the injection pump. (3) Check valve lash and condition of the valves and valve springs. Repair or renew. (4) Adjust injection timing. (5) Check the intake pipe of the air cleaner.
White smoke	Injector nozzle leaked, or injection pressure too low, or fuel not atomized.	Check. Adjust injection pressure. Renew nozzle couple if necessary.

Blue smoke	(1) Piston ring stuck or worn, or ring pressure dropped causing lubricating oil to enter the combustion chamber. (2) Too much oil in the sump.	(1) Clean and check the piston rings. Renew if necessary. (2) Oil filled in should be in accordance with the marks indicated on the oil level.
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E、Lubricating oil pressure abnormal

If lubricating oil pressure drops or rises after a period of operation, it can be readjusted by means of the pressure adjusting screw on the lubricating oil filter. If this can not adjust it back to normal limits, check the following:

Probable causes	Remedies
Lubricating oil pump abnormal due to wear of pump gear or incorrect assembly.	Check and test the pump. Readjust the clearance. If necessary, renew the pump gears or the entire pump assembly.
Oil passages leaked, blocked or damaged.	Check and repair. Renew if necessary.
Oil cooler or oil filter choked.	Check and clean.
Oil pressure adjusting spring distorted or damaged, pressure adjusting valve not in good contact with its seat.	Renew the spring, or lap the valve seating surface.
Serious oil leakage in front extension shaft, crankshaft flange, oil piping to rocker arm shaft, camshaft bearing or connecting rod bearing.	Check. Repair or renew the worn or damaged parts.
Oil pressure gauge damaged or pressure gauge piping blocked.	Renew the gauge or clean the pressure gauge piping.

F、Lubricating oil temperature too high, oil consumption too high and dilution of lubricating oil

Probable causes	Remedies
Oil temperature too high: Due to engine overloaded (engine emits black smoke) or oil cooler choked.	Reduce the load or clean the oil cooler.
Piston rings stuck or seriously worn, or cylinder liner worn causing lubricating oil to enter the combustion chamber and gas to leak into the crankcase. This is accompanied with blue smoke and the crankcase breather also emits smoke.	Renew the worn rings. If the liner is worn, renew it also.
Unsuitable lubricating oil used	Use the correct grade of lubricating oil. See SECTION II
Oil return holes on the oil scraper ring blocked by carbon deposits.	Remove the carbon deposits and clean the ring. Renew if necessary.

G、 Oil level in engine sump rises

If the oil level in the engine oil sump becomes higher than the original level after a period of normal operation, its main cause is probably that cooling water has leaked into the lubricating oil. When this occurs, there will be yellow bubbles in the lubricating oil. (Draw some oil out and put it in a glass. After letting it still for an hour or so, observe whether or not there is water settled at the bottom of the glass.)

Probable causes	Remedies
1. Water seal of cylinder liner damaged.	Renew.
2. Cylinder head cracked. (When this occurs, water content of exhaust increases and water gathers in the exhaust manifold.)	Renew.
3. Cylinder head gasket damaged.	Renew.
4. Lubricating oil cooler (water cooled type) core damaged. (Take a water sample and check whether there is any oil droplet in the water.)	Repair or renew the core.
5. Contact surface between the liner flange and cylinder block leaked.	Check copper gasket. Renew if necessary. (The gasket should be 0.25 mm thick.)
6. Cylinder liner seriously cavitated causing water leakage..	Renew the liner.
7. Water leaks into the sump through the fresh water pump:.	Check and repair. Renew the water seal or the water pump.

H、 Engine outlet water temperature too high

Probable causes	Remedies
1. Air leaked into piping causing vapor lock.	Vent by loosening the thermometer connector. Check the pipes and connections for leakage. Tighten the connectors and repair the leakages.
2. Poor circulation, insufficient water supply or pump impeller damaged.	Tighten water pump drive belt. For the open type cooling system, fill water tank to required level. For the close type system, fill radiator full. Check and adjust clearances. Renew damaged parts.
3. Radiator cooling tubes and fins covered with dust.	Clean.
4. Drive belt tension insufficient causing drop of pump and fan speed	Tighten drive belt. If the belt is worn, renew the drive belt.
5. Thermometer reading incorrect. Thermostat out of order.	Check. Renew if necessary.

I、 Injection pump faults and remedies

Probable causes	Remedies
1. Pump does not inject fuel; (1) Fuel tank empty. (2) Fuel feed pump out of order.	(1) Fill. (2) Check and repair.

(3) Fuel filter choked or fuel piping blocked. (4) Air in fuel system. (5) Plunger stuck. (6) Bad contact between delivery valve seat and barrel.	(3) Clean. (4) Vent. (5) Repair or renew. (6) Clean, repair or renew.
2. Uneven distribution of fuel: (1) Air in fuel system. (2) Delivery valve spring broken. (3) Delivery valve seating surface worn. (4) Plunger spring damaged. (5) Dirt in plunger and barrel impairing its movement. (6) Fuel feed pressure too low. (7) Toothed quadrant loose.	(1) Vent. (2) Renew. (3) Repair or renew. (4) Renew. (5) Clean. (6) Check fuel feed pump and fuel filter. (7) Adjust to marking. Tighten lock screw
3. Fuel injected to little: (1) Delivery valve leaked. (2) Fuel feed pump strainer blocked. (3) Plunger and barrel worn. (4) Incorrect assembly.	(1) Repair or renew. (2) Clean. (3) Renew. (4) Reassemble and recalibrate.
4. Fuel injected too much: (1) Uneven distribution of fuel. (2) Incorrect assembly.	(1) Recalibrate. (2) Reassemble and recalibrate.

J、 Speed control faults and remedies

Faults and remedies of mechanical governor are given in the following table, and faults and remedies of electric governor refer to *operation manual for electric governor*.

Probable causes	Remedies
1. Adjust speed unsteady or engine hunts: (1) Uneven distribution of fuel delivered by the pump elements. (2) Nozzle holes blocked by carbon deposits or nozzle leaked. (3) Clearance of fuel control rack linkage too large. (4) Plunger spring damaged. (5) Delivery valve spring damaged.	(1) Recalibrate. (2) Check. Repair or renew. (3) Repair. Renew the link pin. (4) Renew (5) Renew
2. Engine can not attain the specified low speed: (1) Speed control handle not fully lowered to the limiting position. (2) Governor spring deformed. (3) Toothed quadrant and fuel control rack slight stuck.	(1) Check. Adjust speed control linkage. (2) Adjust or renew. (3) Repair

<p>3. Engine speed unsteady:</p> <p>(1) Spring of governor distorted.</p> <p>(2) Worn between pin hole of flyweight and its seat.</p> <p>(3) Gear of injection pump incorrect</p> <p>(4) Distance between open and close of flyweight disaccord.</p> <p>(5) Loose between shell of governor and injection pump cover hole. clearance of camshaft too large.</p> <p>(6) Clearance between pin hole and the pin too large.</p> <p>(7) Low speed stabilizer incorrect</p>	<p>(1) Adjust or renew.</p> <p>(2) Renew flyweight</p> <p>(3) Readjust</p> <p>(4) Check and repair</p> <p>(5) Check and repair.</p> <p>(6) Renew</p> <p>(7) Adjust</p>
<p>4. Engine over-speeds:</p> <p>(1) Max. speed limiting screw incorrectly set.</p> <p>(2) Fuel control rack or fuel control rod stuck.</p> <p>(3) Link pin of fuel control rack or fuel control rod dropped out.</p> <p>(4) Link rod screw loosen.</p> <p>(5) Governor spring damaged.</p> <p>(6) Control fork deformed.</p>	<p>When this occurs, stop the engine immediately for inspection.</p> <p>(1) Make an overall check. Readjust and reseal.</p> <p>(2) Repair</p> <p>(3) Repair. Renew if necessary.</p> <p>(4) Repair</p> <p>(5) Renew.</p> <p>(6) Repair or renew.</p>

K、 Fuel feed pump faults and remedies

Probable causes	Remedies
<p>1 Fuel supplied by the feed pump insufficient:</p> <p>(1) Feed pump check valve worn or damaged.</p> <p>(2) Piston worn</p> <p>(3) Piping connection leaked.</p> <p>(4) Inlet connection strainer blocked</p>	<p>(1) Renew</p> <p>(2) Renew</p> <p>(3) Tighten or repair</p> <p>(4) Clean</p>

L. Injector faults and remedies

Probable causes	Remedies
<p>1. Fuel injected too little or no injection:</p> <p>(1) Air in fuel system</p> <p>(2) Needle valve stuck</p> <p>(3) Fuel delivery of injection pump irregular</p> <p>(4) High pressure piping leaked</p> <p>(5) Needle valve movement sluggish</p> <p>(6) Nozzle couple worn</p>	<p>(1) Vent</p> <p>(2) Repair or renew</p> <p>(3) Check and repair</p> <p>(4) Tighten the connectors. Repair or renew</p> <p>(5) Clean or lap</p> <p>(6) Renew</p>
<p>2. Injection pressure too low:</p> <p>(1) Pressure adjusting screw loose</p> <p>(2) Pressure regulating spring deformed and fractured</p>	<p>(1) Readjust injection pressure to 17.2 ± 0.49MPa</p> <p>(2) Repair or renew</p>
<p>3. Injection pressure too high:</p> <p>(1) Spring pressure too high</p> <p>(2) Needle valve stuck</p> <p>(3) Nozzle holes blocked by carbon deposits</p>	<p>(1) Readjust pressure or renew</p> <p>(2) Repair</p> <p>(3) Clean, repair or lap</p>

4. Nozzle seriously leaked: (1) Pressure regulating spring damaged (2) Needle valve seating surface damaged (3) Needle valve stuck (4) Nozzle cap nut deformed (5) Nozzle holder sealing surface leaked	(1) Renew (2) Renew nozzle couple (3) Clean or renew nozzle couple (4) Renew the cap nut (5) Lap or renew
5. Fuel spray not well atomized: (1) Needle deformed or worn (2) Needle valve seating surface damaged or worn (3) Injection pressure too low	(1) Adjust (2) Renew nozzle couple (3) Renew nozzle couple
6. Fuel sprayed in straight line; (1) Nozzle hole blocked (2) Needle valve and needle valve seating surface worn (3) Needle valve stuck	(1) Probe holes with a 0.2~0.3mm diameter steel wire (2) Renew nozzle couple (3) Clean, repair or renew nozzle couple
7. Nozzle surface burnt or has a black bluish color (due to engine overheated)	Check engine cooling system and renew nozzle couple

Warranty period of diesel engines:

For users of WD series diesel engines, we guarantee our product can operate satisfactorily if it is properly operated and maintained for a period of 12 months, or 1500h of operation (The warranty period will be terminated after either of these two conditions expires). If any part is damaged due to quality within this period, we will be responsible to repair or renew the damaged part for free.

Appendix

Power correction

Power correction factor for relative humidity of 30% for naturally-aspirated diesel engine

Altitude m	pressure		Ambient temperature (°C)									
	kPa	mmHg	0	5	10	15	20	25	30	35	40	45
100	100.0	750	—	—	—	—	—	1.00	0.98	0.96	0.94	0.92
200	98.9	742	—	—	—	—	—	0.99	0.97	0.95	0.93	0.91
400	96.7	725	—	—	—	1.00	0.98	0.96	0.94	0.93	0.91	0.89
600	94.4	708	—	1.00	0.98	0.97	0.95	0.93	0.92	0.90	0.88	0.86
800	92.1	691	0.99	0.97	0.96	0.94	0.93	0.91	0.89	0.87	0.85	0.84
1000	89.9	674	0.96	0.95	0.93	0.91	0.90	0.88	0.87	0.85	0.83	0.81
1200	87.7	658	0.94	0.92	0.90	0.89	0.87	0.86	0.84	0.82	0.81	0.79
1400	85.6	642	0.91	0.89	0.88	0.86	0.85	0.83	0.82	0.80	0.78	0.76
1600	83.5	626	0.88	0.87	0.85	0.84	0.82	0.81	0.79	0.78	0.76	0.74
1800	81.5	611	0.86	0.84	0.83	0.81	0.80	0.78	0.77	0.75	0.74	0.72
2000	79.5	596	0.83	0.82	0.80	0.79	0.78	0.76	0.75	0.73	0.71	0.70
2200	77.6	582	0.81	0.79	0.78	0.77	0.75	0.74	0.72	0.71	0.69	0.67
2400	75.6	567	0.78	0.77	0.76	0.74	0.73	0.72	0.70	0.69	0.67	0.65
2600	73.7	553	0.76	0.75	0.73	0.72	0.71	0.69	0.68	0.66	0.65	0.63
2800	71.9	539	0.74	0.73	0.71	0.70	0.69	0.67	0.66	0.64	0.63	0.61
3000	70.1	526	0.72	0.70	0.69	0.68	0.67	0.65	0.64	0.62	0.61	0.59
3400	66.7	500	0.67	0.66	0.65	0.64	0.63	0.61	0.60	0.58	0.57	0.55
4000	61.5	462	0.61	0.60	0.59	0.57	0.56	0.55	0.54	0.53	0.51	0.50

Power correction factor for relative humidity 100% for naturally-aspirated diesel engine

Altitude m	Pressure		Ambient temperature(°C)									
	kPa	mmHg	0	5	10	15	20	25	30	35	40	45
100	100.0	750	—	—	—	—	1.00	0.97	0.95	0.92	0.89	0.85
200	98.9	742	—	—	—	—	0.99	0.96	0.94	0.91	0.87	0.84
400	96.7	725	—	—	1.00	0.98	0.96	0.94	0.91	0.88	0.85	0.81
600	94.4	708	—	0.99	0.97	0.95	0.93	0.91	0.88	0.85	0.82	0.79
800	92.1	691	0.99	0.97	0.95	0.93	0.91	0.88	0.86	0.83	0.80	0.76
1000	89.9	674	0.96	0.94	0.92	0.90	0.88	0.86	0.83	0.80	0.77	0.74
1200	87.7	658	0.93	0.91	0.89	0.87	0.85	0.83	0.81	0.78	0.75	0.71
1400	85.6	642	0.90	0.89	0.87	0.85	0.83	0.81	0.78	0.76	0.72	0.69
1600	83.5	626	0.88	0.96	0.84	0.82	0.80	0.78	0.76	0.73	0.70	0.67
1800	81.5	611	0.85	0.84	0.82	0.80	0.78	0.76	0.74	0.71	0.68	0.64
2000	79.5	596	0.83	0.81	0.79	0.78	0.76	0.74	0.71	0.69	0.66	0.62
2200	77.6	582	0.80	0.79	0.77	0.75	0.73	0.71	0.69	0.66	0.64	0.60
2400	75.6	567	0.78	0.76	0.75	0.73	0.71	0.69	0.67	0.64	0.61	0.58
2600	73.7	553	0.76	0.74	0.72	0.71	0.69	0.67	0.65	0.62	0.59	0.56

2800	71.9	539	0.73	0.72	0.70	0.69	0.67	0.65	0.63	0.60	0.57	0.54
3000	70.1	526	0.71	0.70	0.68	0.66	0.65	0.63	0.61	0.58	0.55	0.52
3400	66.7	500	0.67	0.65	0.64	0.63	0.61	0.59	0.57	0.54	0.51	0.48
4000	61.5	462	0.60	0.59	0.58	0.56	0.55	0.53	0.51	0.48	0.45	0.42

Power correction factor for turbocharged diesel engine

Altitude m	Pressure mmHg	Ambient temperature(°C)										
		0	5	10	15	20	25	30	35	40	45	
0	760	—	—	—	—	—	—	0.976	0.945	0.915	0.886	
200	742	—	—	—	—	—	0.993	0.960	0.930	0.900	0.872	
400	725	—	—	—	—	—	0.977	0.945	0.915	0.886	0.858	
600	708	—	—	—	—	0.993	0.960	0.928	0.899	0.870	0.843	
800	691	—	—	—	—	0.976	0.944	0.913	0.884	0.856	0.829	
1000	674	—	—	—	0.994	0.960	0.928	0.878	0.869	0.841	0.815	
1500	634	—	—	0.986	0.952	0.920	0.889	0.860	0.832	0.806	0.781	
2000	596	—	0.977	0.944	0.911	0.880	0.851	0.823	0.797	0.771	0.747	
2500	560	0.971	0.936	0.904	0.873	0.843	0.815	0.788	0.763	0.739	0.716	
3000	526	0.929	0.896	0.865	0.835	0.807	0.780	0.754	0.730	0.707	0.685	
3500	493	0.889	0.857	0.827	0.799	0.772	0.746	0.722	0.698	0.637	0.655	
4000	462	0.848	0.818	0.789	0.762	0.737	0.712	0.689	0.667	0.645	0.625	