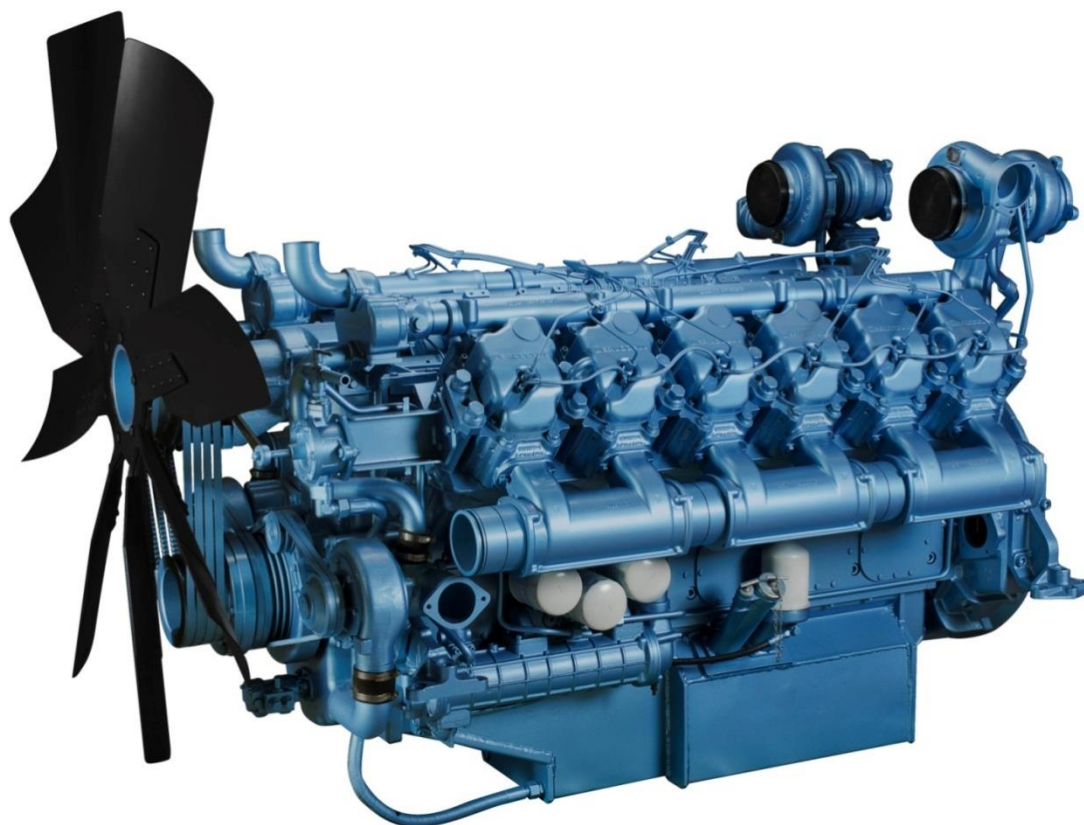


Service Manual of 12M26 Series Diesel Engine for Land Power Generators



Foreword

This series diesel engine features the advantages of excellent technical indicators (compact structure, reliable operations, and high power performance, economy, and emission), rapid start, simple operations, convenient maintenances, and especially advanced emission indicator that meet the international advanced emission standards.

The contents of this service manual are the safety precautions, maintenance methods, and instructions about inspection, adjustment and troubleshooting of 12M26 diesel engines. We have expended every effort to make the contents of this service manual systematic, simple and practical. Judging the malfunction cause of diesel engine is a really precise work. Before the cause is basically identified, do not disassemble the diesel engine casually, or it will not only eliminate the malfunction, but also lead to more serious malfunction due to improper assembly after disassembly. The servicing of critical components particularly the electronic control system and the turbocharger shall be performed by experienced personnel using dedicated instruments. Persons who are inexperienced or have no such instruments may not remove or adjust them.

Following the continuous increasing and improvement of 12M26 series diesel engine variants, all changes will be made without further notice. Please access <http://www.weichai.com> to obtain the latest product information.

Recommendations and opinions on further product improvement from you are welcome.

February 2016

Special Notice

- Before the operations, the operator of the diesel engine must carefully read this maintenance manual and strictly abide by the operation and maintenance practices specified in the operation and service manual.

- The diesel engine has tested strictly in accordance with the testing specification of our company at the time of delivery. It's prohibited to adjust the ECU data or increase the power of the diesel engine without permission. Note that failure to observe this requirement shall invalidate the warranty provided by Baudouin Power;

- The rotor of the turbocharger generally rotates at high speeds when the engine is in operation. It is strictly prohibited to have any moving objects (for examples, hands, tools, cotton yarns) appear near the inlet of the turbocharger, otherwise serious injury or damage could occur. The rotor can only be removed by turbocharger maintenance specialists or by the service stations authorized by Baudouin Power.

- The number of use for significant bolts is limited and shall not exceed the specified reuse number.

- The oil and fuel added to the diesel engine must be of the designations specified in this service manual. Dedicated clean filters must be used for the addition. Before addition, the fuel shall settle for 72 hours. Before driving the vehicle, check that the coolant and oil levels meet the requirements;

- It's prohibited to run the diesel engine without the air filter, in order to prevent the supply of non-filtered air into the cylinders.

- While using a new engine, the user shall fulfill the 50h commissioning;

- After the cold start of the diesel engine, slowly increase the engine speed, instead of running at high speed suddenly or long-term idling. After the running under heavy load, run the engine at low speed for 5~10min before stopping the engine, instead of stopping the engine suddenly (except special cases);

- After the engine is stopped, if the temperature of working environment is probably below 0°C and the coolant without antifreeze additive is used, fully drain the coolant from the water tank and engine;

- The checking and repair for all parts of the electric system must be fulfilled by the professional electric technicians;

- The checking and repair for all parts of electronic control system must be fulfilled by the professionals of our service station;

- The diesel engine is oil sealed at the time of delivery to prevent rusting. The oil sealing period for diesel engine is generally one year. At the expiration of one year, check and take necessary supplemental measures.

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Chapter I General Information

1.1 External View of the Diesel Engine

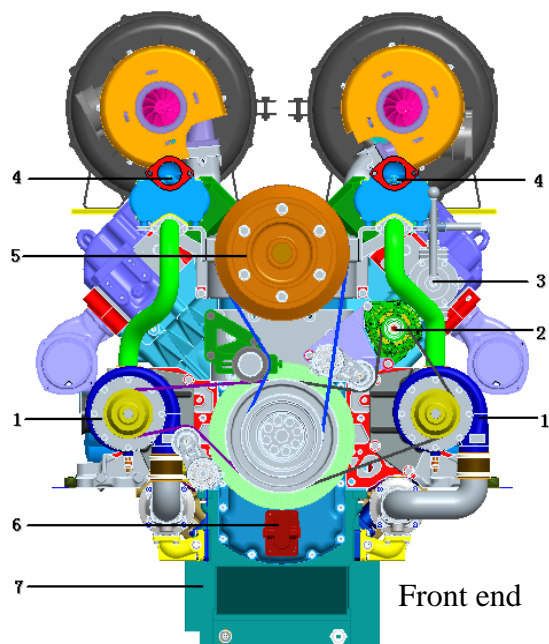


Figure 1-1 Front exterior view of 12M26 series diesel engine

1 Water pump, 2 alternator, 3 Manual engine oil pump, 4 Diesel engine water outlet port (to water inlet port of water tank), 5 Fan pulley, 6 Fuel pre-supply pump, 7 Oil pan

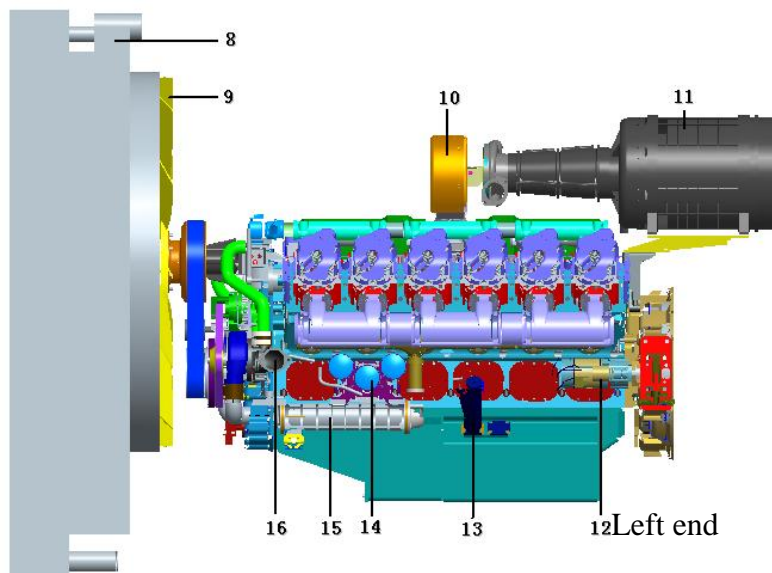


Figure 1-2 Left side of 12M26 diesel engine

8 Radiator and pipeline (optional), 9 Fan, 10 Turbocharger, 11 Air filter, 12 Starter motor, 13 Engine oil filler port and dipstick, 14 Engine oil filter, 15 Engine oil cooler, 16 Water pump water inlet port (to water tank water outlet port)

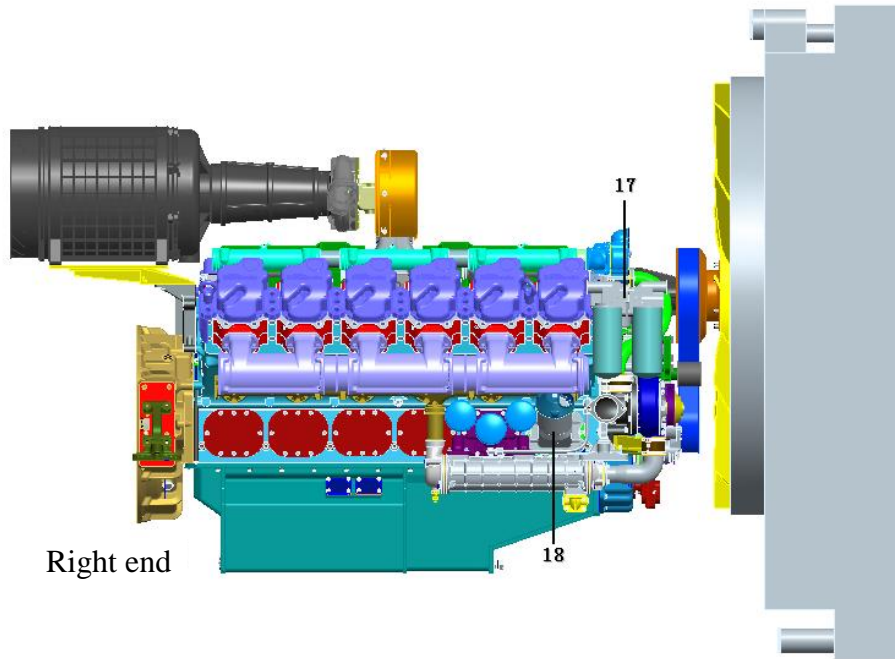


Figure 1-3 Right side of 12M26 diesel engine

17 Fuel filter, 18 Ventilator

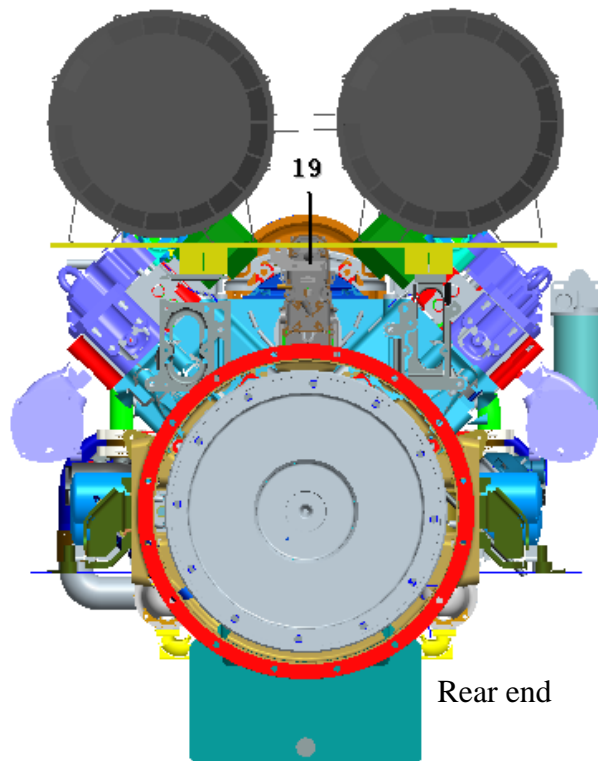
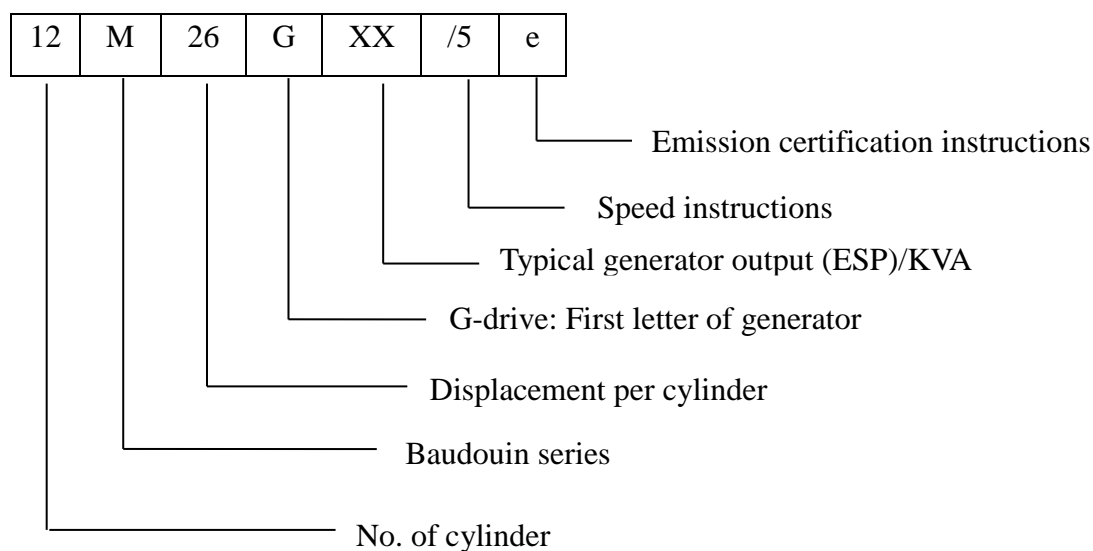


Figure 1-4 Rear side of 12M26 diesel engine

19 Fuel pump

1.2 Model Meaning of Diesel Engine



1.3 Basic parameters of diesel engine

Table 1-1 Performance parameter of 12M26 diesel engine

SN.	Item	Unit	12M26	
1	Intake mode	——	Inter-cooling	
2	Number of cylinders	——	12	
3	Bore/Stroke	mm	150/150	
4	Total piston displacement	L	31.8	
5	Compression ratio	——	15.7	
10	Minimum stable idling speed	r/min	750±30	
13	Maximum burst pressure	MPa	15	
15	Oil consumption at rated working condition	g/(kW·h)	≤0.5	
16	Downstream oil pressure of oil filter	MPa	0.4~0.6	
17	Engine oil pressure of secondary oil way	MPa	≥0.12	
18	Engine oil temperature	°C	85~105	
19	Coolant temperature	°C	75~95	
20	Diesel inlet temperature	°C	38±3	
21	Intake temperature after inter-cooler	°C	50~60	
22	Exhaust temperature after turbine	°C	≤500	
23	Air leakage of pistons	L/min	≤300	
24	Valve timing	Opening of intake valve	°CA	34° prior to top dead center
		Closing of intake valve	°CA	40° after bottom dead center
		Opening of exhaust valve	°CA	70° prior to bottom dead center
		Closing of exhaust valve	°CA	34° after top dead center
25	Firing order	——	A1-B2-A5-B4-A3-B1-A6-B5-A2-B3-A4-B6	
26	Rotation direction	——	Counter-clockwise (facing towards flywheel)	
27	Intake and exhaust valve gap (cold state)	mm	0.3±0.03	
28	Smoke number at rated working condition	FSN	≤1.5	
30	Oil sump capacity	L	113	
31	Overall dimensions	mm×mm×mm	2615×1525×1760	
32	Net weight	kg	2910	

1.4 Operation Notice for New Diesel Engine

◆ Maintenance period of diesel engine

First maintenance (P)	(30~50) running hours of new engine
Level 1 maintenance (WD1)	Every 250 running hours of diesel engine
Level 2 maintenance (WD2)	Every 500 running hours of diesel engine
Level 3 maintenance (WD3)	Every 1000 running hours of diesel engine
Level 4 maintenance (WD4)	Every 3000 running hours of diesel engine

◆ Fulfill the daily maintenances as per the relevant requirements of the Operation Manual.

1.5 Hoisting of Diesel Engine

During the hoisting, maintain level the centerline of engine crankshaft. It's prohibited to hoist in tilted or unidirectional manner. Hoist up and down slowly. (See Figure 1-1).

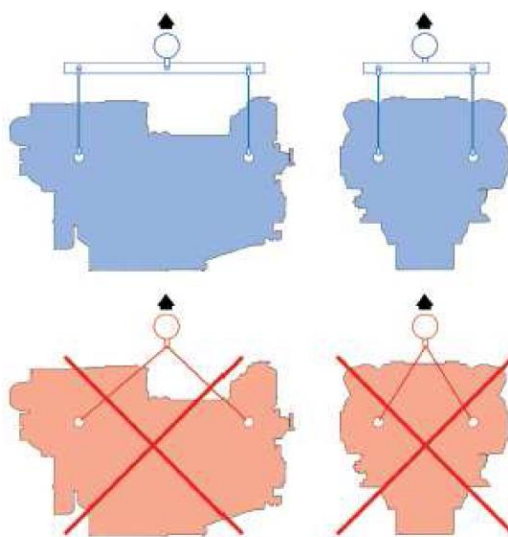


Figure 1-5 Diesel Engine Hoisting

1.6 Unpacking of Diesel Engine

◆ After the diesel engine is unpacked, the user shall firstly count the diesel engine and its accessories as per the delivery packing list, check the exterior of diesel engine for presence of damage and the connectors for presence of looseness, and then fulfill the following works:

- (1) Wipe the anti-rusting layer and anticorrosive agent on the exposed parts;
- (2) Check the water plug and oil plug for presence of blockage, check for water temperature and oil temperature sensors, and ensure that all parts to be self-provided are completely fitted.

Notice: Do not start the diesel engine before it's correctly installed and connected at the final

position. When the diesel engine is running in an enclosed environment, keep well ventilated to ensure that the exhaust gas is drained to the open air.

◆ Adding of engine oil

(1) The engine oil shall meet the specification; otherwise it will probably lead to insufficient engine oil pressure and thus abnormal wear and difficult start. The engine oil must be extremely clean.

(2) Tightening the drain plug.

(3) Open the oil filler cap and add the engine oil. The engine oil must be filtered by the filter screen before adding.

(4) Place the diesel engine at a level position and withdraw the oil dipstick to check the oil level. For the first adding of oil, add the oil till the oil level reaches the upper limit of oil dipstick.

(5) Tighten the oil filler cap.

◆ Adding of fuel

(1) The diesel used shall meet the specification.

(2) Keep clean the diesel. It's better to place the diesel under stationary state for more than 72 hours before adding. The diesel shall be added into the fuel tank via the built-in filter screen.

◆ Air bleeding of fuel system

(1) Loosen the outlet port thru screw of the fuel delivery pump by half turn. Operate the manual pump of fuel delivery pump, till the diesel overflows, and then tighten the thru screw.

(2) Loosen the air bleeding screw on the fuel filter. Operate the manual pump of fuel delivery pump, till the diesel overflows, and then tighten the air bleeding screw.

(3) Loosen the fuel return port thru screw of fuel pump, operate the manual pump of fuel delivery pump, till the diesel overflows, and then tighten the air bleeding screw.

(4) Continue to operate the manual pump, check the fuel pipeline for presence of leakage, and then tighten the manual pump.

◆ Adding of coolant

The coolant is mixed from softened clean water and anticorrosive agent or antifreeze. Ensure to strictly abide by the specification of the additive manufacturer during mixing.

Add coolant through the water filler port of radiator or heat exchanger and bleed the air from the cooling circulation system.

1.7 Preparations before Start

- ◆ Check the coolant level.

Check the coolant level. If the coolant is insufficient, add coolant. If the diesel engine remains hot, do not add a great deal of coolant. Dramatic temperature change could cause damage to the parts. If there is no coolant under special cases, it's allowed to slowly add cold water in moderate temperature. Add the coolant through the filler port, till the coolant overflows. Start the engine. While the engine is running (1,000r/min), continue to add the coolant, till the coolant level is stable, and finally install the filler port cap.

- ◆ Checking of fuel level
- ◆ Check the engine oil level

The engine oil level shall be between upper and lower markings of the oil dipstick. If necessary, add engine oil through the engine oil filler port.

- ◆ Check all accessories of diesel engine for reliable connections and solve any abnormal phenomenon. Check the starter system for normal wiring and check and ensure that the battery is sufficiently charged. Open the valve of the fuel tank. Using the electric oil pump equipped with the primary filter, remove air from the fuel system.

1.8 Startup of Diesel Engine

- ◆ Before starting the engine, operate the acceleration and stop control levers on the fuel injection pump to ensure flexible motions. Rotate the crankshaft of diesel engine for several turns to ensure smooth rotation.

- ◆ Rotate the key to position “1” to power on the control panel. The “oil pressure warning lamp” automatically turns on for 10s (Test of under-low engine oil pressure safety line). It's recommended to test the indicator lamps, bulbs, and buttons once (by pressing the touch button 10 on the control panel).

- ◆ Rotate the key to position “START” to start the engine and then release the key. The key automatically returns to position “1”.

At the start of diesel engine, if the diesel engine fails to start within 10s, immediately release the button and wait for 1min before retry. If the engine can't be started by three consecutive attempts, stop the attempt and find out and solve the malfunction before retry.

During the working of engine, both “oil pressure warning lamp” and the “battery power” indicator lamps are off.

All indicator lamps are off during normal running of engine.

In event of abnormality, the “horn” will issue warning tone.

◆ The auxiliary starter shall be used to start the diesel engine under cold temperature. By running the electric heating flange via relay, the engine can start successfully under -30°C environment.

1.9 Running of Diesel Engine

◆ After start-up, idle the engine for 3 minutes, then increase its speed to 1000 RPM -1200 RPM and apply partial load. Do not have it running under full load until the outlet coolant temperature is above 60°C and engine oil temperature is above 50 °C. Apply load and increase the speed gradually. Avoid the sudden loading and unloading whenever possible.

◆ Within the 60h run-in period (or the initial 3,000km mileage) of the diesel engine, it’s preferable to run the engine under moderate load and it’s not permitted to tow any vehicle.

◆ Timely slow down while driving on a slope and do not run for a long period under high torque working condition. It's also inappropriate to run the engine under really low load or speed, as it will easily lead to the malfunctions such as oil permeation.

◆ Normally the diesel engine can continuously run with rated output and rated speed. The diesel engine may not run for more than 20 minutes at the speed 105% the rated speed or the output 110% the rated output. After the unloading, idle the diesel engine for (1~2) min before stop.

◆ Parameters and checking locations to be observed at all times during operations are as below:

Oil pressure of main oil-way: 350~550 kPa.

The temperature of engine oil in oil sump is ≤ 110 °C.

Coolant outlet temperature is no more than 95 °C.

Exhaust temperature after turbine: ≤ 600 °C.

Check the exhaust fume color, to estimate the performances of the injectors and the load of the engine. In the case of serious black or white fume, stop and check the engine.

Notice to check the diesel engine for presence of water, gas, and oil leakages. If any, stop the

engine for troubleshooting.

◆ The operator shall understand the following characteristics of the engine:

A. Low fuel consumption at the maximum torque. Increase in engine speed will result in that in fuel consumption.

B. Maximum torque occurs in the engine speed range of 1200 r/min -17000 r/min.

C. Engine output increases with engine speed. Rated output is achieved at rated speed.

◆ Precautions for running under cold environments;

A. Fuel: Choose diesel of different trademarks depending on the environmental temperature in winter.

B. Lubricating oil: Choose lubricating oil of different viscosities depending on the seasons.

C. Coolant: Add antifreeze additive into the cooling system and choose the coolant of different trademarks depending on the ambient temperature.

D. Start: The auxiliary starter can be adopted if necessary in winter. After the start of the diesel engine, wait for the oil pressure and water temperature to turn normal before running at high speed under loaded condition.

E. Battery: Before the approach of the cold season, make sure to check the level and viscosity of electrolyte and unit voltage of the battery. If the diesel engine is not to be used for a long time and is under extremely low temperature, disassemble the battery and store in a warm indoor place.

F. Stop: To stop the engine under cold weathers, unload the engine, idle the engine for 1~2min, and wait for the water temperature and oil temperature to cool down before stop. Please be noted that it's disallowed to drain the coolant containing antifreeze additive after the stop of the engine. If the coolant contains no antifreeze additive, make sure to open the water drainage valves or water plugs on the engine block, oil cooler cover, radiator, and water inlet pipe to fully drain the coolant, in order to prevent the frozen cracking of the engine.

1.10 Stop of Diesel Engine

◆ Avoid the stop of engine under full load. Before stopping the engine, reduce the load, lower the speed, and run for 3~5min at idling or low-load working condition. This is intended to cool down the piston, cylinder head, bushing, shaft sleeve, and turbocharger for a sufficient time, in order to prevent the cylinder scuffing and bushing scratch, which is really important. This is really

important for a turbocharged diesel engine. The bearings and oil seals in the turbocharger are subject to the influence of the high temperature exhaust gas. This heat is carried away by the circulating engine oil during the running of the diesel engine. If the diesel engine is stopped suddenly, the turbocharger temperature will increase remarkably to cause overheating, which will lead to seizure of bearings or failure of oil seals.

- ◆ Rotate the key switch to position “OFF” or press the stop button to stop the running of engine, till the flywheel stops rotation or the speed indication on the instrument panel is zero.

- ◆ If the diesel engine circulating water is not added with antifreeze, ensure to drain the coolant after stop in cold days, in order to prevent the frozen damage of diesel engine. The water drainage valve is located beneath the oil cooler. Rotate the water drainage valve switch to drain the water from diesel engine. At the same time, disassemble the water drainage plug from the radiator to drain the coolant from the radiator.

Chapter II Maintenance Guide

2.1 Fuel, Lubricating Oil, Coolant, and Auxiliary Materials for Diesel Engine

2.1.1 Fuel

Summer: 0# diesel (GB252)

Winter: Generally -10# light diesel (GB252). However, choose -20# diesel for -20°C environmental temperature and -35# diesel for -30°C environmental temperature.

The fuel used must conform to the requirements in Table C.6 of Appendix C to national standard GB 17691-2005 (revised after June, 2008).

2.1.2 Engine lubricating oil

The user must purchase Baudouin special parts and special engine oil (grade CF-4 15W-40), in order to guarantee the good running of equipment and prolong the service life.

Choose the viscosity of Baudouin special engine oil based on the temperature, with reference to Table 2-1.

Table 2-1 Correspondence of Viscosity to Ambient Temperature

SAE viscosity grade	Applicable environmental temperature (°C)
15W-40	-20-40

Note:

- 1) **Before starting the diesel engine, ensure to check the engine oil level within oil sump.**
- 2) **Do not check the oil level while the diesel engine is running.**
- 3) **It's prohibited to mix the Baudouin special engine oil with any other manufacturer's oil.**

For the added volumes of engine oil and numbers of filters of Baudouin Power engines, see Table 2-2.

Table 2-2 Added Volumes of Engine Oil and Numbers of Filters of Baudouin Power Engines

Model	Added volume of engine oil (L)	Number of filters			
		Oil filter		Diesel filter	
		Fine filter	Centrifugal filter	Coarse filter	Fine filter
12M26	90~113	6	2	1	1
Remark: 1) The added volumes listed in the table are only for reference. Actual added volumes shall be decided with the oil dipstick. 2) If the vehicle is equipped a highly-cold-resistant filter or					

moisture-removing filter as developed by Baudouin Power, they shall also be replaced when the fuel is replaced.

Remark:

- 1) **The added volumes listed in the table are only for reference. Actual added volumes shall be decided with the oil dipstick.**
- 2) **If the vehicle is equipped a highly-cold-resistant filter or moisture-removing filter as developed by Baudouin Power, they shall also be replaced when the fuel is replaced.**

2.1.3 Engine coolant

The freezing point specification for Baudouin special coolant includes -25°C, -35°C, and -40°C. Please choose Baudouin special coolant of different freezing points based on the local environmental temperature in such manner that the freezing point is less than local air temperature by approximately 10°C, with reference to Table 2-3.

Table 2-3 Baudouin Special Heavy-Duty Engine Coolant

Variety	Product category	Packing specification
Heavy-duty engine coolant	HEC-II-25 HEC-II-35 HEC-II-40	4kg, 10kg

Note:

- 1) **Make sure to periodically check the coolant and, to prevent the corrosion and damage, timely replace depending on actual situation.**
- 2) **It's prohibited to use water or low quality coolant as the engine coolant.**

2.1.4 Auxiliary materials

Table 2-4 Auxiliary Materials Used for Diesel Engines

SN.	Name	Color	Purpose and location
1	Molykote Pulver	Black	Applied on flat and smooth metal surfaces to prevent seize For example, applied onto outer surfaces of cylinder liners
2	Molykote G-N-Uplus	Dark grey	Lubrication before the lubricating oil pressure builds up. For example, applied onto the intake valve stem

Table 2-5 Reference Table for Sealant Application of Diesel Engine

Mark	Main use	List of locations for application of sealant	Supplement
Loctite 242	It's applied onto the threads to prevent being vibrated to looseness, with moderate strength.	Flywheel cover bolt Camshaft thrust plate bolt Camshaft timing gear bolt Bolt, intermediate idler Bolt, front end cover Bolt, engine oil filter base Oil cooler bolt Screw plug, control valve, engine oil cooler, Bolt, fuel return pipe fixing device, fuel pump, Air compressor shaft end thread Strainer bolt Bolts of sensor and harness fixing device	Alternatively, the thread pre-application sealant DriLoc204 can be pre-applied.
Loctite 262	Applied onto outer threads for locking, sealing, preventing vibration from causing looseness	Auxiliary bolt, cylinder head	
Loctite 271	Preventing looseness, fixing	Cup plug, oil drain hole	
Loctite 277	For sealing between element and bore	Other cup plugs	
Loctite 270	Sealing cylinder head top	Push rod -cylinder head	
Loctite 518 (modified from Loctite 510)	It's applied onto shining metal surfaces for sealing purpose.	Interface between cylinder block and crankcase Plates connecting engine body front end face to front end cover, and connecting engine body rear end face to flywheel cover Interface between engine oil filter base and crankcase Interface between water pump rear cover and engine body front end face Interface between flywheel cover and its connecting plate Interface between cylinder block and engine oil cooler cover Interface between cylinder block and engine oil filler pipe	

2.2 Daily maintenance

2.2.1 Daily service

◆ Check the coolant level, engine oil level, and fuel level. Check the lubricating points for grease insufficiency;

◆ Check for oil, coolant or air leakage;

◆ Check the attachments and accessories for loose connection or fixing;

◆ Check the fan and the belts for excessive or insufficient tension;

◆ Check the engine oil pressure;

◆ Check the coolant temperature;

◆ Check whether the temperature, color, sound and vibration of exhaust gas are normal, and whether the engine speed remains steady;

2.2.2 Daily Maintenance

- Check the oil level.

Do not start the engine if engine oil level is above the H mark or below the L mark of the oil dipstick.

After the diesel engine is stopped, wait for at least 5min and then check the oil level, in order to enable the engine oil to flow into the oil sump sufficiently. The oil amount difference between lower marking and upper marking of oil dipstick is 23L.

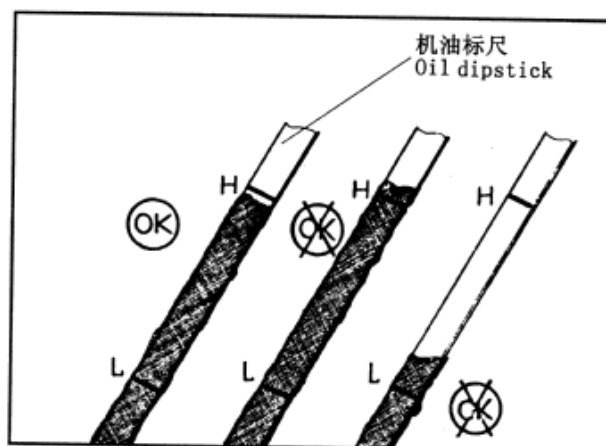


Figure 2-1 Oil dipstick

- Check the fuel level.

- Check for presence of water, gas, and oil leakages.

The whole engine shall be free of water, air, and oil leakage.

Check the fan. Figure:

Visually check the blades of fan for presence of damage and check connecting bolts for secure fastening.

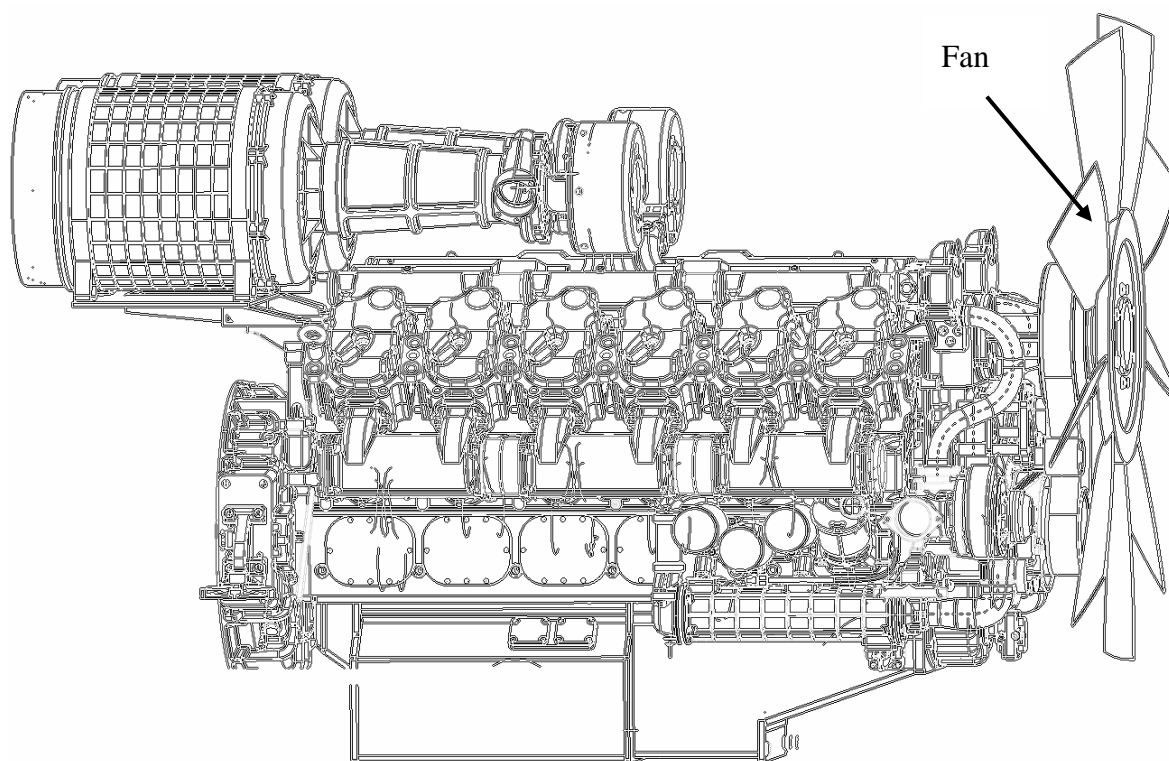


Figure 2-2 Check the fan

- Check the belt. Photo:

The belt is automatically tensioned by belt tensioner. Check the tension of belt by pushing the belt with hand.

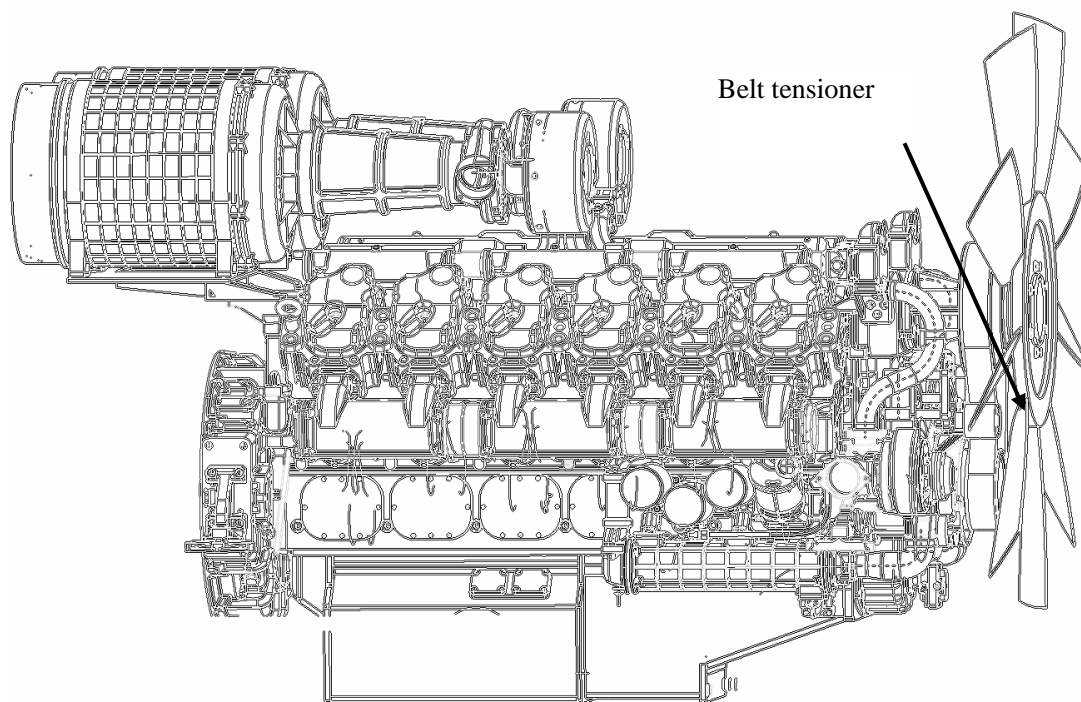


Figure 2-3 Check the belt

- Check whether exhaust gas has a normal color.

The normal color of exhaust gas is light grey. Upon detection of change in color, check and solve the cause.

- Check for normal sound.
- Check for normal engine speed and normal vibration.

2.3 Level-specific maintenance

In addition to the daily maintenance items, fulfill the following items:

- Replace diesel engine oil. As shown in Figure 2-4.

Before replacing old engine oil, remove the drain plug at the bottom of oil pan, and drain the old engine oil. Then tighten the drain plug;

Add fresh engine oil until the oil level meets the requirement. Then tighten the filler cap.

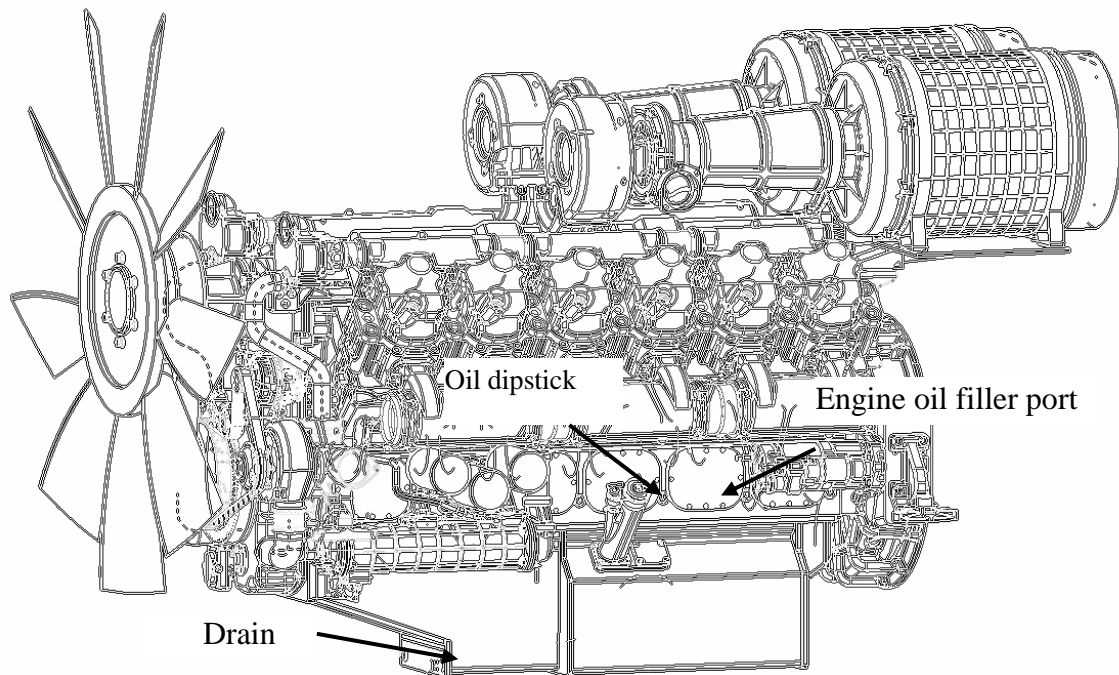


Figure 2-4 Filler Port, Drain Plug and Filter of Engine Oil

- Replace engine oil filter or filter element.

Replace the engine oil filter. Steps:

- Disassemble the used oil filter;
- Fill the new filter completely with clean engine oil.
- Before installing new engine oil filter, apply engine oil onto the rubber gasket.
- After the rubber gasket comes into contact with the base, tighten for 3/4~1 turn to seal.
- Start the diesel engine and check for presence of oil leakage.

- Check and adjust the clearances of intake and exhaust valves.

Check and adjust the intake and exhaust valves clearances. Steps:

A. Under the cold status of diesel engine, turn the engine (along the rotation direction of engine) to the compression top dead center of 1st/6th cylinder. In such case, the notch on the flywheel is aligned with the pointer on the flywheel cover.

B. Disassemble the valve rocker cover from the cylinder head and judge whether the 1st or 6th cylinder is at compression stroke (there is a gap between exhaust valve and rocker for the cylinder under the compression stroke).



Figure 2-5 Adjustment of valve clearance

C. Using the feeler gauges, check the clearance between Valve Bridge top and valve rocker arm (Table 2-1). If the clearance is too large or too small, adjust the adjustment bolt on the rocker to meet the above-mentioned clearance requirement.

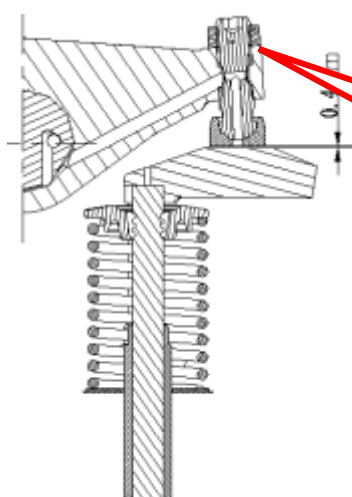


Figure 2-6 Clearances of intake valves under cold status - 0.4mm

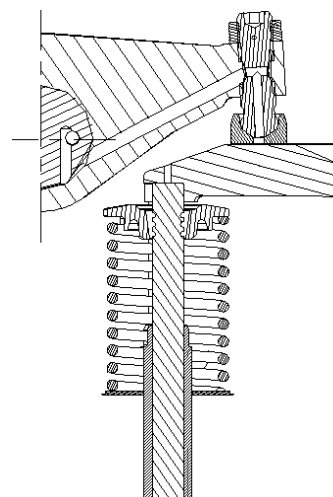


Figure 2-7 Clearances of exhaust valves under cold status - 0.3mm

D. After the checking of A1 or A6 cylinder, turn the engine for 360° to adjust the A6 or A1 cylinder to working stroke and then check and adjust the remaining valves on the A side.

Table 2-6 Adjustable Valves of Cylinders in the Compression Stroke

	A1 cylinder	A2 cylinder	A3 cylinder	A4 cylinder	A5 cylinder	A6 cylinder
A1 cylinder compression stroke	Intake and exhaust valves	Intake valve	Exhaust valve	Intake valve	Exhaust valve	Non-adjustable
A6 cylinder compression stroke	Non-adjustable	Exhaust valve	Intake valve	Exhaust valve	Intake valve	Intake and exhaust valves

After the checking of B1 cylinder or B6 cylinder, turn the engine for 360° to adjust the B6 or B1 cylinder to working stroke and then check and adjust the remaining valves on the B side.

Table 2-7 Adjustable Valves of Cylinders in the Compression Stroke

	B1 cylinder	B2 cylinder	B3 cylinder	B4 cylinder	B5 cylinder	B6 cylinder
B1 cylinder compression stroke	Intake and exhaust valves	Intake valve	Exhaust valve	Intake valve	Exhaust valve	Non-adjustable
B6 cylinder compression stroke	Non-adjustable	Exhaust valve	Intake valve	Exhaust valve	Intake valve	Intake and exhaust valves

- Replacement of fuel filter element

Replace the fuel filter. Steps:

A. Remove the old fuel filter element. Remove the water collector installed on the primary filter if it is reusable.

B. Lubrication seal.

C. Screw the filter by hand, till the seal comes into contact with the port.

D. Continue to screw the filter by hand, till the filter is securely installed (for approximately 3/4 turn).

E. Bleed the air, till there is no presence of air bubble.

F. Conduct the leakage test.

- Check the intake system

Check the intake hose for presence of aging or cracking and check the clamps for presence of looseness. When necessary, tighten or replace parts to ensure air-tightness of intake system.

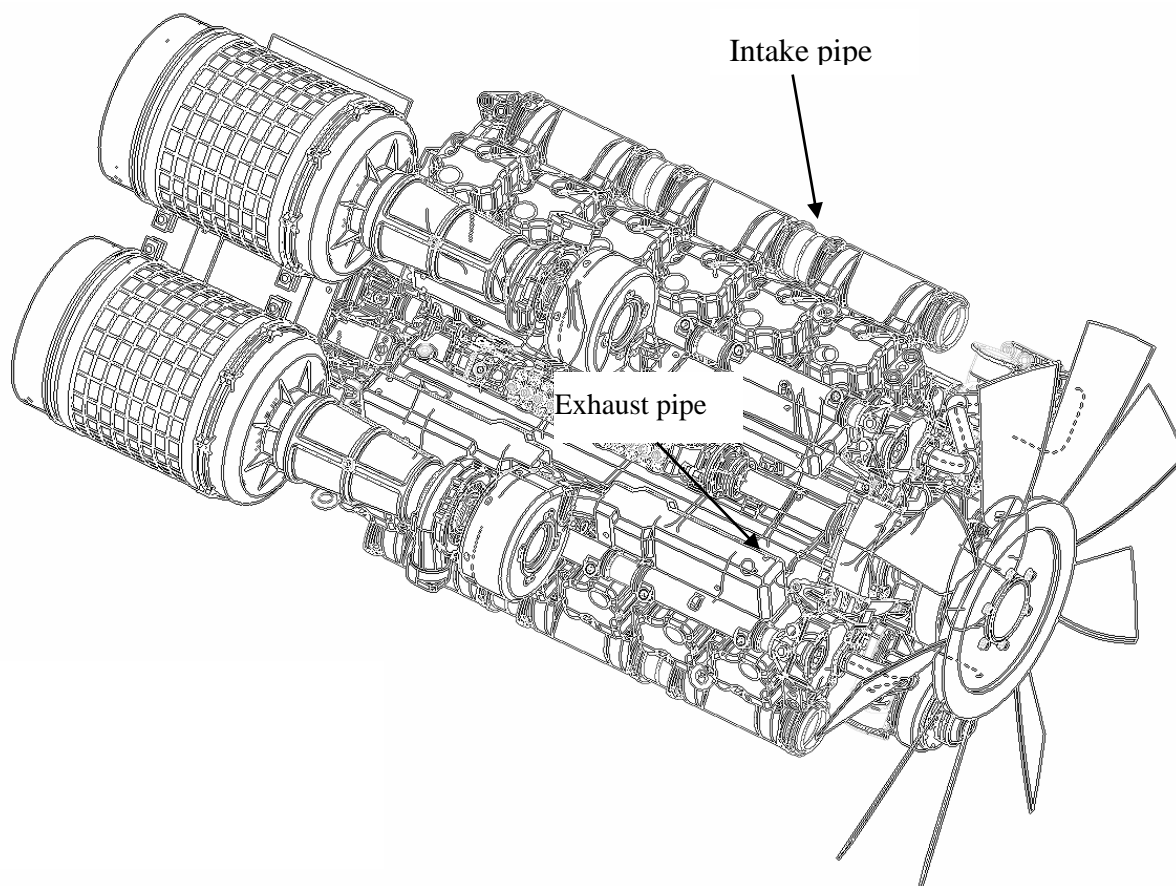


Figure 2-8 Intake and exhaust pipe

- Check the air filter element.

The maximum intake resistance of diesel engine is 7kPa; Check the maximum intake resistance only when the diesel engine is running at rated speed under full load. When the intake resistance reaches the maximum permissible limit, clean or replace the filter element as per the manufacturer's instructions.

Caution: It's absolutely prohibited to run the engine without the air filter, otherwise the ingress of dusts and impurities into the diesel engine will lead to earlier wear of engine.

Disassemble the filter element from the air filter and flap lightly the end face to fall off the dust or blow backward (from inside to outside) by compressed air.

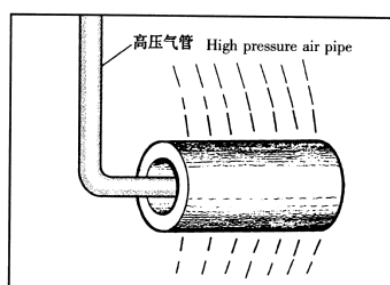


Figure 2-9 Cleaning of Air Filter Element

**Caution: Do not blow through the filter paper,
Do not clean the filter paper by water or oil, or
Do not clap or knock the filter element forcibly.**

2.4 Maintenance for Long-Term Storage of Diesel Engine

- Cleaning diesel engine;
- Protection measures:
 - After the engine warm-up, drain the engine oil, clean engine oil filter, and add anti-rusting oil;
 - Drain the fuel and add anti-rust oil mixture;
 - Drain the coolant and add coolant with anti-rust agent;
 - Start the engine and idle for 15~25min.
 - Fully drain the engine oil, fuel and coolant;
 - Take protection measures for other portions.
- Protection during storage:
 - Plug with caps or wrap with plastic film for all oil, gas, and water inlets and outlets and seal up the entire diesel engine with weather anti-rusting film.

If the transport is required, the external package shall be supplemented.

Chapter III Typical Malfunctions and Troubleshooting of Diesel Engine

12M26 series diesel engine is designed and manufactured under strict quality assurance system and each delivered diesel engine passed the specified tests. In addition, the diesel engine is a kind of high precision machinery and the long-term guarantee of its functionality is closely related to the normal maintenances. The causes leading to earlier failure of diesel engine are generally as below:

- ◆ Operations against rules or improper management and operations.
- ◆ Failure to fulfill maintenance as specified or even repair instead of maintenance.
- ◆ Poorly manufactured parts, especially the counterfeit products procured due to temptation of cheap prices, which will greatly shorten the service life of diesel engine.
- ◆ Inappropriate trademark of fuel or lubricating oil or disqualified fuel or lubricating oil.

3.1 Diagnostic method

The common diagnosis methods for malfunctions of diesel engine are generally as below:

- ◆ Observation method: Judge the malfunction situation by observing the malfunction symptom, such as exhaust smoke of diesel engine (Figure 3-1).
- ◆ Listening diagnosis method: Judge the characteristic and extent of the malfunction portion by listening as per the abnormal sound of diesel engine (Figure 3-2).



Figure 3-1 Observation method



Figure 3-2 Listening diagnosis method

- ◆ Cylinder interruption method: Interrupt the working of certain cylinder to judge whether the malfunction occurs in such cylinder. Generally, the cylinder interruption method is to cut off the fuel supply to the suspiciously malfunctioned cylinder and compare the status changes of the diesel engine before and after the interruption of cylinder, in order to narrow the scope for further determination of the malfunction location or cause.

Comparison method: For some assemblies or parts, the replacement method is adopted to determine the presence of malfunction.

Note:

1. Judging the malfunction cause of diesel engine is a really precise work. Before the cause is basically identified, do not disassemble the diesel engine casually, or it will not only eliminate the malfunction, but also lead to more serious malfunction due to improper assembly after disassembly. 2. The servicing of critical components particularly the high pressure oil pump and the turbocharger shall be performed by experienced personnel using dedicated instruments. Persons who are inexperienced or have no such instruments may not remove or adjust them.

3.2 General malfunction causes and troubleshooting of diesel engine

3.2.1 Start failure of diesel engine

Cause	Troubleshooting
(1) Working failure of starter motor	If the starter motor fails, firstly exclude the malfunctions of electric circuits.
(2) Low air temperature	Take the auxiliary starter measure.
(3) Air content in fuel system	Bleed the air, check sealing performance of connectors, and repair accordingly.
(4) Blockage of fuel delivery pumps inlet filter screen or fuel lines (such as hoses).	Check and remove dirt and check fuel cleanliness.
(5) Malfunction of fuel injection pump	Check plunger and fuel outlet valve and repair or replace damaged parts.
(6) Damage or leakage of valve or fuel supply pipes	Check and adjust
(7) Damage and leakage of high pressure fuel pipes	Repair and replace
(8) Malfunction of fuel injector	Check atomization state of fuel injector.
(9) Insufficient compression pressure of cylinder	Check sealing performance of valves and cylinder gasket, check wear of piston rings, and repair or replace.

3.2.2 Stop of engine shortly after start

Cause	Troubleshooting
(1) Air content in fuel system.	Check the sealing performance of fuel pipes and connectors, check and ensure the tightening of bleeder screw, and bleed the remained air.

(2) Blockage of fuel filter.	Disassemble the filter body, remove internal contaminant and water, and when necessary replace filter element.
(3) Poor fuel quality and high water content	Clean filter and replace fuel
(4) Working failure of fuel delivery pump	Check piston and valve of fuel delivery pump, clean, and repair
(5) Low regulated idling speed	Re-adjust

3.2.3 Low power

Cause	Troubleshooting
(1) Intake blockage (blockage of air filter)	Check air filter and intake pipe and clean or replace filter element.
(2) Over-high exhaust backpressure	Check valve timing, check exhaust pipeline for blockage, and adjust and repair
(3) Insufficient pressure of turbocharger system	Check and solve leaks at pipeline connections.
(4) Abnormal working of turbocharger	Replace assembly
(4-1) Blockage of air compressor or turbine runner by dirt	Clean or replace
(4-2) Failure of floating bearing	Replace
(4-3) Carbon deposit and oil sludge at back gap of turbine and compressor	Clean
(5) Damage and air leakage of inter-cooler	Replace or repair
(6) Leakage or blockage of fuel pipeline	Check sealing performance of fuel pipes and connectors, check the contamination degree of filter, repair the fuel pipeline or dredge the blockage dirt, and replace filter element.
(7) Poor fuel quality	Clean fuel tank, filtration parts and fuel pipes, and replace fuel
(8) Excessive wear of fuel injection pump or speed regulator	Repair or replace
(9) Damaged diaphragm of fuel injection pump smoking limiter	Replace or repair
(10) Damage and air leakage of smoking limiter air pipe	Replace
(11) Poor atomization of fuel injector nozzle	Check fuel injection pressure and carbon deposit of fuel injector nozzle and adjust and repair
(12) Incorrect valve or fuel supply timing	Check and adjust
(13) Under-low high-speed adjustment of speed regulator	Check speed regulation characteristic and adjust accordingly
(14) Over-high oil level of oil sump	Check oil dipstick and drain excessive engine oil
(15) Air leakage of cylinder gasket	Check compression pressure during warm-up and replace damaged cylinder gasket

(16) Wear and breakage of piston rings and excessive gap of bearing shells	Replace worn parts or overhaul the engine
(17) Wear or scuffing of cylinder sleeve or piston	Repair or replace

3.2.4 Excessive fuel consumption

Cause	Troubleshooting
(1) Blockage of intake pipe	Check the air filter and intake pipeline and clean accordingly
(2) Over-high exhaust backpressure	Check exhaust pipeline and clean accordingly
(3) Poor fuel quality	Replace with specified fuel
(4) Blockage of fuel pipeline	Check and repair.
(5) Leakage of fuel pipeline	Check and repair.
(6) Poor atomization of fuel injector nozzle	Check and adjust or repair
(7) Incorrect valve or fuel supply timing	Adjust valve clearance and fuel supply advance angle as per specification
(8) Air leakage of cylinder gasket	Check compression pressure
(9) Excessive gap of bearing shells. The overhaul is required for the engine.	Check and overhaul
(10) Expanding of piston	Replace cylinder sleeve, piston, and piston rings
(11) Insufficient pressure of turbocharger system	Check and solve leaks at pipeline connections.
(12) Abnormal working of turbocharger	Check and replace
(13) Damage or air leakage of inter-cooler	Replace or repair

3.2.5 Black exhaust gas

Cause	Troubleshooting
(1) Blockage of intake pipe or excessive exhaust backpressure	Clean
(2) Poor fuel quality	Clean and replace
(3) Incorrect valve or fuel supply timing	Adjust as per specification
(4) Poor atomization of fuel injector nozzle	Check, repair, or replace
(5) Excessive fuel volume of fuel injection pump	Check and adjust

(6) Insufficient pressure of turbocharger system	Check and solve leaks at pipeline connections.
(7) Abnormal working of turbocharger	Check and replace assembly
(8) Damage and air leakage of inter-cooler	Replace or repair
(9) Incorrect application point of smoking limiter	Re-adjust

3.2.6 White or blue exhaust gas

Cause	Troubleshooting
(1) Poor fuel quality and high water content	Replace fuel
(2) Under-low coolant temperature	Check working temperature of thermostat and replace when necessary.
(3) Wear of turbocharger seal rings	Check and replace
(4) Wear of turbocharger thrust bearing	Check and replace
(5) Blockage of turbocharger oil return pipe	Clean or repair
(6) Poor atomization of fuel injector nozzle	Check and repair
(7) Incorrect valve or fuel supply timing	Check and adjust
(8) Low compression pressure, incomplete combustion, and piston expanding	Check piston rings, cylinder sleeve, and cylinder gasket and repair accordingly
(9) Improper run-in of piston rings and cylinder sleeves	Continue the run-in
(10) Non-staggered openings of piston rings	Adjust and reassemble
(11) Failure of piston oil rings	Replace
(12) Large fit clearance between piston and cylinder sleeve	Repair and replace

3.2.7 Deposit of engine oil at air inlet port and air inlet pipe of turbocharger

Cause	Troubleshooting
(1) Turbocharger sealing failure	Repair or replace turbocharger
(2) Failure of fuel-air separator	Replace
(3) Over-high oil sump level and excessively added engine oil	Check and drain engine oil as appropriate to meet the required level

3.2.8 Unstable speed

Cause	Troubleshooting
(1) Poor fuel quality, with water or paraffin content	Replace fuel
(2) Air ingress of fuel suction pipe	Check sealing performance of fuel pipes and connectors and bleed air
(3) Abnormal working of speed regulator (mechanical pump) counterweight and speed regulation spring	Check and adjust
(4) Non-uniform fuel supply	Check and adjust
(5) Unstable atomization of fuel injector nozzle	Check and repair
(6) Vibration of turbocharger	Check and clean air compressor runner, dredge blockage, and remove carbon deposit from exhaust passage
(7) Damage of turbocharger bearing	Replace

3.2.9 Engine oil pressure too low

Cause	Troubleshooting
(1) Under-low oil sump level or oil shortage	Add oil to the specified level of oil dipstick.
(2) Inappropriate engine oil trademark	Replace with specified engine oil and choose an appropriate oil trademark
(3) Over-high water temperature of cooling system and over-high engine oil temperature	Check the cooling system for normal working.
(4) Excessive resistance of engine oil filter	Replace with new filter element
(5) Blockage of oil cooler	Check and clean
(6) Check strainer, engine oil pipeline, and connector gaskets for presence of blockage and cracking	Check and clean air compressor runner, dredge blockage, and remove carbon deposit from exhaust passage
(7) Leakage of oil pump inlet pipe	Check oil pipes and connectors and repair or replace
(8) Malfunction of main oil-way pressure regulator valve	Check valve and clean and repair
(9) Blockage of main oil-way	Check and clean
(10) Excessive gap of bearing shells or damage of bearing shell	Check and replace
(11) Excessive wear of parts. The overhaul is required.	Check the working condition of engine and overhaul
(12) Leakage of diesel into engine oil	Check for presence of diesel odor and measure

	and ensure that the flashing point of engine oil is no less than that of new oil
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3.2.10 High coolant temperature

Cause	Troubleshooting
(1) Under-low level in water tank	Check for water leaks and add water
(2) Blockage of water tank radiator fins	Clean water tank radiator fins
(3) Loose water pump belt	Adjust tension as per specification
(4) Damage of water pump gasket and wear of water pump impellor	Check and repair or replace
(5) Damage of water pipe and ingress of air	Check water pipes, connectors, and gaskets and replace damaged parts
(6) Thermostat malfunction	Replace
(7) Blockage of water tank	Check water tank and clean or repair
(8) Under-low oil sump level or oil shortage	Check oil level and oil leaks, repair, and add oil

3.2.11 Excessive wear of parts

Cause	Troubleshooting
(1) Disqualified or damaged air filter element	Check and replace with qualified filter element.
(2) Short-circuit of intake system.	Check intake pipe, gasket, and connecting pipe sleeve and repair or replace
(3) Failure for timely replacement of oil filter element	Replace as per specification
(4) Under-low oil sump level or oil shortage	Check oil level and oil leaks, repair, and add oil
(5) Inappropriate engine oil trademark	Replace with specified oil
(6) Use of disqualified engine oil	Use qualified oil trademark
(7) Blockage of oil-way	Clean oil-way
(8) Breakage or wear of piston ring	Replace damaged parts
(9) Wear or scuffing of cylinder sleeve or piston	Disassemble and check piston and cylinder sleeve and repair or replace
(10) Non between crankshaft and driven shaft	Check mounting bracket and repair
(11) Excessive wear of parts. The overhaul is required.	Check current mileage and determine overhaul

3.2.12 Excessive noise

Cause	Troubleshooting
(1) Poor fuel quality	Replace fuel
(2) Under-low coolant temperature	Check thermostat and replace when necessary.
(3) Incorrect valve or fuel supply timing	Check, repair, and adjust
(4) Poor atomization of fuel injector nozzle	Check, repair, and adjust
(5) Excessive fuel volume of fuel injection pump	Check and adjust
(6) Wear of shock absorber	Check for damage, check state of connecting bolts, and replace damaged parts
(7) Air leakage or improper adjustment of valve	Disassemble and check valves and adjust
(8) Excessive gear backlash or broken teeth	Check and replace damaged parts
(9) Wear or scuffing of cylinder sleeve or piston	Check and repair or replace
(10) Bending or breakage of push rod and breakage of rocker arm	Replace
(11) Breakage or wear of piston ring	Check and replace damaged parts

3.2.13 Working failure of starter motor

Cause	Troubleshooting
(1) Burnt fuse	Replace fuse
(2) Poor contact of connecting wires	Clean circuits and tighten wiring posts
(3) Insufficiently charged battery	Check and charge or replace battery
(4) Short-circuit of starter motor	Check and repair motor or replace assembly
(5) Poor contact of electric brush	Clean electric brush surfaces or replace electric brush

3.2.14 Weak starter motor

Cause	Troubleshooting
(1) Insufficiently charged battery	Charge or replace battery.

(2) Wear of bearing bushing	Replace assembly
(3) Poor contact of electric brush	Clean electric brush surfaces or replace electric brush
(4) Dirty or burnt commutator	Remove oil dirt and polish with sand paper or replace assembly
(5) Loose weld of wire ends	Re-weld
(6) Poor contact of switch	Check and repair switch
(7) Slip of friction clutch	Adjust working moment of clutch or replace assembly

Chapter IV Dismantling and Assembling of Engine

4.1 Overview

During dismantling and assembling of diesel engine, please follow operating instructions in this manual strictly and pay attention to operation steps containing danger and safety marks, so as to ensure personal safety and avoid accidents.

For the reason that the diesel engine is dismantled in reverse installation procedures, only one item is selected for instruction in this maintenance manual unless otherwise specified herein.

Tightening torque of special bolts will be specified in relevant installation procedures, and unless otherwise specified herein, please refer to Chapter V, Tightening Torque of Standard Bolts.

4.1.1 Danger signs



This sign is a “safety warning sign” for industrial purposes, which stresses the importance of the following information. Please make sure that you know what potential risks are and how to ward off such risks.

This warning sign indicates a potential danger, which, if not warded off, may lead to severe injury, death or major property loss.

The common hazard signs are always used for general warning.. In this manual, warnings are divided into three different types(moderate injury, serious injury and death) according to the level of dangerous consequences














This warning sign indicates a potential danger, which, if not warded off, may lead to slight injury or property loss. It is also used to warn against dangerous operations.

The instructions herein are provided to explain how to correctly operate and install the engine. Simply reading through this document will not prevent risks from happening. But only through adequate understanding can these instructions will be correctly applied.

The warning information provided herein may not cover all possible situations! If you decide to use a procedure or a method that is not recommended, please make sure that such operation will not bring harm to yourself, any other person or the equipment.

4.1.2 Safety signs







Table 4-1 Safety signs

Picture	Definition
	Wear hand protectors
	Wear ear protectors
	Wear eye protectors
	Wear a head protector
	Wear foot protectors
	Wear protective mask
	Wear protective clothing
	No fire
	No smoking
	No use of mobile phone
	Danger: Battery acid liquor
	Danger: Live cables and contacts
	Combustibles
	Keep away from suspended heavy objects!
	Fire extinguisher available at a nearby position

During use of the diesel engine, many potential dangers occur without any signs. Hence, this manual cannot give warning instructions for all kinds of potential danger. If the procedures taken by you are not recommended ones, please ensure the same procedures are safe to operate and do not result in any damage to property.

4.1.3 Tools

Table 4-2 Tools

Picture	Definition
	2.5mm hex wrench
	5mm hex wrench
	8mm socket
	Slotted screwdriver
	Special tool
	10mm flat hexagon wrench

Should any method or tool used is not recommended in this manual, the user must first ensure personal safety, and avoid jeopardizing the life of the user or other personnel, as well as guarantee that the use, maintenance or repairing method will not cause damage risks or jeopardize personal safety.

4.1.4 Precautions for health protection

The following "Precautions for health protection" are to reduce pollution risks.

- a) Avoid the long-term repeated touch of used engine oil.
- b) If possible, please wear the protective clothing and water-proof gloves.
- c) Never place any oil-immersed rag into your pocket.
- d) Guard your clothing, especially the underwear, against the oil contamination.
- e) Wash your working clothing frequently. Throw away oil-immersed clothing and shoes that can't be cleaned.
- f) In event of cuts or injuries, please immediately take the emergency treatment.
- g) Make sure to apply to apply the protective paste before operations, which will make the removal of oil easier if your skin is contaminated by mineral oil.
- h) Use soap and hot water or use liquid soap and fingernail brush to wash hands, in order to completely remove oil dirt. If the naturally secreted grease on your skin is removed during the hand-washing, a product with wool fat content can replace this naturally secreted grease to help moisturize the skin.

- i) Do not clean the skin by gasoline, kerosene, fuel, thinner, or solvent.
- j) Upon detection of skin irritation, please immediately seek for medical treatment.
- k) If possible, deoil the parts before the handling of parts.
- l) Please use goggles or face mask whenever your eyes are endangered. Make sure to prepare the eye flushing fluid at all accessible places.
- m) During the repair of diesel engine, never splash oil or other liquid onto the ground. In event of accidental leakage of hydrocarbon or other liquid, take all necessary measures to quarantine this area to keep clean the environment and guard personnel against injuries.
- n) The handling, storage, and recovery of hydrocarbon, ethylene, glycol, and petroleum must abide by the safety and environmental standards of the country in which the operations are fulfilled.

4.1.5 Environmental protection measures

Please observe relevant environmental protection laws and regulations with respect to disposal of waste oil and hydrocarbons. For details, consult local officials.

4.1.6 Precautions for dismantling and assembling of diesel engine

Most accidents in connection with use, maintenance and service of diesel engine are resulted from failure to observe safety rules and basic precautions. So, you should know risks you face and take corresponding preventive measures to avoid occurrence of accidents. To conduct operation, maintenance and service of the diesel engine, you should be trained, and have relevant skill and use appropriate tools.

Failure to follow relevant instructions given in this manual may result in serious accidents, even endangering the operator's life. Baudouin Power Co., Ltd. cannot foresee all potential risks. Similarly, guidelines and instructions specified in this manual are not exhaustive.

Before proceeding with maintenance or repairing, a signboard containing "Don't Use" or a similar sign should be placed on the starter switch.

Before use of the barring rod, necessary preventive measures should be taken.

Ensure that the maintenance site and surrounding environment are suitable for safe operation.

Ensure the maintenance workshop or area around the diesel engine is clean and neat.

Before working, please take off your ring, necklace and watch. Please wear a suitable working

uniform.

Before working, please check whether corresponding protection equipment (goggles, gloves, shoes, masks, working uniform, helmet, etc.) are within effective life.

Do not use faulty or unsuitable tools.

Stop the diesel engine during maintenance or service.

4.2 Cylinder head subassembly

4.2.1 Cylinder head

The cylinder head is located on the upper portion of the cylinder block and works with piston head to form the combustion chamber. The parts connected with the cylinder head include intake pipe, exhaust pipe, water outlet pipe, fuel injector, cylinder head cover, cylinder head gasket, and some parts of valve mechanism.

4.2.2 Dismantling procedures

The connected parts of cylinder head should be disassembled first before disassembling the cylinder head. The detailed disassembling procedure is indicated in sequence.

- 1) Disassemble the turbocharger and connecting pipeline. Please refer to the disassembling instructions of intake and exhaust system for details.
- 2) For details about dismantling of the fuel injection pump, see the Instructions for Dismantling of ;
- 3) Disassemble the thermostat and water outlet pipe.
- 4) Disassemble the lifting rings;
- 5) Disassemble the fuel injector return pipe, cylinder head cover and the cylinder head cover gasket.
- 6) Disassemble the fuel injector and related parts. Refer to dissembling instructions of fuel system for details.
- 7) Disassemble the lubricating oil pipes of cylinder head.
- 8) Disassemble the intake and exhaust pipe and related parts. Refer to the disassembling instruction of intake and exhaust system for details.
- 9) Disassemble the rocker arm assembly and push rod. Refer to disassembling instruction of valve mechanism for details.

10) Disassemble the cylinder head and the cylinder head gasket.

11) Disassemble the inner and outer springs of valves, spring upper and lower seats of intake and exhaust valves, valve collets, and valves. Refer to disassembling instruction of valve mechanism for details.

12) Disassemble the valve stem sealing sleeve.

4.2.3 Assembling procedures

The assembling procedure is in reverse order of the disassembling procedure.

4.2.4 Disassembling, checking, repair, and assembling essentials

4.2.4.1 Water outlet pipe

[Disassembling]

Loosen the water outlet pipe bolts in turn, take out the water outlet pipe assembly, and disassemble the seal gaskets from cylinder head, as shown in the figure.

[Checking and repair]

1) Before disassembling, check the water outlet pipe for presence of water leakage and observe the water outlet pipe for presence of cracking and corrosion. If the cracking is present, replace water outlet pipe as necessary. For the corrosion that influences the reliability, analyze the cause and replace with new water outlet pipe.

2) If the water leak occurs at connectors, replace connector and tighten and then observe for presence of water leakage.

[Assembling]

1) Add O-ring and connect three segments of water outlet pipe together.

2) Place the rubber seal ring neatly at the water outlet port of cylinder head.

3) Fix three segments of water outlet pipe onto the cylinder head by hexagon flange bolt.

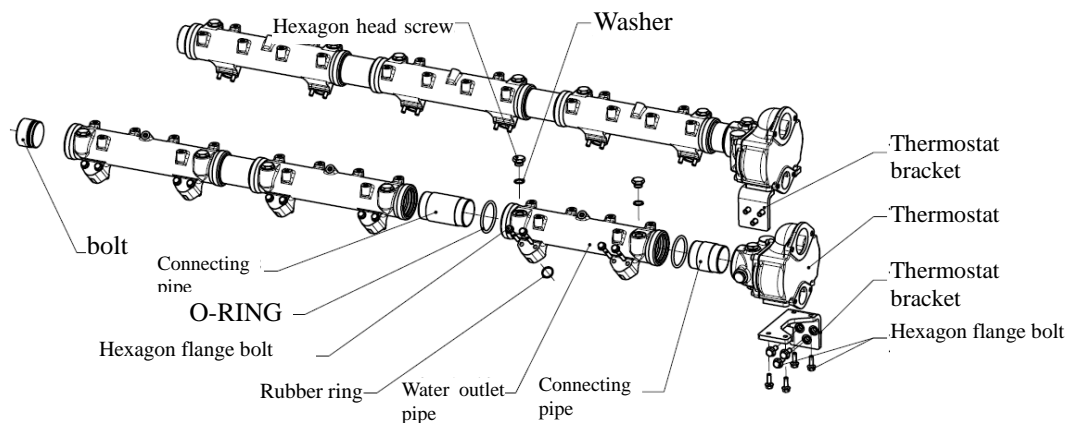


Figure 4-1 Assembling of water outlet pipe

4.2.4.2 Engine lifting rings

[Disassembling]

Loosen and take out the lifting rings in turn.

[Checking and repair]

Check the front and rear lifting ring for cracking and other failure and check the threads of rings for presence of failure. Upon detection of such failure, replace with new parts.

[Assembling]

The engine lifting rings are of M22 threads and the tightening torque is $(660 \pm 5N \cdot m)$.

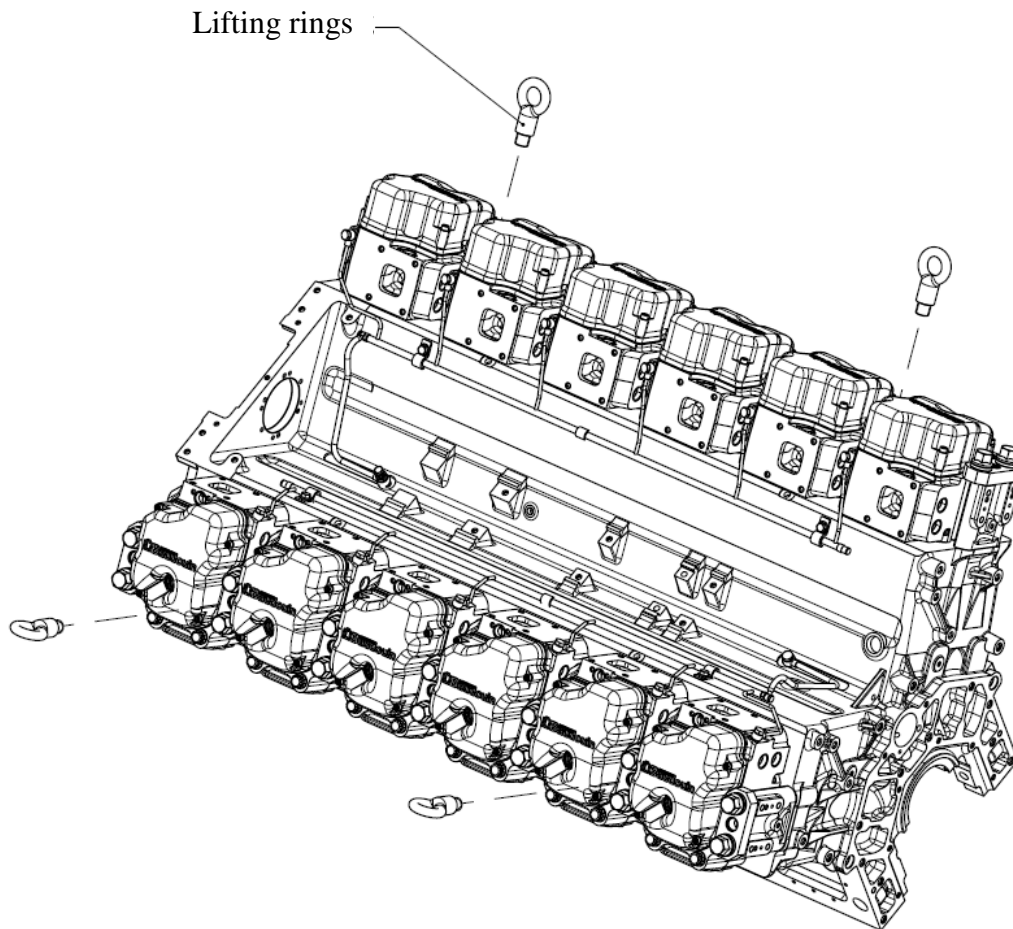


Figure 4-2 Assembling of engine rings

4.2.4.3 Cylinder head cover

[Disassembling]

Loosen the cylinder head cover bolts in turn and vertically take out the cylinder head cover and cylinder head cover gasket, as shown in the figure.

[Checking and repair]

1) Observe the cylinder head cover for presence of cracking and other damage. Upon detection of cracking, replace with new cylinder head cover.

2) Upon detection of oil permeation or leakage at cylinder head cover gasket, check the cylinder head gasket for failure and replace with new cylinder head cover gasket.

[Assembling]

1) The cylinder head cover gaskets can be used only once. Replace with new ones in event of repair. Before installing cylinder head cover gaskets, check and ensure that new cylinder head cover gaskets are free of manufacturing and operation defects and damages.

2) Wipe clean the top face of cylinder head and assemble cylinder head gaskets correctly in turn.

3) Apply oil to the rubber O-rings, install O-rings into grooves of cylinder head cover, wipe clean the cylinder head cover, and assemble the cylinder head cover onto the cylinder head in correct sequence.

4) Install and tighten the cylinder head cover bolts.

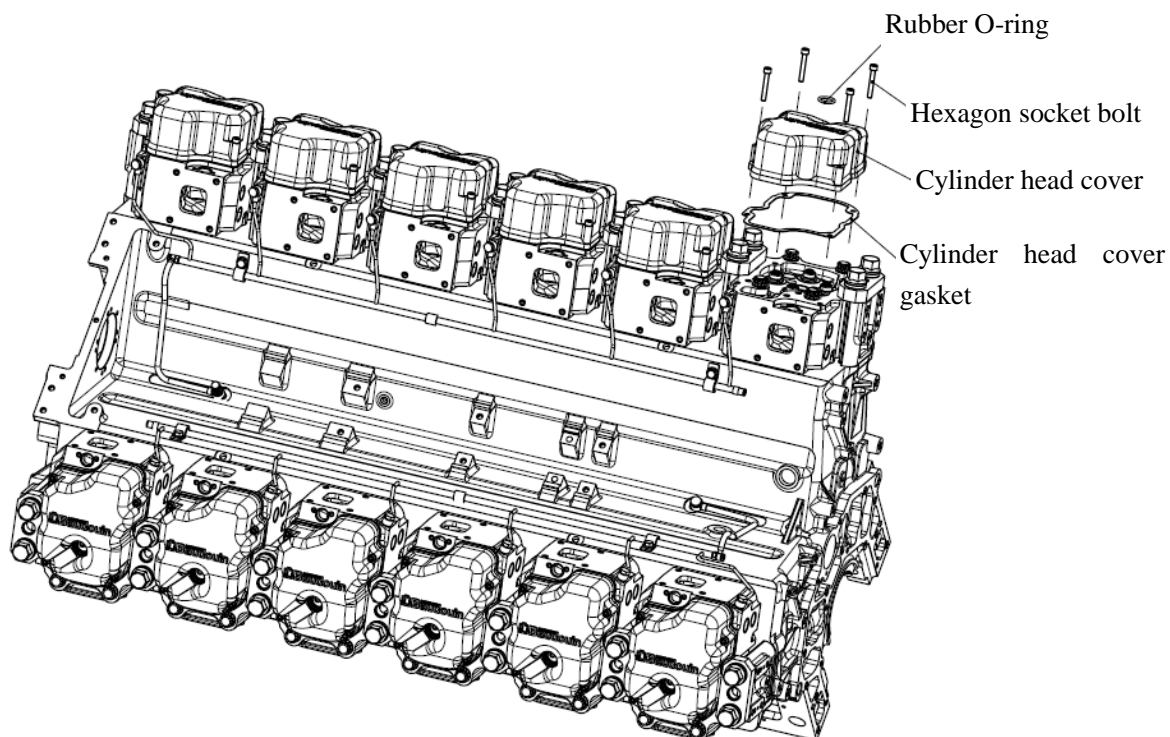


Figure 4-3 Assembling of Cylinder Head Cover

4.2.4.4 Lubricating oil pipes of cylinder head

[Disassembling]

Loosen and take out the hollow fastening bolts of the lubricating oil inlet pipe from the cylinder block and cylinder head oil pipes respectively and take out the lubricating oil inlet pipe. Loosen the fastening flange bolts of pipe clamps and take out the bolts and pipe clamps. Loosen and take out the hollow fastening bolts from the cylinder head in turn and take out the lubricating oil pipes of cylinder head.

[Checking and repair]

Check the oil pipes for presence of oil permeation and leakage. Upon detection of oil permeation or leakage, judge the failure state and replace with new lubricating oil pipes or sealing

gaskets.

[Assembling]

The assembling procedure is in reverse sequence of the disassembling procedure.

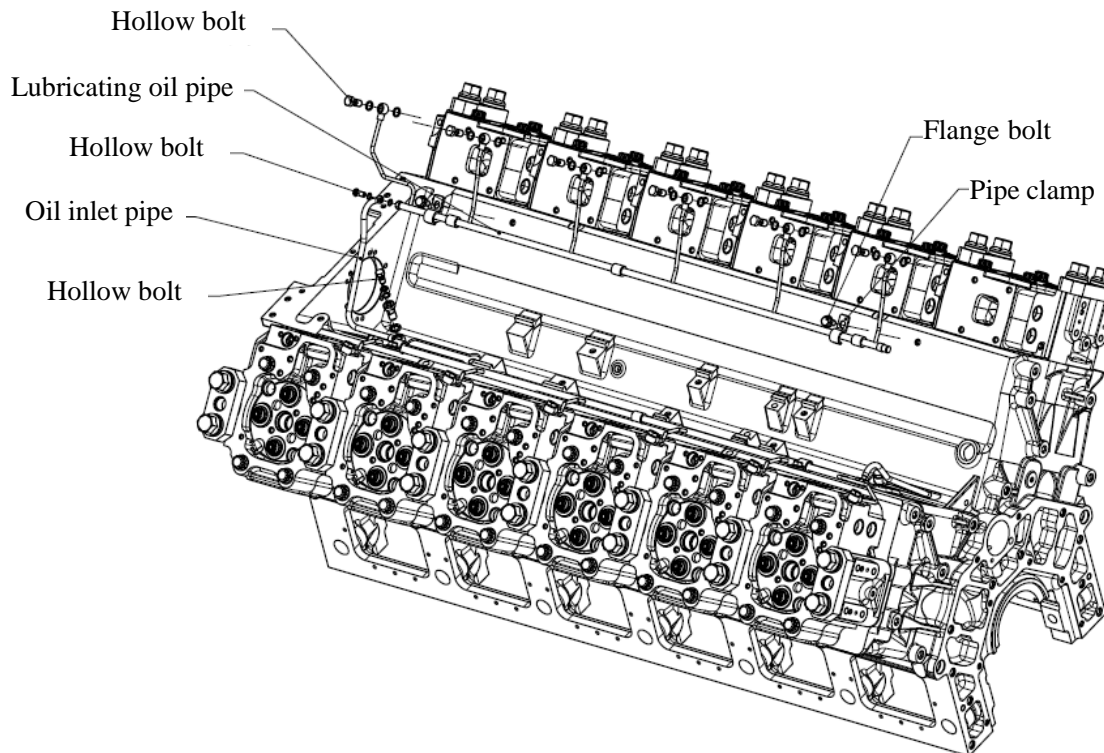


Figure 4-4 Assembling of cylinder head lubricating oil pipes

4.2.4.5 Cylinder head

[Disassembling]

- 1) Loosen auxiliary bolts of cylinder head and take out clamping blocks.
- 2) Loosen the cylinder cover main bolts.
- 3) Before disassembling the cylinder head, ensure that the fuel injectors are disassembled, otherwise the heads of fuel injectors will be easily damaged during the placement of cylinder head.
- 4) Disassemble the cylinder head and place the disassembled cylinder head on a paper board, in order to prevent wearing the top surface of combustion chamber and other sealing surfaces. If the disassembling of multiple cylinder heads is required, mark the cylinder heads with cylinder numbers to ease the problem analysis.
- 5) Disassemble the cylinder head gasket. If the disassembling of multiple cylinder head gaskets is required, mark the cylinder numbers on the cylinder head gaskets to ease the problem analysis.

6) Dismantle the intake and exhaust valves by referring to Instructions for Dismantling of Valve Mechanism;

7) Disassemble the valve stem sealing sleeve.

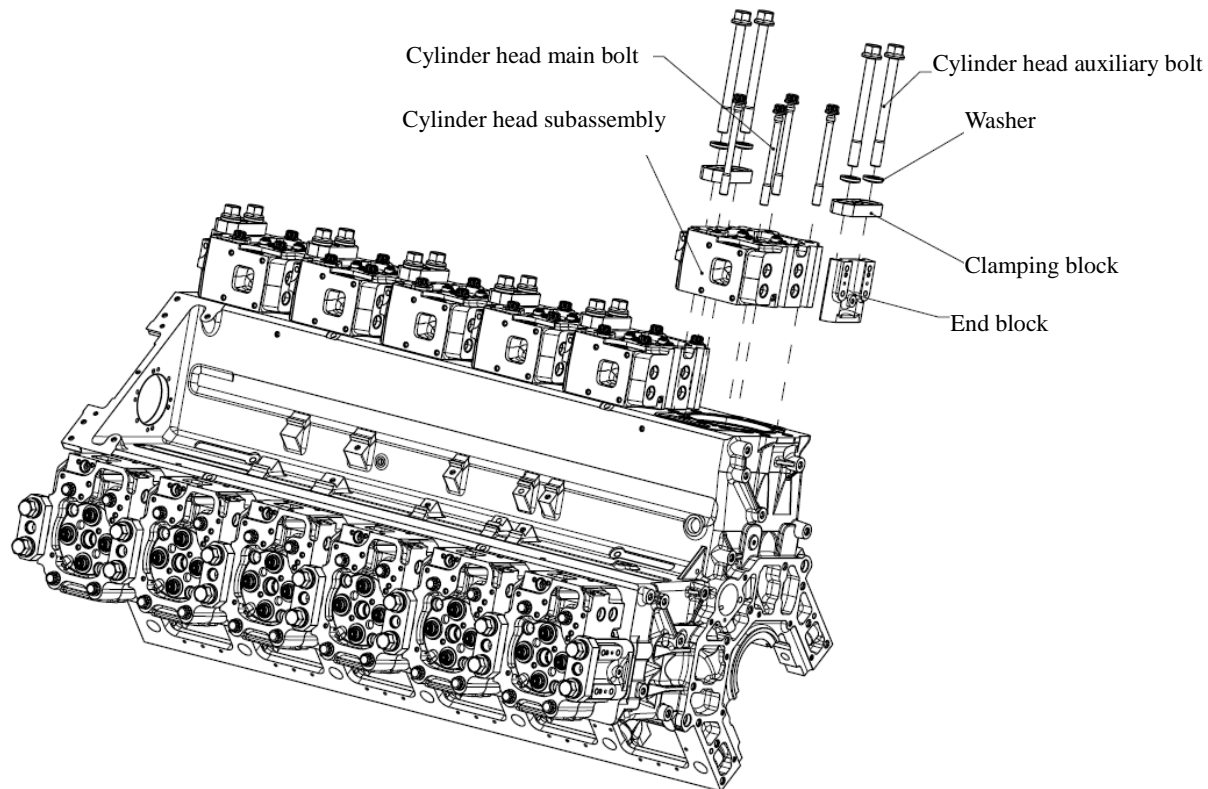


Figure 4-5 Assembling of cylinder head

[Checking and repair]

(1) Cylinder head

Before dismantling of the cylinder head, first inspect whether there is water leakage, oil leakage, gas leakage and other signs, as well as other abnormal phenomena, so as to accurately locate position where the problem occurs, and accurately analyze the problem.

Clean the cylinder head, and clean the surfaces of the combustion chamber, valve seat, intake and exhaust valves, intake and exhaust ports, and remove the carbon deposit and varnish, as well as inspect surface conditions.

① Appearance inspection

Inspect discoloration and crack of the cylinder head carefully, and in case of crack, carry out penetrant inspection.

② Valve sinkage

The valve sinkage is the vertical distance from the bottom surface of the valve to the bottom surface of the cylinder head, and the difference between the valve sinkage measurement value and the required valve sinkage value can reflect degree of wear of the valve and valve seat. It is possible to use depth micrometer to measure the valve sinkage as shown in Figure;



Figure 4-6 Depth Micrometer

For the required valve sinkage value, refer to the Table 1, and if the valve sinkage exceeds the permissible range, it is required to replace the cylinder head with a new one to ensure reliability of the engine. If the valve sinkage does not exceed the permissible value, dismantle the valve for inspection and then inspect the sealing surface of the valve seat ring. Check whether there is apparent wear and abnormal damage to the valve and the sealing surface of the valve seat ring.

Table 4-3 Valve Sinkage Values

	Required Valve Sinkage Values (mm)
Intake	0.6~1.1
Exhaust	1.2~1.7

③ Clearance between exhaust valve rod and valve guide

The inside diameter of the valve guide is the contact surface between the valve guide and the valve, and if the clearance between exhaust valve rod and valve guide exceeds the permissible value due to wear, it will result in influence on guiding effect of the valve, reducing reliability of the diesel engine operation. The inside diameter of the valve guide can be measured by use of an inside micrometer, as shown in Figure. The outside diameter of the valve guide can be measured by use of an outside micrometer. The permissible range is (0.04~0.07) mm for the clearance between intake valve stem and valve guide pipe and is (0.06~0.09) mm for the clearance between exhaust valve stem and valve guide pipe. If out of the permissible range, replace the cylinder head to ensure the working reliability of the diesel engine.

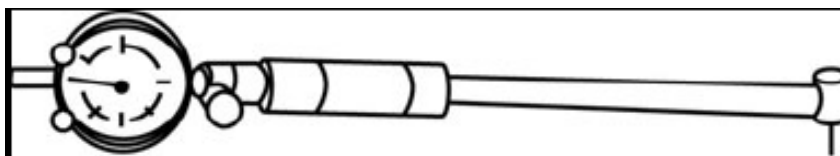


Figure 4-7 Inside Micrometer

④ Cylinder head gasket

In case of gas leakage, water leakage, fuel leakage and other problems at the cylinder head gasket, it is required to inspect the cylinder head gasket and replace it wherever necessary.

Inspect whether there is visible damage to the cylinder head gasket and analyze the cause. Regardless of problems at the cylinder head gasket, it should be replaced with a new one after being dismantled.

[Assembling]

(1) Cylinder head gasket assembly

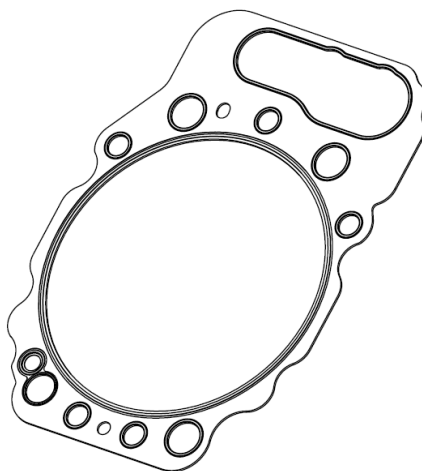


Figure 4-8 Cylinder head gasket

① The cylinder head gasket can be used once only, and in case that it is returned for repairing, it must be replaced with a new one.

② Wipe clean the top plane of cylinder block and place the cylinder head gasket as per the corresponding pin holes.

③ Inspect whether the cylinder head gasket is assembled properly.

(2) Attach the cylinder head gasket and then install the cylinder head to the cylinder block.

① Wipe clean the cylinder head carefully and ensure that there is not dust, debris, sand and other contaminants, and then further wipe clean the bottom surface of the cylinder head.

② Inspect whether there is foreign bodies in the cylinder, and the cylinder head gasket is clean.

③ Use the guide rods to screw them into the cylinder head bolt holes.

④ The cylinder head gasket shall be free of distortion, deformation, and damage.

(3) Loosen the cylinder cover main bolts.

① Apply an appropriate amount of lubricating oil to the threads and support faces of cylinder head main bolts.

(4) Add the clamping blocks and circular washers, loosely install the cylinder head auxiliary bolts, and assemble end plates on two ends of cylinder block.

① Apply an appropriate amount of lubricating oil to the threads and support faces of cylinder head auxiliary bolts.

(5) Tighten the main and auxiliary bolts of cylinder head.

Tighten the main and auxiliary bolts of cylinder head by 5 steps.

Step 1: Tighten the M16 main bolts to 80N.m and tighten the M20 auxiliary bolts to 80N.m.

Step 2: Tighten the M16 main bolts to $45^{\circ} \pm 5^{\circ}$ and tighten the M20 auxiliary bolts to $45^{\circ} \pm 5^{\circ}$.

Step 3: Tighten the M16 main bolts to $45^{\circ} \pm 5^{\circ}$ and tighten the M20 auxiliary bolts to $45^{\circ} \pm 5^{\circ}$.

Step 4: Tighten the M20 auxiliary bolts to $45^{\circ} \pm 5^{\circ}$ and tighten the M20 main bolts to $40^{\circ} \pm 5^{\circ}$.

The main bolts can be reused for 3 times.

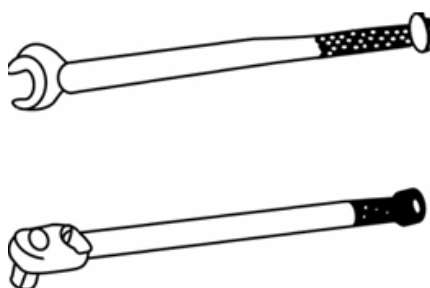


Figure 4-9 Torque wrench

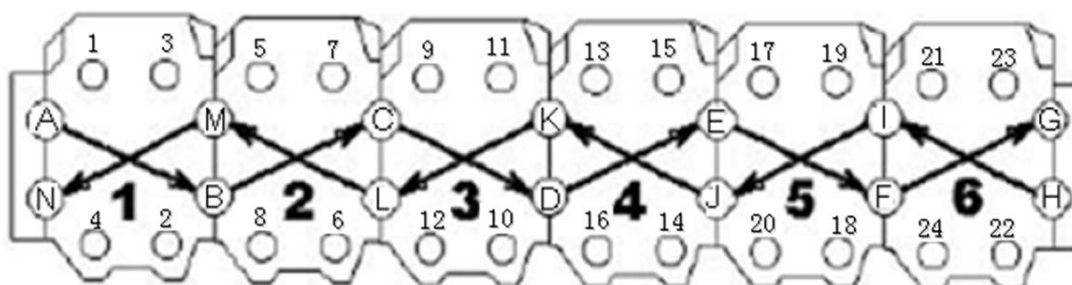


Figure 4-10 Tightening sequence for cylinder head bolts

(6) Assemble the valve stem sealing sleeves.

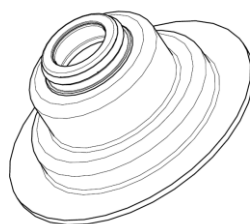


Figure 4-11 Valve stem sealing sleeve

[Disassembling]

To disassemble the valve stem sealing sleeve, use the special tooling or use pliers to clamp the outer walls of valve stem sealing sleeve and rotate upward to lift out the valve stem sealing sleeve.

[Checking and repair]

Before disassembling, observe the rubber lips of valve stem sealing sleeve for presence of damage. Once being disassembled, replace with new valve stem sealing sleeve.

[Assembling]

① The valve stem sealing sleeve can be only used once. Make sure to replace with new one in event of repair.

② Check the valve stem sealing sleeve for presence of defect and check valve stem sealing sleeve spring for intactness.

③ Install valve stem sealing sleeve on valve guide pipe.

④ Apply lubricating oil to the lips of valve stem sealing sleeve.

⑤ Use valve stem sealing sleeve assembling tool and rubber hammer to install the valve stem sealing sleeve.

4.3 Engine Block Group

4.3.1 Flywheel cover

4.3.1.1 Parts

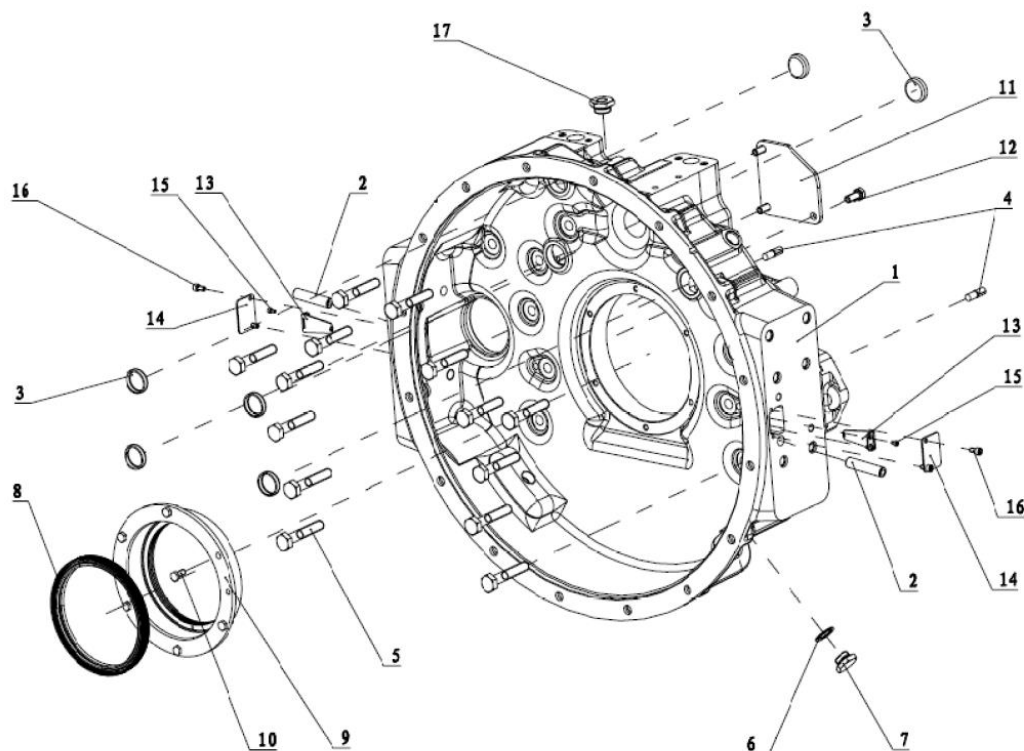


Figure 4-12 Disassembling diagram of flywheel cover

Table 4-4 List of flywheel cover

序号 Pos	图号Teile.number	规格标准DIN/Fremdfabr.nr.	中文名称Designation	英文名称Designation	件数Quan.
1	X6253.005-1		飞轮壳	FLYWHEEL HOUSING	1
2	X6253.005-2		导管	PIPE	2
3	77701580P		碗形塞	BOWL PLUG	6
4	90019230003	10×35-TF2GB/T13829.7	槽销	GROOVED PIN	2
5	90011350110	Q150B1480TF2	六角头螺栓	HEXAGON HEAD BOLT	14
6	77707630Q		垫圈	WASHER	1
7	14011250V		六角头螺塞	HEXAGON BOLT	1
8	13505601B		后油封	REAR OIL SEAL	1
9	15010850R		后油封座	REAR OIL SEAL SEAT	1
10	90011270109	M8×20GB/T5783-10.9-H.Y	六角头螺栓 全螺纹	HEXAGON HEAD BOLT, FULL	6
11	13601570Q		盖板	COVER BOARD	1
12	90011350084	Q150B1025TF2	六角头螺栓	HEXAGON HEAD BOLT	3
13	X6253.006		调整指针	ADJUSTMENT POINTER	2
14	X6253.008		指针板	POINTER PLATE	2
15	90013050051	M4×8GB/T70.1-A2-70	内六角圆柱头螺钉	Hexagon socket cylindrical head screw	4
16	90013050058	M6×12GB/T70.1-A2-70	内六角圆柱头螺钉	Hexagon socket cylindrical head screw	4
17	X6231.150W	11-S32.0-GB/T905	传感器座	SENSOR	1

4.3.1.2 Disassembling

It's in reverse to the installation sequence

4.3.1.3 Dismantle

It's in reverse to the installation sequence

4.3.1.4 Checking

Check for completeness of parts against the table of parts. Check the statuses of rear end plate, flywheel cover, and cylinder block and ensure that all junction surfaces are free of burrs, oil dirt, and knocking damages.

4.3.1.5 Assembling

- 1) Fix the cover plate to the flywheel cover by three M10×35 hexagon head bolts.
- 2) Fix two adjustment pointers to the flywheel cover by M4×8 hexagon socket cylindrical head screws.
- 3) Fix two pointer plates to the flywheel cover by M6×12 hexagon socket cylindrical head screws.
- 4) Attach washers to hexagon head screws and install these screws to flywheel cover.
- 5) Apply clean oil to the rear oil seal and use the oil seal press-in tooling to press it into the rear oil seal seat.

4.3.1.6 Installation

- 1) Deoil the junction surface between cylinder block and flywheel housing and wipe them clean. Then apply the Kingbond sealant 596 to the junction surface of rear end plate.
- 2) Install the guide bar and knock in the slotted pin into cylinder block. Install the flywheel housing onto the cylinder block and tighten by 14 M14×80 hexagon head bolts.
- 3) Apply sealant 596 onto the oil seal seat, install the oil seal seat onto the flywheel housing, and tighten by 6 hexagon head bolts.

4.3.1.7 Tightening torque specification

Table 4-5 Tightening torque specification

Bolt size	Tightening torque /N.m
M4	2.7

M6	9.5
M8	32
M10	64
M12	110
M14	180

4.3.1.8 Special tools

Oil seal pressing tooling, oil seal alignment tooling, copper hammer, flywheel housing guide bar, and flywheel housing hoist.

4.3.2 Cylinder block

4.3.2.1 Parts

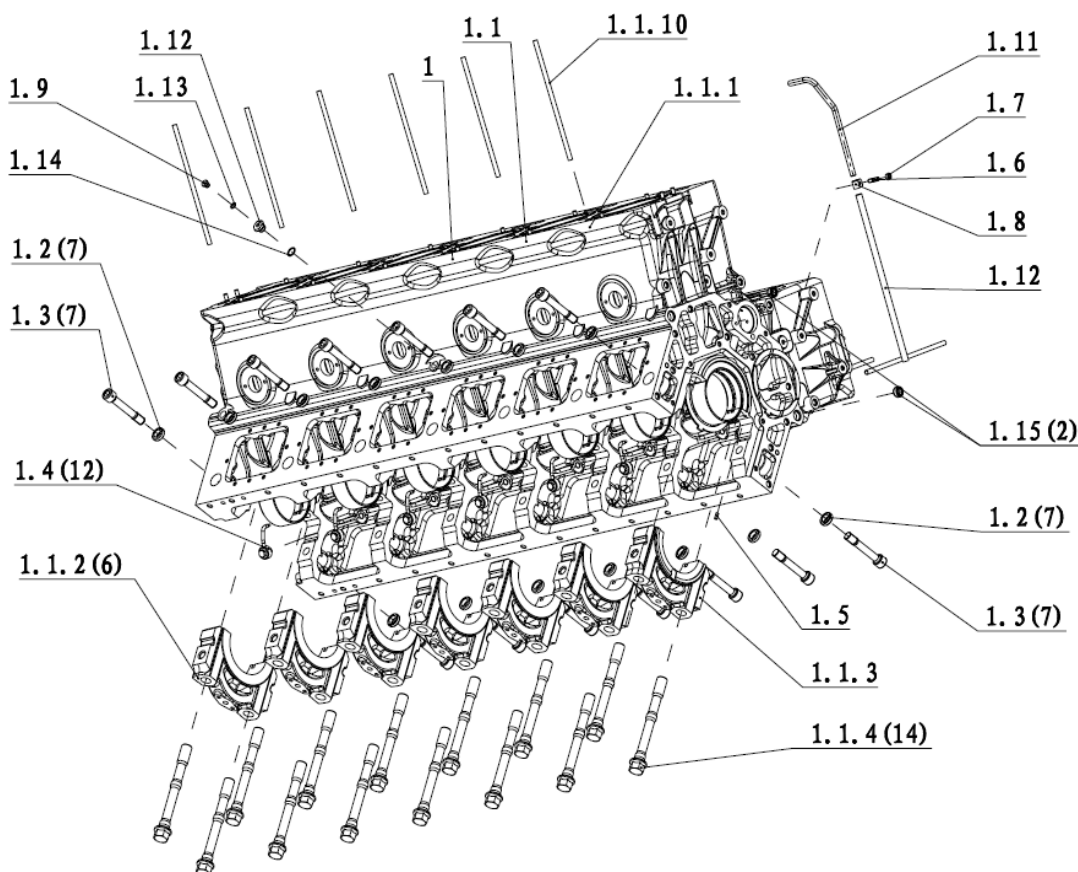


Figure 4-13 Diagram of cylinder block parts

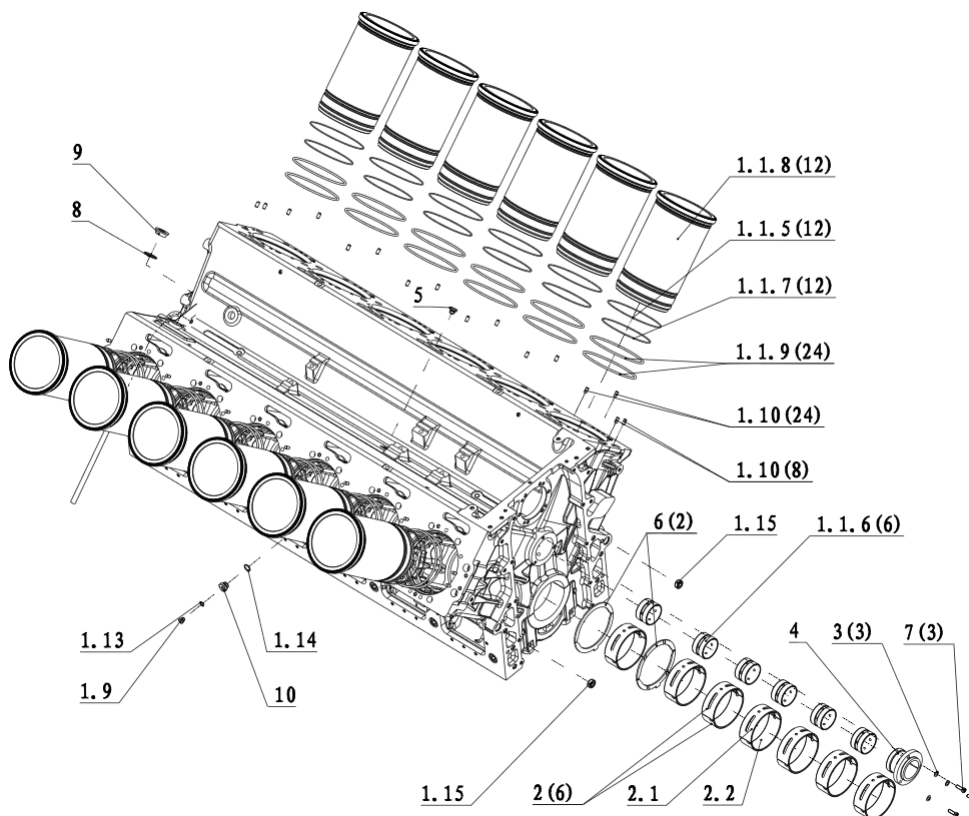


Figure 4-14 Diagram of cylinder block parts

Table 4-6 List of cylinder block parts

机体结合组 ENGINE BLOCK GROUP					
序号 Pos	图号Teile.number	规格标准DIN/Fremdfabr. nr.	中文名称Designation	英文名称Designation	件数Quan.
1	330201000009		机体分总成	ENGINE BLOCK ASSEMBLY	1
1.1	330201000010		机体组件	CYLINDER BLOCK ASSEMBLY	1
1.1.1	X6231.165W		气缸体	CYLINDER BLOCK	1
1.1.2	13607870H		主轴承盖	MAIN BEARING CAP	6
1.1.3	13607860C		止推主轴承盖	THRUST BEARING CAP	1
1.1.4	15011770R		主轴承螺栓	MAIN BEARING BOLT	14
1.1.5	330201000034		O型密封圈	O-RING	12
1.1.6	13501210D		凸轮轴衬套	CAMSHAFT BEARING	6
1.1.7	330201000035		O型密封圈	O-RING	12
1.1.8	X6260.114		气缸套	CYLINDER LINDER	12
1.1.9	330201000036		O型密封圈	O-RING	24
1.1.10	13601300X	HAL77-2-Y2-Φ10×1-GB/T8890	润滑油回油管	OIL RETURN PIPE	12
1.2	13607900W		垫圈	WASHER	14
1.3	13607910G		主轴承盖辅助螺栓	MAIN BEARING CAP AUXILIARY SCREW	14
1.4	330201000191		活塞冷却喷嘴总成	PISTON COOLING NOZZLE ASSEMBLY	12
1.5	90015050030		定位销	LOCATING PIN	1
1.6	77771030D		双头螺栓	DOUBLE END STUDS	1
1.7	90003871248	Q340B08T13F2	六角螺母	HEXAGON NUT	1
1.8	12410430Y		卡箍	CLAMP	1
1.9	13502940J		六角头螺塞	HEXAGON HEAD PLUG	2
1.10	90015210006	Q5220816	圆柱销	PARALLEL PIN	32
1.11	15010681H	冷20-12×1.0-GB/T8162	润滑油回油管	OIL RETURN PIPE	1

1.12	74400238Z		橡胶管	RUBBER PIPE	1
1.13	77707510K		垫圈	WASHER	2
1.14	90003098020		密封垫圈	SEALING GASKET	2
1.15	612600040269		碗型塞	SCREW PLUG	4
2	13579960B		轴瓦	MAIN BEARING SHELL	7
2.1	13607890K		主轴承上瓦	MAIN BEARING UPPER	1
2.2	13607880Z		主轴承下瓦	MAIN BEARING LOWER	1
3	77721010J		垫圈	WASHER	3
4	330201000154	QSn6.5-0.4-GB/T5231	凸轮轴止推轴承	CAMSHAFT SLEEVE	1
5	1440234D		六角头螺塞	HEXAGON HEAD PLUG	1
6	13607820J		止推片	THRUST PLATE	2
7	330201000271		内六角圆柱头螺钉	HEXAGON SOCKET HEAD CAP	3
8	11140200N		垫圈	WASHER	1
9	11128190J		螺塞	SCREW PLUG	1
10	77733040K		空心螺塞	SCREW PLUG	2

4.3.2.2 Dismantle

It's in reverse to the installation sequence of diesel engine.

4.3.2.3 Checking

1) Check all machined surfaces of cylinder block. All machined surfaces shall be free of burrs, oil dirt, and knocking damage.

2) Check all water lines and oil lines of cylinder block. All water lines and oil lines shall be free of burrs, chippings, and flashes.

3) The tappet holes shall be free of burrs, with qualified chamfers.

4) Check the chamfers of cylinder sleeve bore openings. There shall be free of sharp edges and knocking damage.

4.3.2.4 Assembling

Main bearing bolt and main bearing cover auxiliary bolt:

1) Before assembling the main bearing bolts and auxiliary bolts, apply lubricating oil to the threads and carrying surfaces. Tighten the main bearing bolts in sequence of B4-A4-B2-A2-B6-A6-B3-A3-B5-A5-B1-A1-B7-A7. Tighten the auxiliary bolts of main bearing cap in sequence of 4-2-6-3-5-1-7.

2) Pre-tighten the main bearing bolts in sequence to 80N.m.

3) Pre-tighten the auxiliary bolts of main bearing cap on the side A in sequence to 80N.m.

4) Pre-tighten the auxiliary bolts of main bearing cap on the side B in sequence to 80N.m.

5) Tighten the main bearing bolts alternatively and uniformly in sequence by two steps.

Manual tightening: 200N.m for first step and (575±50) N.m for second step.

Automatic tightening: 200N.m for first step and (575±25) N.m for second step.

6) Pre-tighten the auxiliary bolts of main bearing cap uniformly on the side A in sequence to (270±20) N.m.

7) Pre-tighten the auxiliary bolts of main bearing cap uniformly on the side B in sequence to (270±20) N.m.

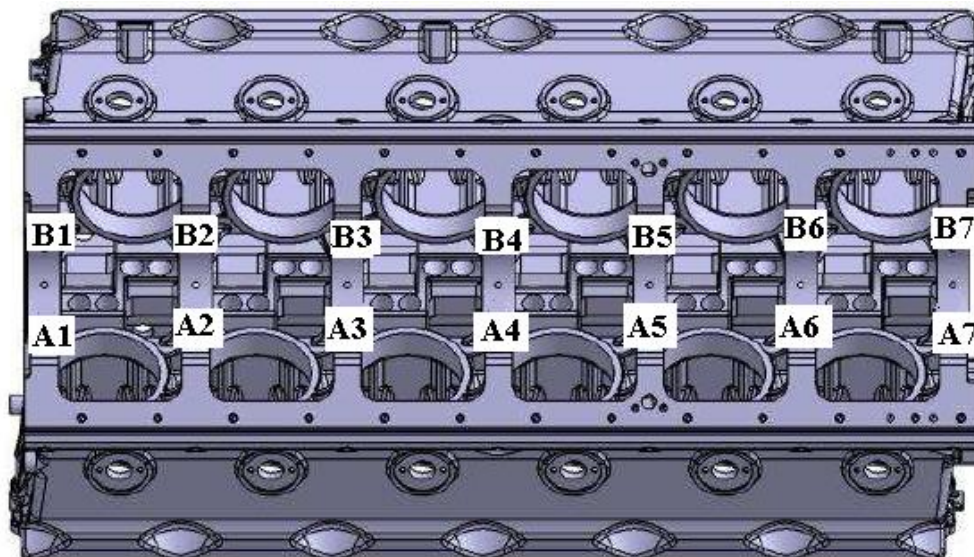


Figure 4-15 Tightening Sequence of Main Bearing Bolts

4.3.3 Oil sump and piston cooling nozzle parts

Structure of parts

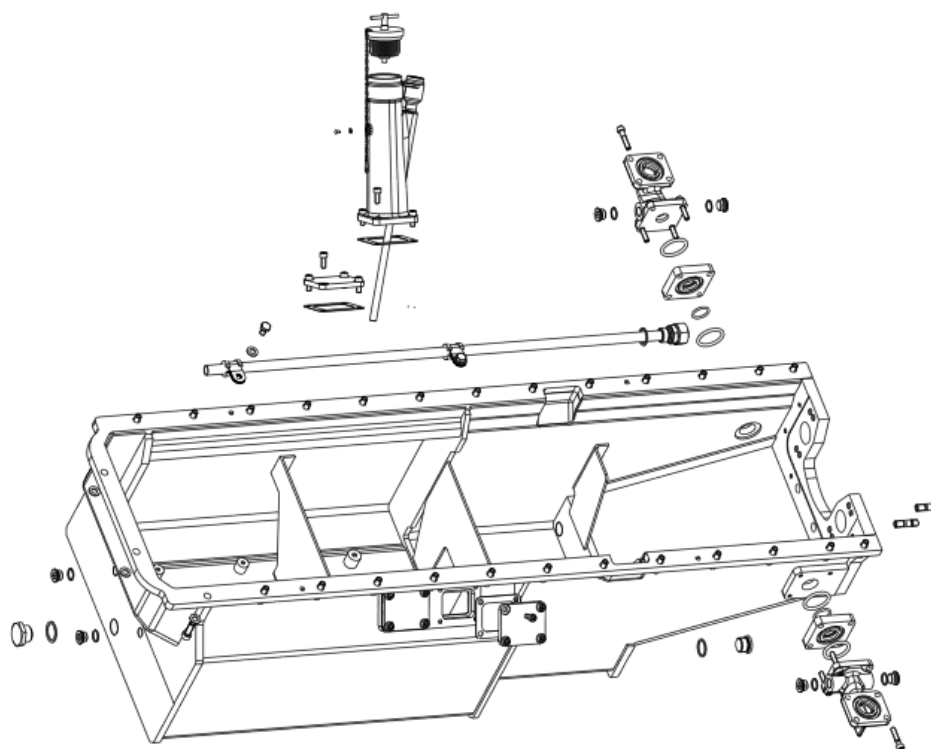


Figure 4-16 Diagram of oil sump parts

Table 4-9 Diagram of oil sump parts list

SN.	Name	SN.	Name
1	Oil sump	9	Washer
2	Oil dipstick tube	10	Hexagon head screw plug
3	Pipe connector	11	Magnetic hexagon head screw plug
4	Washer	12	Washer
5	Hexagon socket cylindrical head screw	13	Hexagon head screw plug
6	Hexagon socket cylindrical head screw	14	Washer
7	Hexagon head screw plug	15	Rubber O-ring
8	Fuel inlet elbow	16	Cover plate

4.3.3.1 Disassembling

I. Disassembling of oil sump

- 1) Prior to dismantling of the oil sump, empty the oil. Place the container containing oil

beneath the oil drainage plug of the oil sump, and use a screw plug wrench to loosen the oil drainage plug to empty oil.

2) Disassemble the oil dipstick assembly. Notice not to damage the oil dipstick during disassembling.

3) Disassemble the bolts of the junction surface between oil sump and cylinder block by a wrench and then separate the cylinder block from oil sump by equipment such as overhead traveling crane (Notice to remove the silicone sealant at all times during separation and do not hoist the cylinder block too high).

4) After the separation of oil sump, check the levelness and check for damage.

II. Disassembling of piston cooling nozzle

Loosen the hollow bolts of piston cooling nozzle and take out the piston cooling nozzle.

4.3.3.2 Installation

I. Installation of oil sump

1) Clean the oil sump and ensure that the inside of oil sump is clean without foreign material or dust.

2) Install all screw plugs on the external surface of oil sump and all internal devices (such as strainer). During the installation, tighten strictly as per the specified tightening torques to ensure the normal operations after installation.

3) Apply silicone sealant to the gaps of junction surfaces among front end cap, cylinder block, and oil sump. The silicone sealant shall be applied uniformly without any interruption.

4) Install the oil sump assembly onto the cylinder block by hexagon socket head bolts (Before installation, check the inside of cylinder block for presence of foreign material, turn the crankshaft for 360° along the rotation direction of flywheel, and check the crankshaft crank arm and oil pump gears for presence of interference with the oil sump. If present, handle accordingly. Tighten the fastening bolts of oil sump to (60~66) N.m in a symmetric manner.)

5) Space with seal ring and screw the magnetic plug assembly (Wipe clean the magnetic plug assembly before installation).

II. Installation of piston cooling nozzle

Insert the locating pin of piston cooling nozzle into pin hole and tighten the hollow bolt.

Tightening torque is 40N.m.

4.3.3.3 Torque specification

Tightening torque for hexagon socket cylindrical head screws: 60~66N.m

Tightening torque for hollow bolts of piston cooling nozzle: 40N.m

4.4 Crank Connecting Rod Mechanism

4.4.1 Crankshaft and flywheel subassembly

4.4.1.1 Parts

The crankshaft and flywheel subassembly is mainly composed of crankshaft, flywheel, timing gear, crankshaft pulley, and shock absorber which is mainly functioned to convert the reciprocating motion of piston to rotating motion to output torque, drive the accessories (including valve timing mechanism and water pump), and store energy and overcome rotating resistance for uniform running of crankshaft system. The flywheel ring gear installed on the outer ring of flywheel engages with the gear of starter motor to start the diesel engine.

4.4.1.2 Disassembling

1) The thermal assembling apparatus is required for the assembling between crankshaft gear and crankshaft and between flywheel and flywheel ring gear, with thermal assembling temperature requirement. Therefore, do not disassemble these parts, except the special cases. The crankshaft and the counterweight are of split type. Never disassemble the counterweight, except the special cases.

2) Check the journals and oil-ways. The main journal and the connecting rod journal shall be free of damages. Check and ensure there is no cracking, deformation, or discoloration around the oil orifices of the bushing.

3) All parts dismantled should be put by category as required.

4.4.1.3 Assembling

1) Keep the oil-ways clean, without blockage of oil dirt or chipping. Wipe clean the main journal and connecting rod journal, guard the bushings against the scratch by impurities, and notice to check the status of bushings. Assemble the main bushings and connecting bushings as per the cylinder numbers, without any error.

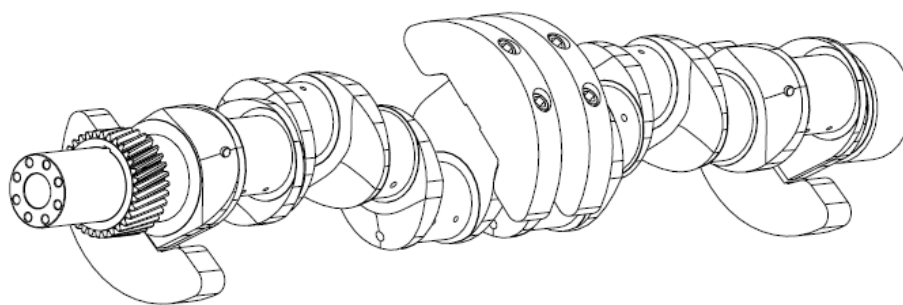


Figure 4-17 Crankshaft assembly

2) Check the junction surface between crankshaft and flywheel and ensure that the junction surface is free of burr, oil dirt, and damage.

3) Knock the locating pin into the front pinhole of crankshaft to the end and tighten the flywheel bolts as per the following requirements.

12M26: 300N.m for first step and (700 ± 35) N.m for second step.

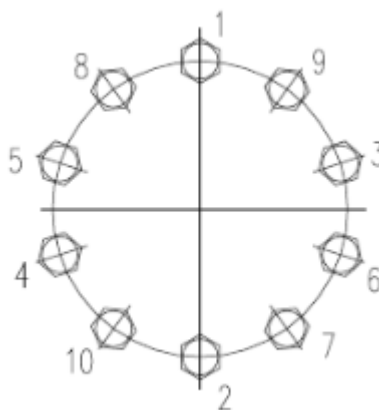


Figure 4-18 Tightening sequence

4) Face outward the beveled end of flywheel ring gear.

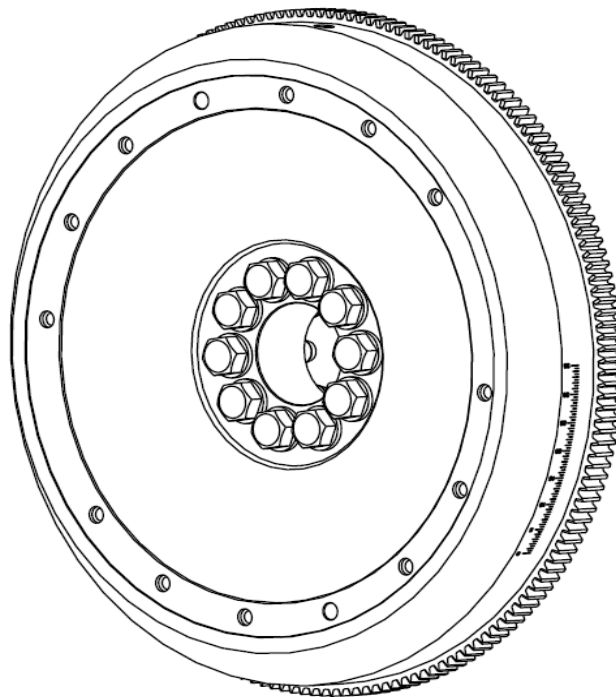


Figure 4-19 Flywheel assembly

5) Rotate for several turns, check the axial clearance, and ensure the flexible rotation of crankshaft without obstruction. Ensure that the axial clearance of the crankshaft is 0.1~0.346.

6) Check the junction surface between crankshaft pulley and crankshaft. The junction surface shall be free of burr, oil dirt, and damage. Pass 6 M14×75 and 2 M14×65 hexagon flange bolts through the turning flange and crankshaft pulley and tighten these bolts onto the crankshaft in diagonal manner.

Tightening torque for fastening bolts of crankshaft pulley: 220N.m.

7) Install the shock absorber onto the crankshaft pulley by 6 M12×30 hexagon flange bolts and tighten the shock absorber bolts in diagonal manner in turn after coming into contact with the shock absorber.

Required tightening torque for shock absorber bolts: 140N.m.

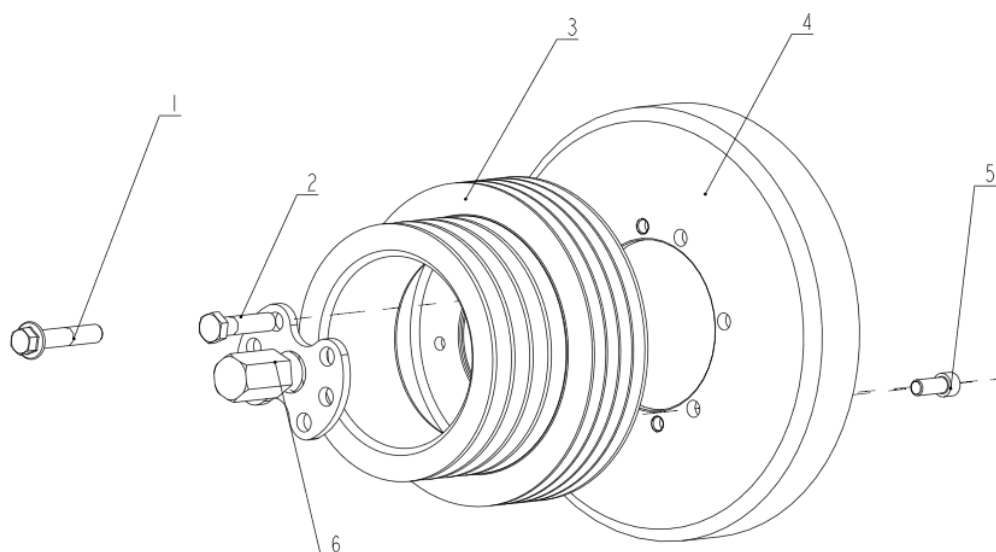


Figure 4-20 Crankshaft and pulley subassembly

1. M16×75 Hexagon head bolts with flange 2. M14×65 Hexagon head bolts with flange 3. Crankshaft pulley 4. Shock absorber 5. M12×30 Hexagon head bolts with flange 6. Turning device

4.4.2 Piston and connecting rod

4.4.2.1 Parts

The piston and connecting rod subassembly is functioned to convert the reciprocating motion of piston to rotating motion of crankshaft and at the same time convert the force applied onto the piston to the output torque of crankshaft. The main parts include piston, connecting rod body, piston rings, piston pin, connecting rod bolts, connecting rod cap, connecting rod bearing shell, and retainer rings.

4.4.2.2 Breakdown

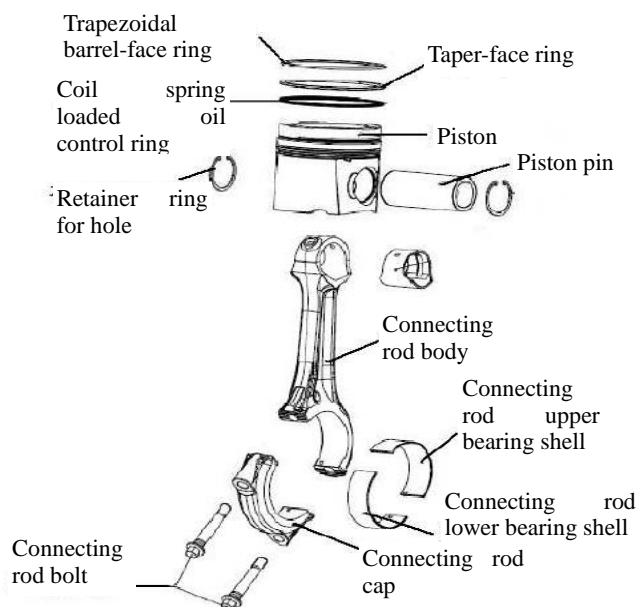


Figure 4-21 Breakdown diagram of piston and connecting rod

4.4.2.3 Disassembling

1) Disassembling of piston and connecting rod subassembly

Carefully remove the carbon deposit from the cylinder top and do not damage the inside of cylinder. Turn to place the piston at bottom dead center and disassemble the connecting rod bolts and connecting rod bearing pressure cap. Then, turn to the top dead center and knock out the piston by the wooden hammer. Operate carefully to prevent the large end of connecting rod from blocking the cylinder block. Arrange the bearing shell and connecting rod caps as per original sequence.

2) Disassemble the retainer ring for hole, the piston pin, and connecting rod body.

Use a pair of internal circlip pliers to dismantle the circlips on both sides of the piston carefully, and push out the piston pin to remove the connecting rod body. Assign numbers to the piston pin and connecting rod body, and put them in numerical sequence.

3) Disassembling of piston rings

Use a pair of piston ring pliers to dismantle the 1st & 2nd gas rings and oil ring respectively, and mark them.

4.4.2.4 Checking

1) Check and ensure that the large and small ends of connecting rod are free of burrs and knocking damage and check and ensure that there is no cracking, deformation, and discoloration

around the oil orifices of small end bearing shell.

2) Mark one end of the connecting rod bolt with the cylinder number, and the end of the piston toward the flywheel with the cylinder number.

3) Inspect whether the piston surface and inner cavity, piston ring, and piston pin surfaces are free from burr, oil stains and collision.

4) For one same engine, the weight group marking "G" shall be consistent for both pistons and connecting rods.

5) The fitting numbers must be consistent for the connecting rod body and connecting rod cap.

4.4.2.5 Assembling

1) Use a pair of internal circlip pliers to install one circlip onto the piston circlip groove, and turn the circlip to have it inserted completely. The rough side of the circlip should be inward.

2) Insert the piston pin into piston pin hole. After the piston pin is protruded from the piston, insert the small end of connecting rod into piston, and then insert the piston pin through small end of connecting rod. Notice: The punching marking at large end of connecting rod shall be opposite to the dimensional marking of the piston head.

3) Install the retainer ring for hole on the other side and rotate the retainer ring to ensure complete installation. The rough side of the circlip should be inward.

4) Put the assembled parts of the piston connecting rod aside in sequence of the cylinder numbers, and use a pair of piston ring pliers to mount the oil ring, taper-face ring and trapezoidal barrel-face ring into the piston ring groove in sequence. The "TOP" end of the piston ring should be upward, and the ring should be turned flexibly in the ring groove.

5) Adjust direction of opening end of rings: the first ring is installed in such a manner that its opening end is deflected from the centerline of the piston pin by 30°, and the second ring is installed in such a manner that its opening end is staggered from the opening end of the first ring by 120°, and the oil ring is installed in such a manner that its opening end is staggered from the opening end of the first ring and the second ring by 120°, respectively, and is at position where the perpendicular bisector of the piston pin centerline is placed. As shown in the figure below.

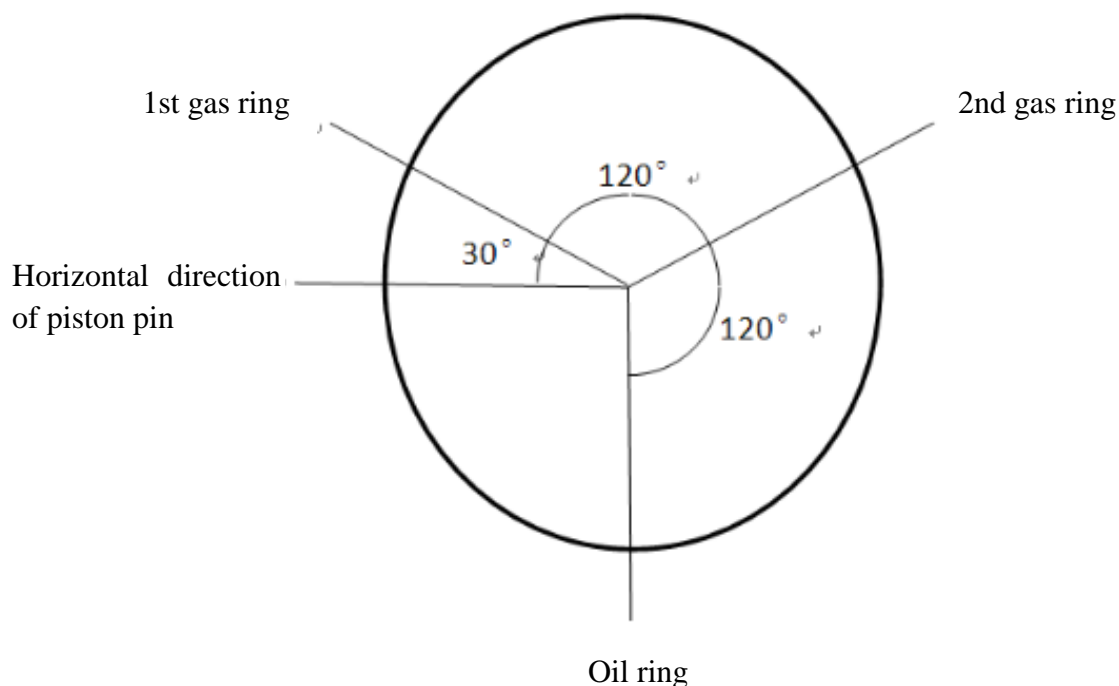


Figure 4-22 Opening direction of piston ring

- 6) Ensure that the piston rings are installed parallelly in the ring grooves, without any distortion.
- 7) Check and ensure the consistent fitting numbers for the connecting rod body and connecting rod cap and then install the upper connecting rod bearing shell.
- 8) The bearing shell shall be free of damage. If necessary, replace with new one.

4.4.2.6 Installation

Hoist the cylinder block and place it on the overturning device, ensure to face upward the observation hole of cylinder block, and prevent the collision of cylinder block. Stamp the cylinder number on the connecting rod bolt hole side and stamp the cylinder number on cylinder end facing side of the piston head. For one same engine, the weight group marking “G” shall be consistent for both pistons and connecting rods. Wipe clean the inner walls of cylinder sleeve, crank arm of crankshaft, and piston and connecting rod subassembly and apply clean oil. Adjust the opening angles of piston rings, apply clean oil to the portions above piston skirt, and attach guide sleeve onto the piston. Turn to the top dead center of each cylinder, place the connecting rod and piston subassembly into tooling, and lower it into the cylinder as per the corresponding cylinder number. Slowly press down the piston and at the same time drag the large end of connecting rod onto the

crank arm. Before assembling, notice to face the oil orifice of piston towards the nozzle. While lowering the connecting rod, prevent collision with nozzle and crank arm. After the assembling, ensure that the opening of connecting rod bolt faces towards the observation hole. The cylinder numbers and fitting numbers shall be consistent and no swap is allowed. Install the connecting rod bearing shells, pre-tighten by connecting rod bolts, tighten the bolts in vertically symmetric manner, and add the paint sealing. Check the opening clearance. The axial clearance of connecting rod: 0.2~0.346 mm. Turn to check the crankshaft for flexible rotation, check the cylinder sleeve for scuffing, check nozzles for collision with pistons, and wipe clean the lubricating oil on the top face of cylinder block.

4.4.2.7 Torque specification

Install the connecting rod bolts and tighten uniformly and alternatively by three steps: 70N.m for first step, 200N.m for second step, and $350\pm 30\text{N}\cdot\text{m}$ for third step. Apply lubricating oil to the threads and carrying surfaces of connecting rod bolts.

4.4.2.8 Special tools

1. Hole retainer ring pliers – For installation of retainer ring for piston pinhole
2. Piston ring installation pliers – For disassembling or installation of piston rings



Figure 4-23 Piston ring installation pliers

3. Guide sleeve – Piston
4. Micrometer – For measurement of outside diameters for pistons and piston pins.

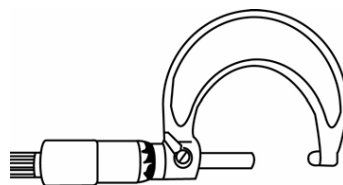


Figure 4-24 Micrometer

5. Feeler gauge – For measurement of piston ring closed gap and the gap at ring groove and shaft connections during assembling.

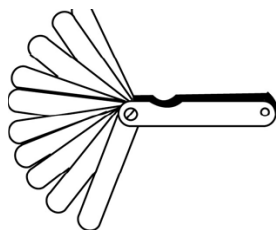


Figure 4-25 Feeler gauge

4.5 Valve mechanism

4.5.1 Rocker arm

4.5.1.1 Rocker overview

The rocker is actually a double armed lever (as shown in the Figure 4-26) and is functioned to change the direction of the force transmitted from the push rod and apply it to the valve stem end to drive the valves. For M26, the end connected with connecting rod is a ball pin and the other face is a circular face. These two ends are functioned to apply the force along the valve axis to the maximum extent.

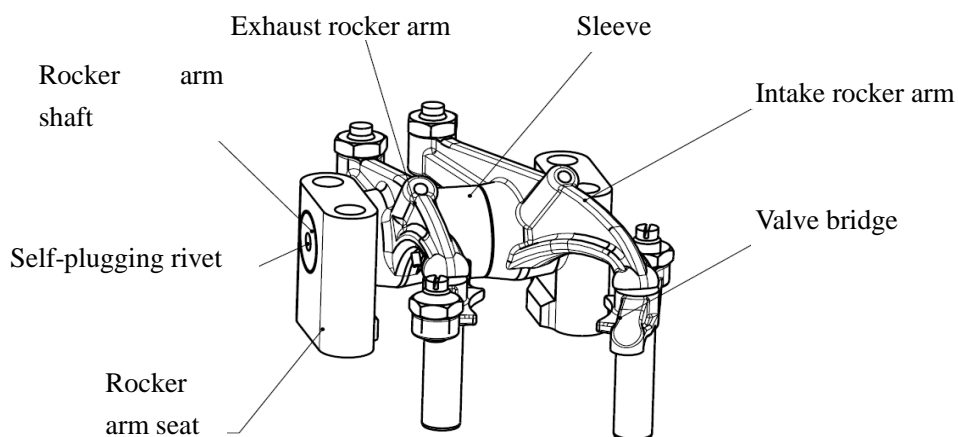


Figure 4-26 Rocker arm assembly

4.5.1.2 Checking before disassembling of rocker

- 1) Check the rocker for deformation, breakage, and serious cracking.
- 2) Turn the crankshaft, and observe whether the rocker arm is turned flexibly.
- 3) Measure clearance of individual valves, and inspect change in clearance of the valves.

4.5.1.3 Disassembling of rocker

Open the rocker cover. After the checking, loosen the screws of rocker seat, lightly take out the rocker, and add the markings to prevent the confusion among the rockers of different cylinders.

4.5.1.4 Checking of rocker

- 1) Clean the rocker arm, observe appearance of the rocker arm, and determine whether there is crack and other defects.
- 2) Observe the bores of rockers for presence of wear and scratch.
- 3) Check the contact surface between rocker and valve bridge and check the ball pin for wear.
- 4) Inspect whether individual oil passages are unobstructed or not.

4.5.1.5 Installation of rocker

- 1) Loosely install the rocker seat to the cylinder head by hexagon bolts, with the bosses of rockshaft seat face-to-face.
- 2) Assemble the self-plugging rivets on two ends of rockshaft.
- 3) Attach intake and exhaust rockers onto rockshaft, attach the sleeve, install to the rockshaft seat, and ensure that the axial clearance of rocker sleeve is 0.4~0.6.
- 4) Tighten the bolts of rockshaft seat to 54N.m.
- 5) Turn to the top dead center of each cylinder and adjust the valve clearance. The intake valve clearance is 0.3mm and the exhaust valve clearance is 0.3mm.

The tooling and auxiliary materials used for the installation of rocker are listed in Table below.

Table 4-10 Table of tooling and auxiliary materials for installation of rocker

Installation procedures	Number/model/specification of tooling	Tooling name	Auxiliary material
d	8	Allen wrench Torque wrench	
e	17x18 200x1.2x8 150 0~5-0.01	Double offset ring spanner Straight screwdriver Feeler gauge Dial indicator Magnetic stand	

4.5.1.6 Checking after installation of rocker

- 1) Turn the crankshaft, and observe whether the rocker arm is turned flexibly.

- 2) Check and adjust the clearances of intake and exhaust valves.
- 3) Check the phase angles for opening of intake valve and closing of exhaust valve for 1st cylinder and record.

Valve timing of M26 diesel engine:

Opening of intake valve: $(34 \pm 5)^\circ$ prior to top dead center.

Closing of intake valve: $(40 \pm 5)^\circ$ after bottom dead center.

Opening of exhaust valve: $(70 \pm 5)^\circ$ prior to bottom dead center.

Closing of exhaust valve: $(34 \pm 5)^\circ$ after top dead center.

4.5.2 Camshaft

4.5.2.1 Overview of camshaft

The M26 camshaft mainly includes the main journal and intake and exhaust cams, as shown in Figure 4-27, and is mainly functioned to open and close the valves as per the preset working sequence and valve timing and ensure the sufficient lift for the valves. The cams are subject to the periodic impact load during the intermittent openings of the valves so that the cams require wear-resistant surfaces and the camshaft requires sufficient toughness and stiffness. The M26 adopts full-support mode to prevent the deformation of camshaft from influencing the valve timing.

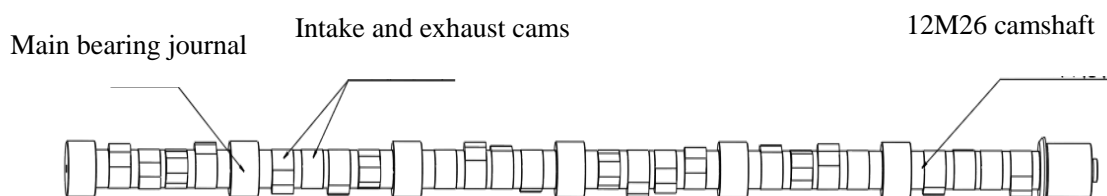


Figure 4-27 12M26 camshaft

4.5.2.2 Checking before disassembling of camshaft

Rotate the camshaft and check the camshaft for flexible motion without obstruction.

Use a dial indicator to inspect whether the camshaft is subject to axial float, as shown in table 4-11.

Table 4-11 Camshaft axial float

Product	Axial clearance	Axial clearance	Difference
M26		0.1~0.25	

4.5.2.3 Disassembling of camshaft

On the working bench for installation and dismantling of the engine, turn the crankshaft to enable the camshaft timing gear to be at the top dead center of the 1st cylinder. Disassemble the camshaft timing gear, camshaft bushing, and camshaft and guard the camshaft against collision.

4.5.2.4 Checking after disassembling of camshaft

- 1) Check the cam surfaces in contact with tappets for presence of wear and check the main journals for presence of seizure and wear.
- 2) Measure the circular run-out of camshaft main journal, as shown in Table 4-12.

Table 4-12 Circular run-out of main journal

Cam	Permissible circular	Measured
2nd main bearing journal	0.06	
3rd main bearing journal	0.08	
4th main bearing journal	0.10	
5th main bearing journal	0.08	
6th main bearing journal	0.06	

4.5.2.5 Installation of camshaft

After dismantling, inspect the camshaft and timing gear. If wear occurs or a big deviation in other parameters is produced, it is required to repair them, or have them replaced with a new camshaft and/ or timing gear.

- 1) Wipe clean the camshaft bore, inspect whether the camshaft bushing is collided, and apply adequate amount of lubricating oil onto it. Apply an appropriate amount of lubricating oil into the camshaft bushing by an oil pot, without any oil flow or drip.
- 2) Install the camshaft, wipe clean the camshaft, check the camshaft for collision damage, connect the camshaft and camshaft guide sleeve together, and apply an appropriate amount of lubricating oil. Carefully insert the camshaft and camshaft guide sleeve into the camshaft bushing.
- 3) Install the camshaft bushing, apply thread sealant 242 to three threads of M8 hexagon socket head screws, attach the washers, and then tighten the screws, with the oil groove of thrust plate facing towards the oil sump (forward direction of engine).
- 4) Rotate the camshaft for several turns. If the camshaft rotates flexibly without obstruction,

measure the axial clearance of camshaft and ensure that the axial clearance is 0.1~0.25mm. Install the camshaft cover plate flange on the flywheel end.

The tooling and auxiliary materials used for the installation of camshaft are listed in Table 4-13.

Table 4-13 Table of tooling and auxiliary materials for installation of camshaft

Installation procedures	Number/model/specification of tooling	Tooling name	Auxiliary material
a			Lubricating oil, towel, brush, and oil pot
b		Camshaft guide sleeve	Lubricating oil, towel, brush, and oil pot
c		Allen wrench 6	Thread sealant 242
d	0~5-0.01	Dial indicator Magnetic stand	

4.5.2.6 Checking after installation of camshaft

1) Check the axial clearance, rotate the camshaft for several turns, and observe for flexible rotation, without any obstruction.

2) If the camshaft rotates flexibly without obstruction, measure the axial clearance of camshaft and ensure that the axial clearance is (0.1~0.25) mm.

4.5.3 Timing gear

4.5.3.1 Gear train diagram

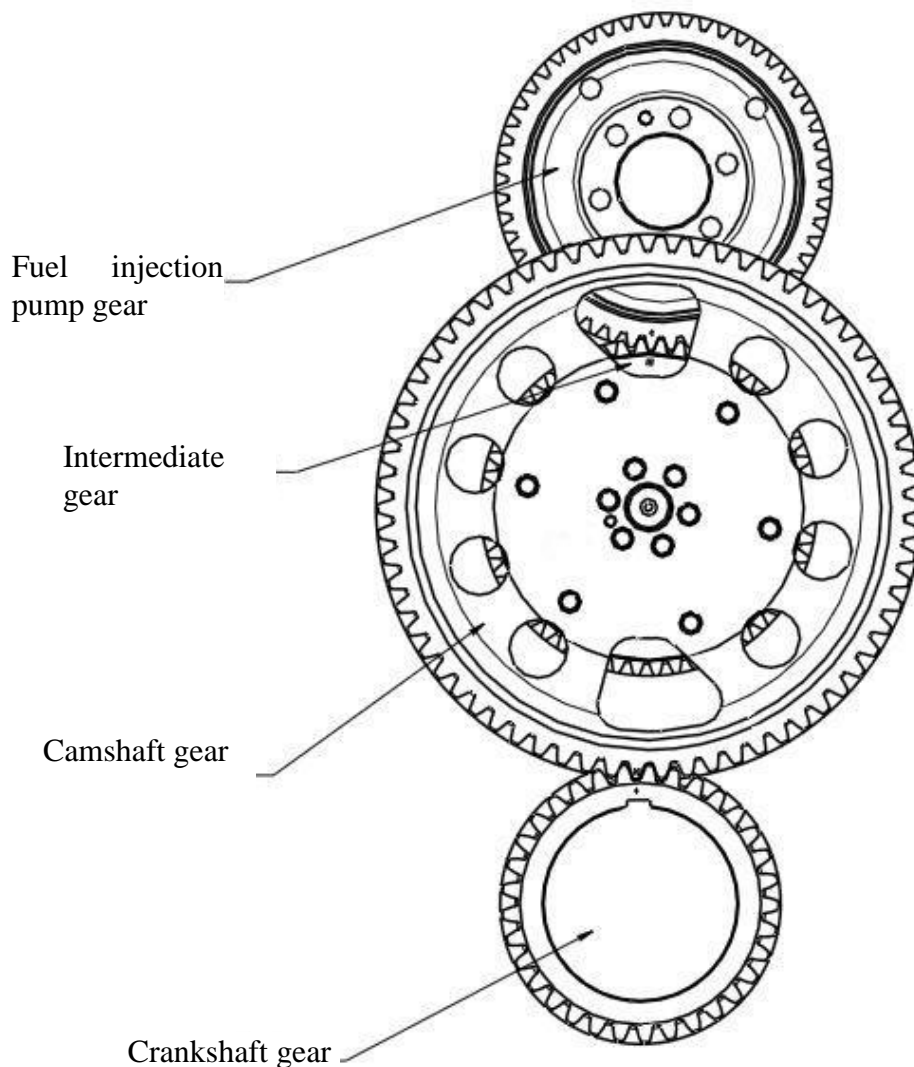


Figure 4-28 Diagram of gear train

4.5.3.2 Disassembling

- 1) Complete the disassembling of front accessories (including water pump and pulley) and the front end cover plate.
- 2) Inspect the mark on the mounting bolt of the camshaft timing gear and confirm whether the bolt turns or not. Disassemble six M10 fastening bolts from the camshaft.
- 3) Disassemble the subassembly of camshaft timing gear and fuel injection intermediate gear

and then disassemble six M10 connecting bolts between camshaft gear and fuel injection pump intermediate gear to separate them.

4) Inspect the mark on the mounting bolt of the injection pump gear and confirm whether the bolt turns or not. Disassemble the 6 hexagon flange bolts on the oil pump gear and thus disassemble the fuel injection pump gear.

4.5.3.3 Checking

1) Check the fastening bolts for good threads and check the bolt shanks for presence of shear trace.

2) All fitting surfaces shall be free of burrs, oil dirt, knocking damage, and non-metal adhesions and all oil-ways shall be free of obstruction, burr, flash, and chipping.

3) The gears shall be free of cracking, broken teeth, and large area of tooth face pitting.

4.5.3.4 Installation

1) Complete the installation of engine oil pump and crankshaft in turn. The engine oil pump gears and the crankshaft timing gears are installed along with the engine oil pump and crankshaft onto the diesel engine.

2) Assemble the camshaft gear and fuel injection pump intermediate gear together by six M10 hexagon flange bolts and align the markings "N" of camshaft gear and fuel injection pump intermediate gear, as shown in the figure:

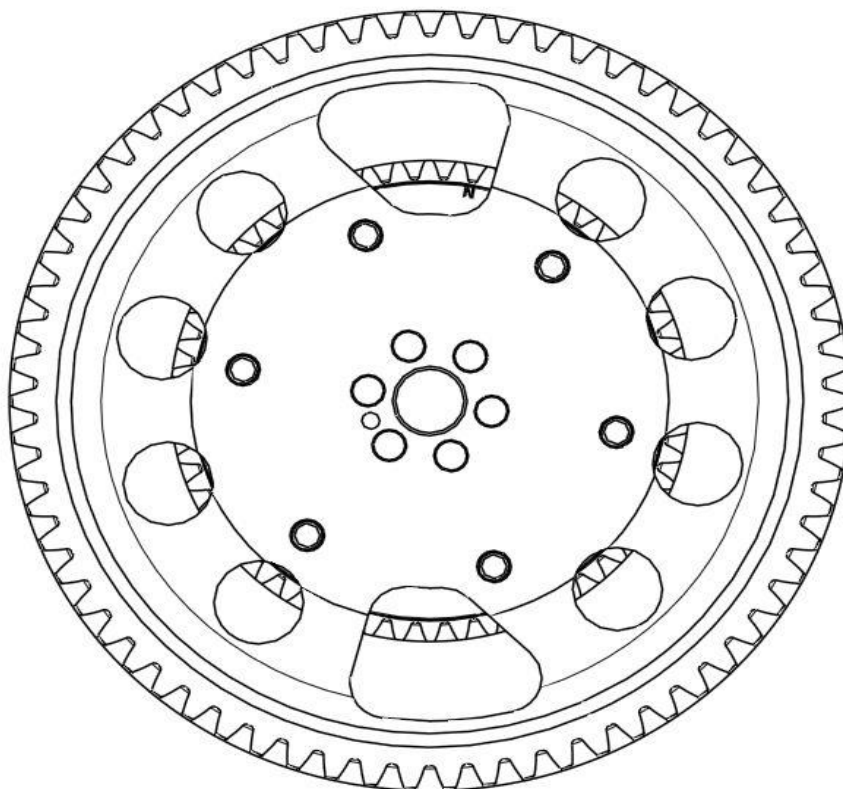


Figure 4-29 Installation of gear

3) Rotate the crankshaft to place the marking “.” of crankshaft gear with respect to the vertical plane, install the camshaft gear subassembly onto the camshaft, and align the marking “N” of camshaft gear with the marking “.” of crankshaft gear, as shown in the figure:

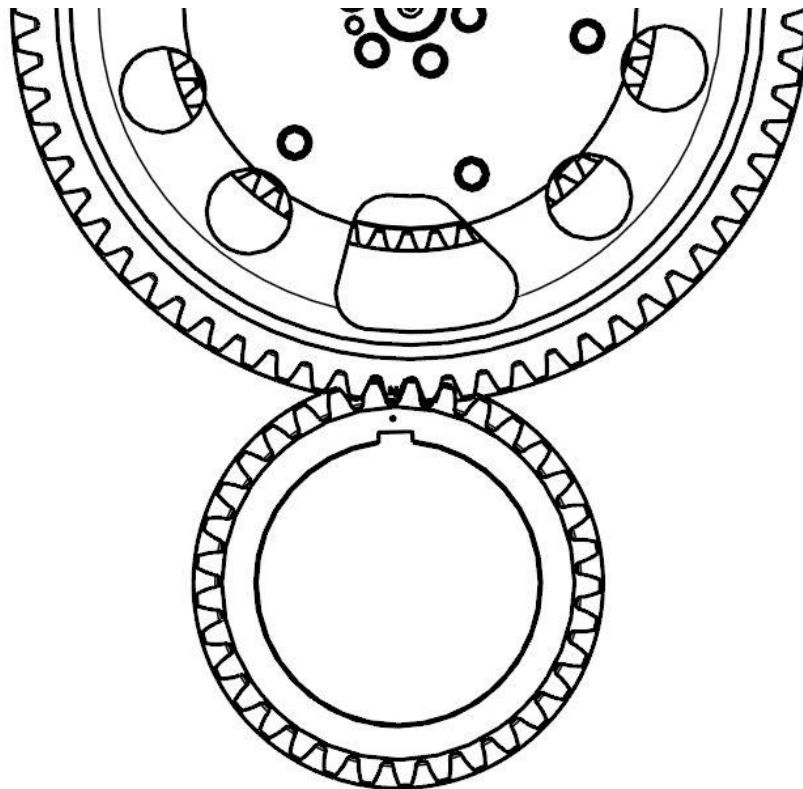


Figure 4-30 Installation of gear

Tighten the camshaft gear and camshaft by six M10 hexagon head bolts. Check the backlash between crankshaft gear and camshaft gear. The backlash range is 0.09~0.15.

4) Place the high pressure fuel pump on the fuel pump bracket above the cylinder block and assemble the drive shaft subassembly together. Connect one end of drive shaft subassembly to the high pressure fuel pump and pass the other end through the flange hole on cylinder block and pre-tighten it onto the cylinder block by hexagon socket bolts through the flange. Turn the engine to the firing top dead center of 1st cylinder, align the marking “N” of fuel injection pump gear with marking “.” of intermediate gear, and rotate the fuel pump gear onto the drive shaft. Adjust the fuel supply advance angle to the required value and tighten the connecting hexagon socket cylindrical head screws of the fuel injection pump gear. Check and ensure that the backlash between intermediate gear and fuel pump gear is 0.08~0.125.

5) The water pump gears are installed along with the water pump assembly onto the front cover plate.

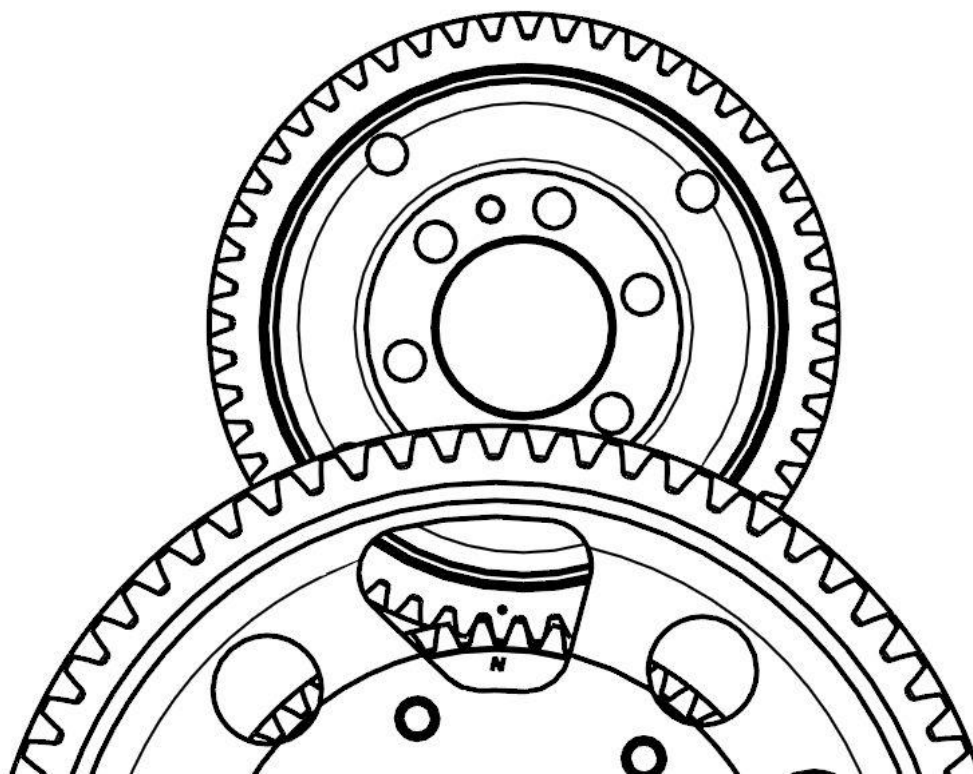


Figure 4-31 Installation of gear

4.5.3.5 Torque specification

Intermediate gear bolts: Apply sealant uniformly to the threads and tighten to (75 ± 5) N.m.

Camshaft gear bolts: Apply sealant uniformly to the threads and tighten to (70 ± 5) N.m.

Fuel injection pump gear bolts: Apply sealant uniformly to the threads and tighten to (65 ± 5) N.m.

4.5.3.6 Special tools

Feeler gauge or lead wire – For measurement of gear backlash.

4.6 Intake and exhaust system

4.6.1 Intake and Exhaust Systems

4.6.1.1 Introduction of intake and exhaust system

1. The air filtered by the air filter is supplied to the turbocharger.
2. The turbocharged air outputted from the turbocharger flows through the inter-cooler.
3. The air outputted from the inter-cooler is supplied to the intake pipe and then to the intake valve.

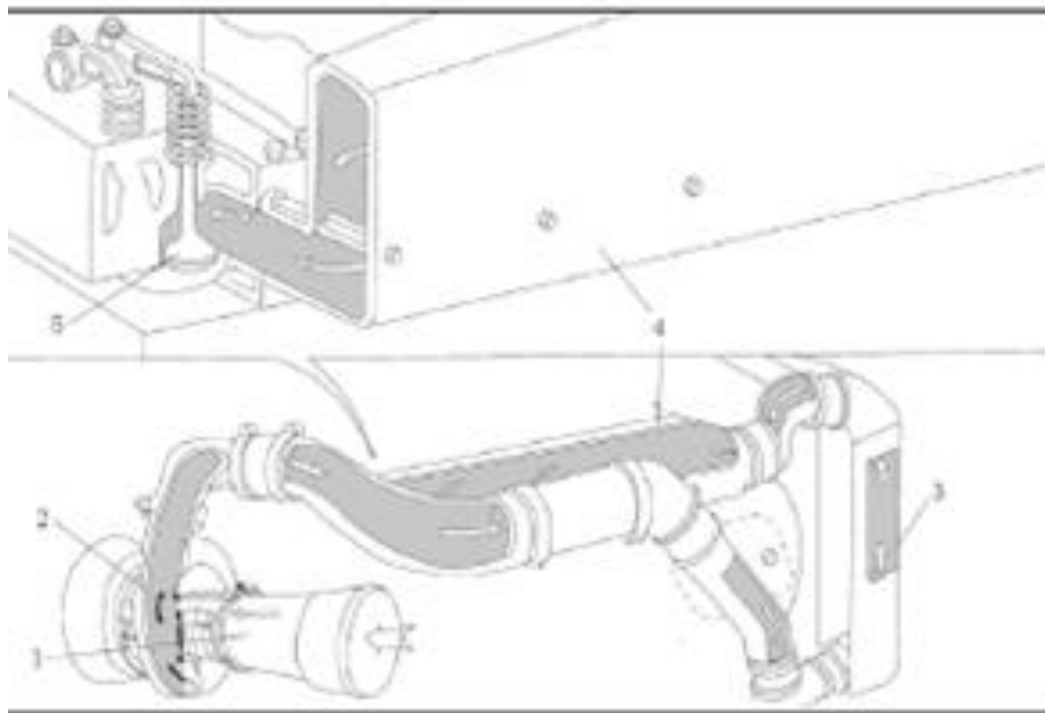


Figure 4-32 Intake diagrammatic sketch

4. The combusted exhaust gas is supplied to the exhaust pipe via exhaust valve.
5. The exhaust gas is supplied to the turbine of turbocharger via exhaust pipe.
6. The exhaust gas is exhausted from the outlet port of turbocharger.

4.6.1.2 Check the air filter element.

The maximum resistance of diesel engine is 7kPa; Check the maximum intake resistance only when the diesel engine is running at rated speed under full load. When the intake resistance reaches the permissible limit, clean or replaces the filter element as per the manufacturer's instructions.

Disassemble the filter element from the air filter and flap lightly the end face to fall off the dust or blow backward (from inside to outside) by compressed air.

- Caution:
- Do not blow through the filter paper
 - Do not clean the filter paper by water or oil
 - Do not clap and knock the filter element forcibly

4.6.1.3 Check the intake system

Check the intake hose for aging, cracking, and loose hoop and when necessary tighten or replace parts to ensure the airtightness of intake system.

4.6.2 Turbocharging system

4.6.2.1 Maintenance

To ensure the reliable and normal running of turbocharger and engine, the maintenance in line with the engine is required for the turbocharger. □

1) Daily maintenance

2) Inspect whether the connecting pipe between the turbocharger and the engine is loosened or not, and if any, eliminate the problem.

3) Inspect whether the turbocharger is subject to air leakage or oil leakage, and if any, it is required to timely eliminate the problem in time.

4) Inspect whether the fastening screws of the turbocharger are loosened or not, and if any, it is required to eliminate the problem in time.

5) Inspect the air filter, and if the air filter is dusted heavily, it required to clean it in time. □

● Periodic maintenance

1) Inspect operation condition of the rotor □

By lightly turning the air compressor impeller with hand, rotation of the impeller by more than 1 turn indicates that it is in normal condition. If the impeller stops immediately, it indicates that the bearing is worn abnormally or collision or jamming between the rotating part and the stationary part occurs, it is required to analyze cause and carry out troubleshooting.

2) Inspection of rotor displacement □

Enable the dial indicator probe to be against the air compressor end, and push and pull the rotator shaft, and measure and record difference indicated on the dial indicator, as shown in Figure 1. The rotor displacement should be within 0.088mm~0.118mm, and in case of exceeding this range, it indicates that the thrust bearing plate or thrust plate and bearing body are worn, and it is required to analyze cause and eliminate the problem.

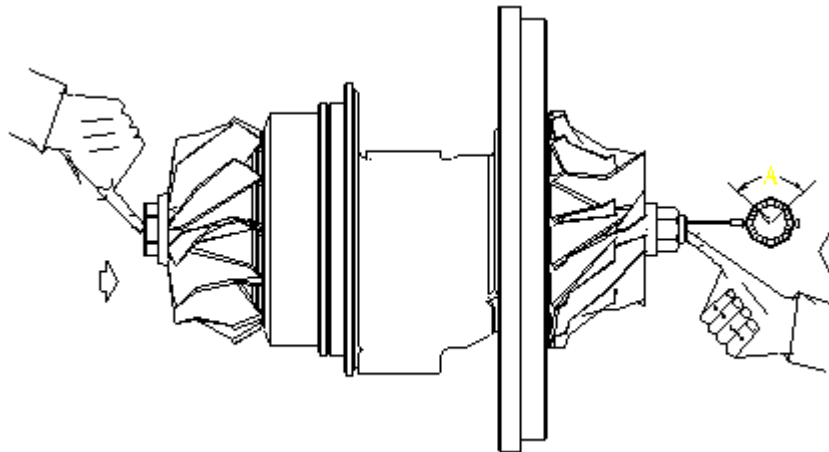


Figure 4-33 Diagram for measurement of axial clearance

3) Inspection of axial clearance of the air compressor impeller

Press the air compressor impeller by hand in axial direction, and use a plug gauge to measure the minimum and maximum clearance between the air compressor impeller and air compressor scroll, shown as following figure: This value should be within 0.4mm~0.8mm, and in case of exceeding this range, it is required to inspect the bearing, and eliminate the problem. □

Note: The measurement should be carried out in cold state of the turbocharger.

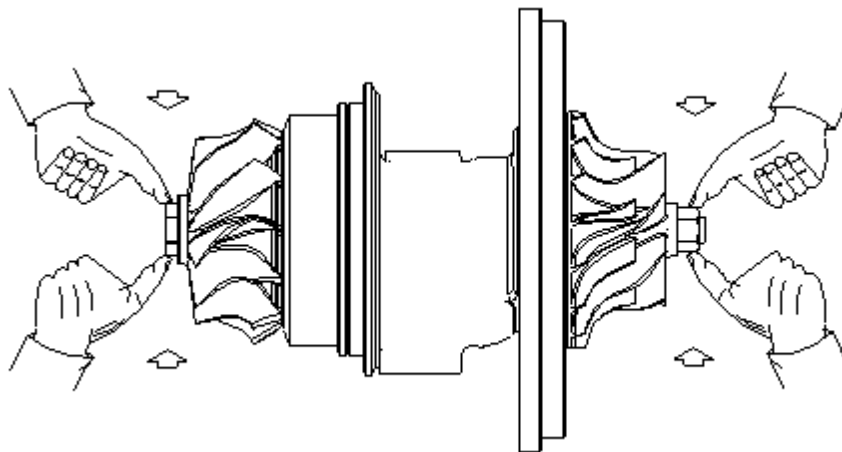


Figure 4-34 Diagram for measurement of radial clearance

● Re-disassembling and re-assembling maintenance of turbocharger □

During the disassembling or assembling of turbocharger, upon detection of non-solvable malfunction or unavailable disassembling or assembling condition, hand over to the production or service department for handling.

1) Disassemble the fastening screws on the compressor volute, shake the compressor volute lightly along the perimeter of impeller, and hammer the volute outward uniformly by a rubber

hammer. It's prohibited to collide the impellor blades with the housing or loosen the shaft end nut.

2) Wipe away the oil dirt from the impellor passage and housing inner chamber by gasoline.

3) While reinstalling the compressor volute, tighten the fastening screws to the specified 15N.m.

4) If the disassembling of shaft system parts is required, please disassemble by professional or contracted supplier.

4.6.2.2 Function and operation descriptions

The turbocharger system increases the intake volume by compressed air. It utilizes the inertia force of the engine exhaust gas to drive the turbine within the turbine chamber. The turbine drives the impellor on the same shaft and the impellor compresses the air supplied from the air filter pipeline and conveys the compressed air into the cylinder so that the pressure and density of the air are increased to consume more fuel and accordingly increase the fuel volume, adjust the engine speed, and improve the engine power output.

To guarantee the normal working of turbocharger, after the installation of turbocharger on the engine, all fastening screws must be tightened. Then, lightly operate the impellor by hand and check it for flexible rotation. Start the operations only after all things are normal.

Operation instructions:

1) The turbocharger must be correctly installed to face the engine oil outlet of the intermediate body downward. Under special cases, the engine oil outlet can be inclined, provided that the inclination angle is no higher than 30°.

2) The lubricating oil of turbocharger can be directly supplied by the engine oil line (or forcibly supplied independently). A fine filter can be installed on the upstream of turbocharger so that the oil is free of impurities in particle size of >15um. To ensure the reliable working of bearings, the lubrication is of great importance.

3) The oil inlet pipe shall be larger than Ø13mm in inside diameter and shall be arranged as close as possible to the outlet of engine oil pump. Generally, it's prohibited to apply sealant to the connection between oil inlet pipe and turbocharger; otherwise the measure shall be taken to prevent the ingress of sealant into turbocharger pipeline. The oil return pipe shall be larger than Ø26mm in inside diameter and shall be fitted with reducing connector to gradually incline to the oil level of

crankcase.

4) The capacity of the diesel engine intake pipe shall be as large as possible, in order to reduce the intake pressure pulsation. The air filter must have appropriate capacity to prevent the excessive inlet pressure loss of the compressor.

5) The sectional area of the exhaust pipeline must be basically consistent with the total sectional area of the cylinder exhaust port. The sectional area of the turbine housing outlet pipeline shall be large, otherwise it will impair the turbocharging effect. All inlet and outlet pipelines must be carefully arranged to prevent the sudden change of sectional area and ensure good airflow performance.

6) During the installation, ensure that there is no foreign material falling into the turbocharger and the engine exhaust pipe system is free of foreign material, otherwise the turbocharger will be damaged. After the installation of turbocharger on the engine, all fastening screws must be tightened. Then, lightly operate the impellor by hand and check it for flexible rotation. Start the operations only after all things are normal.

7) The engine shall be generally fitted with the instruments for measurement of turbine upstream exhaust gas temperature, turbocharged air pressure, lubricating oil temperature, lubricating oil pressure, and turbocharger speed and shall also be fitted with warning devices for high oil temperature and low oil pressure.

8) The engine shall be fitted with air filter and intake muffler.

9) The crankcase ventilator pipe shall not be connected with the inlet of turbocharger. If connected, an effective oil-gas separator shall be fitted on the inlet.

4.6.2.3 Malfunction diagnosis

For the malfunction detection and diagnosis, if the engine is malfunctioned, the turbocharger and the engine will have low power output. In event of such problem, firstly check all engine parts for malfunction. Then, perform the malfunction analysis for the turbocharger depending on different symptoms occurred.

4.6.2.4 General malfunctions and troubleshooting of turbocharger

If the engine performance fluctuates remarkably due to turbocharger cause, replace the entire turbocharger or return it to the manufacturer for repair. The general malfunctions and the

troubleshooting are listed in Table 4-14.

Table 4-14 General malfunctions and troubleshooting of turbocharger

SN.	Symptom	Cause	Troubleshooting
1	Reduced engine power or black exhaust gas	1. Blockage of air filter and reduced intake volume	Clean the air filter.
		2. Excessive oil dirt of compressor impellor and volute inner chamber, reduce compressor efficiency, and reduced turbocharging pressure	Clean the impellor and volute inner walls
		3. Over-high backpressure due to deformation or blockage of turbine downstream exhaust pipe	Take corresponding measure to solve problem
		4. Reduced turbocharging pressure due to air leakage of compressor outlet pipeline or turbine inlet pipeline	Take corresponding measure to solve problem
		5. Wear of floating bearing	Replace
2	Inflexible rotation, slight friction sound, or even no rotation of rotor	1. Damage or seizure of bearing due to insufficient oil supply, oil inlet pipeline blockage, or dirty oil	Clean oil line or replace oil or bearing
		2. Elasticity loss, wear, sintering, or breakage of seal rings	Replace
		3. Excessive accumulation of oil dirt and formation of carbon deposit due to serious leakage at seal rings during operation.	Replace parts and clean
		4. Accumulation of oil dirt and friction with impellor arc due to excessive oil mist ingress of compressor impellor and volute during operation.	Clean the impellor and compressor volute inner chamber
		5. Serious wear of thrust bearing plate	Replace
		6. Ingress of foreign material and collision or wear with rotor and housing	Remove foreign material and clean intake passage
		7. Carbon deposit on turbine back	Clean
		8. Deformation of turbocharger	Check installation location
3	Oil leakage of turbocharger and blue exhaust gas	1. Sealing failure due to serious wear of seal ring and groove	Replace
		2. Wear of shaft bushing or ring groove at turbine shaft Due to wear of floating bearing	Replace
		3. Blockage or deformation of return pipe	Take corresponding measure to solve problem
		4. Low speed oil drainage due to over-long no-load idling time of engine	Reduce the low-speed idling time
4	Abnormal noise or vibration of	1. Bending and deformation of turbocharger rotor shaft or deformation of blades	Replace damaged parts and verify the dynamic balance

	turbocharger	2. Eliminated gap and friction between impeller outer arc and housing Due to damage of bearing	Replace bearing or entire turbocharger
		3. Deteriorated dynamic balance precision due to carbon deposit of rotor	Clean and verify dynamic balance
		4. Partial leakage of pipeline connected with turbocharger	Take corresponding measure to solve problem
5	White exhaust gas	1. Oil flow to blade or turbine side Due to blockage or deformation of oil return pipe	Repair or replace oil pipe.
		2. Excessive wear of seal ring due to excessive wear of bearing	Disassemble and repair turbocharger

4.6.2.5 Main data and technical specification

The main data of J135A series turbocharger are listed in Table 4-15.

Table 4-15 Main specification of J135A series turbocharger

SN.	Name	Parameter	Unit	Remark
1	Turbocharger overall efficiency	0.56~0.60		
2	Compressor impellor diameter	Φ122	mm	
3	Rated speed	75000	r/min	At engine rated power
4	Maximum permissible speed	82500	r/min	
5	Rated compression ratio	3.3		
6	Rated flow	0.74	kg/s	Flow in standard region $P_0=1.00 \times 10^5 P$ $at_0=25^\circ C$
7	Turbine inlet temperature	≤ 700	$^\circ C$	
8	Turbine outlet pressure	≤ 3	kPa	
9	Oil inlet pressure	0.2~0.4	MPa	
10	Minimum permissible oil supply pressure	≥ 0.15	MPa	
11	Temperature at oil inlet	≥ 40	$^\circ C$	
12	Temperature at oil outlet	< 120	$^\circ C$	
13	Overall dimensions	Φ440×350	mm×mm	
14	Mass	42±1	kg	
15	Model of lubricating oil	40CD ⁺		

The fit clearances of J135A series turbocharger are listed in Table 4-16.

Table 4-16 Table of fit clearances of J135A series turbocharger

Name	Clearance	Unit
Front clearance of compressor impellor	0.505~1.075 in axial direction 0.467~0.995 in normal direction	mm
Back clearance of compressor impellor	0.59~0.98	mm
Front clearance of turbine impellor	0.801~1.319 in axial direction 0.538~0.886 in normal direction	mm
Back clearance of turbine impellor	0.74~1.148	mm
Axial run-out of rotor	0.088~0.118	mm
Radial clearance between impellor and compressor housing	0.4~0.8	mm
Radial clearance between turbine impellor and turbine casing	0.5~0.9	mm

4.6.3 Turbocharger

4.6.3.1 Parts

Diagram of turbocharger parts:

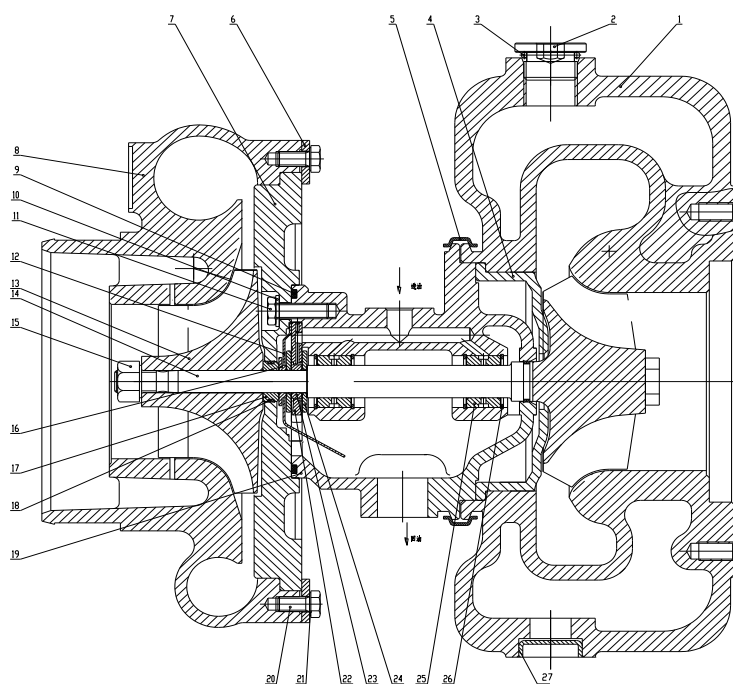


Figure 4-35 Diagram of J135A turbocharger

Table 4-17 List of turbocharger

SN.	Name	SN.	Name	SN.	Name
1	Turbine casing	10	Nut washer	19	Bearing body
2	Screw plug	11	Back plate screw	20	M8 bolt
3	O-ring	12	Oil baffle plate	21	Washer
4	Heat insulating cover	13	Compressor impellor	22	Thrust bearing plate

5	Turbine end clamping band assembly	14	Turbine shaft	23	Spacing sleeve
6	Volute pressure plate	15	Shaft end nut	24	Thrust plate
7	Compressor back plate	16	Oil slinger	25	Floating bearing
8	Compressor volute	17	Shaft sleeve	26	Floating bearing retainer ring
9	Rubber O-ring	18	Seal ring	27	Process plug

4.6.3.2 Checking

(1) Check the turbine rotor and compressor impellor for good contact and check the rotor for normal rotation.

(2) Check the rotor condition.

Axial rotation of rotor: wear limit at 0.09mm

Radial rotation of rotor: wear limit at 0.17mm

4.6.3.3 Disassembling

The installation angle of turbine seat and the installation angles of bearing seat and compressor seat depend on the installation condition of the engine. Add markings before the start of disassembling.

1) Disassemble the compressor seat.

(1) Disassemble the flat hexagon head bolts and compressor side plate.

(2) Disassemble the compressor seat.

Note:

(1) Apply liquid sealant to the compressor surface for installation of bearing seat.

(2) While disassembling the compressor seat, take cautions to prevent damaging the compressor impellor.

2) Disassemble the compressor impellor.

(1) Disassemble the shaft end clamping plate by a socket wrench (10mm) on the turbine end of turbine shaft.

Notice: Notice the loosening direction, as the shaft end nut is of left-hand thread.

(2) Disassemble the compressor impellor.

3) Disassemble the turbine seat.

(1) Loosen the hexagon nut and turbine end metal plate.

(2) Disassemble the turbine seat.

4) Take out the turbine shaft.

(1) Hold the thermal shield lightly by hand and withdraw the turbine shaft.

Notice: If it's difficult to withdraw the turbine shaft, lightly knock the compressor end by a wood hammer.

(2) Take out the thermal shield.

5) Disassemble the sealing plate.

(1) Loosen the T-shaped torque screws by a torque adjustable screwdriver.

(2) While disassembling the sealing plate, notice that the installation surfaces of sealing plate and bearing seat are applied with liquid sealant.

(3) Take out the engine oil slinger from the sealing plate.

6) Disassemble the sliding bearing and thrust bushing.

(1) Loosen the M3 T-shaped torque screws of thrust bearings by a torque adjustable screwdriver.

(2) Knock out the thrust bearing and thrust bushing by a copper bar.

7) Disassemble the floating bearing.

(1) Take out the retainer ring from the bearing seat by a thrust ring pliers.

(2) Take out the floating bearing from the bearing seat.

8) Disassemble the seal ring.

(1) Take out the turbine end seal ring from the turbine shaft.

(2) Take out the compressor end seal ring (small) and the compressor end seal ring (large) from the engine oil slinger.

4.6.3.4 Cleaning

1) Checking before cleaning

Before cleaning, visually observe every part and check for trace of seizure, wear, foreign material, and carbon deposit. Check and judge the problem cause by self, especially at the occurrence of problem.

Table 4-18 Main checking items

Checking point	Checking location
Adhesion of carbon chipping	1) Turbine shaft 1, turbine end seal ring, and turbine rear end face 2) Installation location of thermal shield disc 20 and inside of bearing chamber 15

Lubricating oil status (such as wear, seizure, and discoloration)	<ol style="list-style-type: none"> 1) Turbine shaft 1, journal location, and thrust bearing oil slinger 2 2) Floating bearing 5 and thrust bearing 6 3) Bearing chamber 15 and bearing fixing ring inner walls
Oil leakage status	<ol style="list-style-type: none"> 1) Inner walls of turbine chamber 11 2) Inner walls of turbine chamber 11 and installation location of thermal shield disc 20 3) Turbine shaft 1, turbine end seal ring, and turbine rear end cap 4) Inner walls of compression chamber 7 5) Rear end of compression blade 18

2) Cleaning procedure

Table 4.19 Cleaning procedure

Parts	Tools and cleanser	Procedures
a) Turbine shaft	<p>Tools</p> <ol style="list-style-type: none"> 1) Bucket (500*500) 2) Heat source <p>Steam or gas</p> <ol style="list-style-type: none"> 3) Brush <p>Cleanser</p> <p>Standard carbon chipping detergent</p>	<ol style="list-style-type: none"> 1) Boil the turbocharger in a barrel and do not scrape the carbon chipping by a sharp blade. 2) Immerse it within the detergent, till the carbon chipping and other deposits are softened. 3) Remove the softened deposits by a plastic scrape or a hard brush. 4) Guard the bearing surfaces and seal ring grooves on the turbine shaft against damage. 5) The residual deposits on the turbine shaft due to incomplete cleaning will lead to unbalance of turbine shaft. Ensure the thorough clean and do not use a metal brush.
b) Turbine chamber	<p>Tools</p> <p>The same as above</p> <p>Detergent</p>	<ol style="list-style-type: none"> 1) Boil the turbocharger in a barrel. 2) Immerse it within the detergent, till the carbon chipping and other deposits are softened.
	The same as above	<ol style="list-style-type: none"> 3) Remove the deposits by a plastic scrape or a hard brush.
c) Blade and chamber	<p>Tools</p> <ol style="list-style-type: none"> 1) Bucket (500*800) 2) Brush <p>Detergent</p>	<ol style="list-style-type: none"> 1) Immerse within a barrel, till the deposits are softened. 2) Remove the deposits by a plastic scrape or a hard brush and do not use a metal brush.

d) Others	<ol style="list-style-type: none"> 1) Clean other parts by diesel. 2) Blow the lubricating oil ways by compressed air. 3) Take special cautions not to damage or corrode the parts.
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4.6.3.5 Checking

1) Compressor seat Check the compressor seat for contact trace with compressor impellor, for surface damage, and for indentation or cracking at junction surface. Upon detection of such problem, replace the parts.

2) Turbine seat Check it for the contact trace with turbine rotor and check it for the falloff, thermal deformation, and cracking due to surface oxidizing annealing of castings.

Upon detection of such problem, replace with new parts

3) Compressor impellor

Check for contact trace, fragment, corrosion, and deformation. Upon detection of such problem, replace with new parts

4) Turbine shaft

(1) Check the turbine rotor for contact trace, fragment, thermal discoloration, and deformation.

Check for bending of shaft, for thermal discoloration and abnormal wear at shaft journal, and for surface damage and wear at seal ring grooves. Upon detection of such problem, replace with new parts

(2) Measure the outside diameter of turbine shaft and width of seal ring groove (E). If out of wear limit, replace with new turbine shaft.

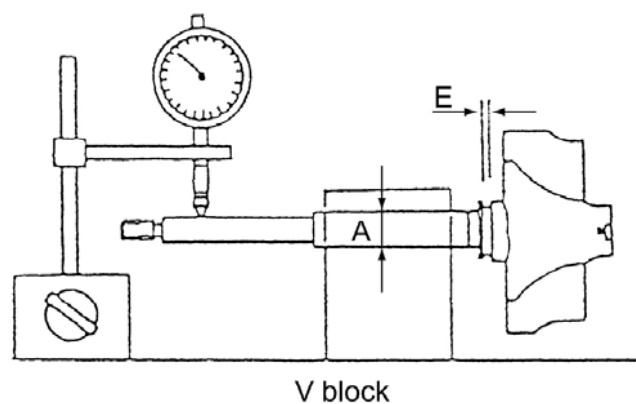


Figure 4-36 Measurement drawing

(3) Measure the wear extent of turbine shaft. If beyond the 0.011mm, replace with new turbine shaft.

5) Thermal shield 20

Check thermal shield for contact trace, thermal deformation, and wear. Upon detection of damage, replace with new parts.

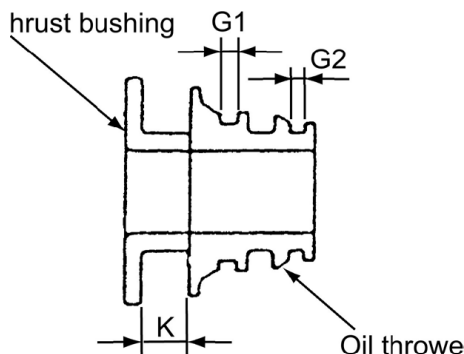


Figure 4-37 Schematic diagram

6) Thrust bearing, engine oil slinger, and thrust bearing

Check every part for wear, surface damage, and discoloration. Upon detection of any above-mentioned damage, replace with new parts, even if they are still within the wear limit.

(1) Thrust bushing

Measure the distance (K) between the groves of thrust bushing.

If out of wear limit, replace with new parts.

(2) Engine oil slinger

Measure the widths (G1) and (G2) of seal ring grooves. If beyond wear limit, replace with new parts.

Wear limit RHF5.....G1:1.31mm, G2:1.11mm RHB51.....G1:1.31mm, G2:1.11mm
 RHB31.....G1:1.04mm, G2:0.84mm

(3) Thrust bearing

Measure the width (J) of thrust bearing. If beyond the wear limit, replace with new parts.

Wear limit RHF5.....3.98mm RHB51.....3.98mm RHB31.....3.58mm

7) Floating bearing

(1) Check the floating bearings for abnormal wear, discoloration, and surface damage. Upon detection of such defect, replace with new parts.

(2) Measure the outside diameter (C) and inside diameter (D). If either is beyond the wear limit, replace with new part.

Wear limit

RHF5.....Outer diameter (D):12.31mm

Inner diameter (C):8.04mm

RHB51.....Outer diameter (D):12.31mm

Inner diameter (C):8.04mm

RHB31.....Outer diameter (D):9.93mm

Inner diameter (C):6.29mm

8) Bearing seat 15

(1) Check the surfaces of bearing seat castings for oxidizing falloff, deterioration, indentation, and cracking. Upon detection of such defect, replace with new parts.

(2) Check the retainer ring 16 for breakage and cracking. Upon detection of such defect, replace with new parts.

(3) Check the locations (B) and (F) in the bearing seat, as shown in the figure below. If the wear exceeds any limit, replace with new parts.

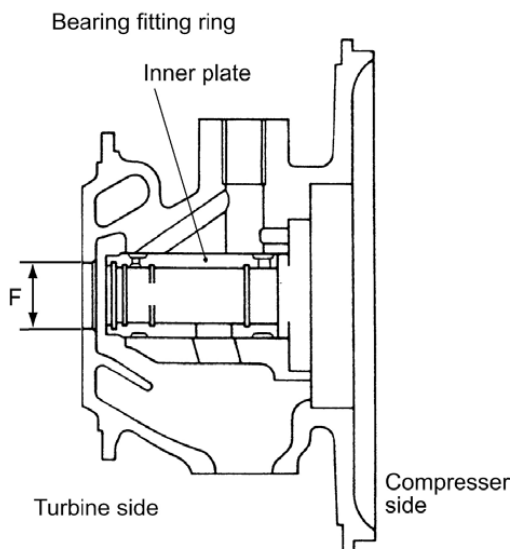


Figure 4-38 Measurement drawing

Wear limit for inside diameter (B) of bearing seat

RHF5.....12.42mm RHB51.....12.42mm RHB31.....10.01mm

Insertion position (F) of seal ring on turbine side

RHF5.....15.05mm RHB51.....15.05mm RHB31.....11.03mm

Compressor end

9) Seal plate 4

(1) Check the contact trace of seal plate and check it for surface defect, indentation, and cracking. Upon detection of such defect, replace with new parts.

(2) Check the installation dimensions (H1 and H2) of seal ring on the compressor side. If beyond wear limit, replace with new seal ring.

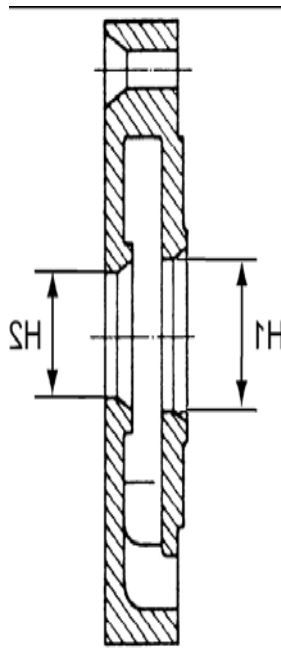


Figure 4-39 Measurement drawing

Wear limit RHF5.....H1:12.45mm, H2:10.05mm RHB51.....H1:12.45mm,
H2:10.05mm RHB31.....H1:10.04mm, H2:8.01mm

10) Seal ring

New seal ring.

11) Check the pressure plate and bolts for deformation. Upon detection of such defect, replace with new parts. Replace with new M3 torque screws.

4.6.3.6 Assembling

1) Before the assembling of turbocharger, prepare the common tools, special tools, liquid gasket sealant, and solid sealant.

2) During the assembling, replace the following parts: One turbine end seal ring

One compressor end seal ring (large)

One compressor end seal ring (small)

Three M3 screws

Four M3 screws

Assembling:

- (1) Install the floating bearing.
 - 1) Install the inner retainer ring into bearing seat by pliers.
 - 2) Install the floating bearing to the bearing seat.
 - 3) Install the outer retainer ring into bearing seat by pliers.

Note:

1) The joint of retainer ring shall follow the location shown in right figure. The round edge of retainer ring shall face towards the bearing.

2) Before assembling, add lubricating oil to the place of floating bearing.

(2) Install the turbine shaft.

- 1) Attach the seal ring onto the turbine shaft.
- 2) Install the thermal shield to the turbine end bearing seat.
- 3) Apply lubricating oil to the turbine shaft journal and install from the turbine end of bearing seat.

Notice: Operate carefully to prevent the turbine shaft from damaging the floating bearing. After the centering of turbine shaft, the joint of seal ring shall be at the oil inlet side.

(3) Install the thrust bearing.

- 1) Attach the thrust bearing onto the turbine shaft.
- 2) Apply lubricating oil to the bearing face of thrust bearing and install the thrust bearing into the bearing seat.
- 3) Apply the sealant to the threads of M3 screws and then fix the thrust bearing to the specified torque by a torque wrench. Tightening torque: $1.3 \pm 0.1 \text{ N} \cdot \text{m}$ ($13 \pm 1 \text{ kgf} \cdot \text{cm}$)

(4) Install the seal plate.

- 1) Attach the seal ring onto the oil slinger 2.
- 2) Install the oil slinger 2 into sealing plate 4.

Notice: The joint of the seal ring shall be installed as per the above figure.

- 3) Apply liquid gasket sealant to the installation face of sealing plate and to the bearing bore of compressor end. Sealant application thickness: 0.1-0.2mm.
- 4) Install the sealing plate 4 to the bearing bore 15.
- 5) Apply the sealant to the threads of screws and fix the sealing plate to the specified torque by a torque wrench. Tightening torque: $1.3 \pm 0.1 \text{ N} \cdot \text{m}$ ($13 \pm 1 \text{ kgf} \cdot \text{cm}$)

(5) Install the compressor impellor

- 1) Attach the compressor impellor 18 to the turbine shaft 1.
- 2) Fix the turbine end of turbine shaft 1 by a 10mm socket and tighten the shaft end nut 19.

Notice: The shaft end is of left-hand thread. Notice the disassembling direction during tightening. Tightening torque: $2.0 \pm 0.2 \text{ N} \cdot \text{m}$ ($20 \pm 2 \text{ kgf} \cdot \text{cm}$)

(6) Install the turbine chamber.

- 1) Align the marking of bearing chamber 15 added during disassembling with the marking of turbine chamber 11 and install.

Notice: For replacement of parts, please check the locations of engine oil inlet and outlet and the location of exhaust gas inlet before assembling.

- 2) Install the turbine support plate and tighten the M8 12 hexagon head bolts.

Tightening torque: $285 \pm 10 \text{ N} \cdot \text{m}$ ($28 \pm 1 \text{ kgf} \cdot \text{cm}$)

(7) Install the compressor chamber.

- 1) Apply liquid gasket sealant to bearing chamber 15 and compressor end flange.

Notice: Refer to (4) 3) for the application locations. Sealant application thickness: 0.1~0.2mm

- 2) Check the marking on the compressor chamber and install the compressor chamber 7 onto the bearing seat 15.

Notice: During replacement of parts, determine the locations of oil inlet and exhaust port and reinstall the parts.

- 3) Install the compressor support plate and tighten the M8 hexagon head bolts.

Tightening torque: $48 \pm 15 \text{ N} \cdot \text{m}$ ($4.7 \pm 0.5 \text{ kgf} \cdot \text{cm}$)

(8) Perform the rotor running test.

If the running of rotor fails to meet the specification, it should be caused by an assembling error or the use of incorrect parts. Ensure to reassemble the parts.

Maintenance criterion of rotor during axial running	RHF5.....0.03~0.06mm
RHB51.....0.03~0.06mm	RHB31.....0.022~0.053mm
Maintenance criterion of rotor during radial running	RHF5.....0.08~0.13mm
RHB51.....0.08~0.13mm	RHB31.....0.061~0.093mm

4.6.3.7 Installation instruction of turbocharger

Handling after assembling

Strictly abide by the following installation instruction while installing the turbocharger to the engine or during the handling after reinstallation. Take special cautions to prevent the falling of foreign material into turbocharger.

4.6.3.7.1 Lubrication System

- 1) Before installing the turbocharger to the engine port, add new engine oil through oil filler port and rotate the turbine shaft by hand to lubricate the floating bearings and thrust bearings.
- 2) Flush the oil inlet and return pipes. Check for cracking, dust, and foreign material.
- 3) Properly connect the oil return pipe to prevent oil leakage.

4.6.3.7.2 Intake system

- 1) Check the intake pipe for presence of oil dirt and dust.
- 2) Properly connect the intake pipe and air filter to prevent air leakage.

4.6.3.7.3 Exhaust system

- 1) Check the exhaust system for presence of foreign material.
- 2) The bolts and nuts used for the exhaust system are made of heat-resistant steel. Do not use common bolts or nuts. Apply the anti-lubricant while tightening the bolts or nuts.
- 3) Properly connect the exhaust pipe to prevent the air leakage from the joint.

4.7 Fuel system

4.7.1 Fuel System

Composition diagram of fuel system:

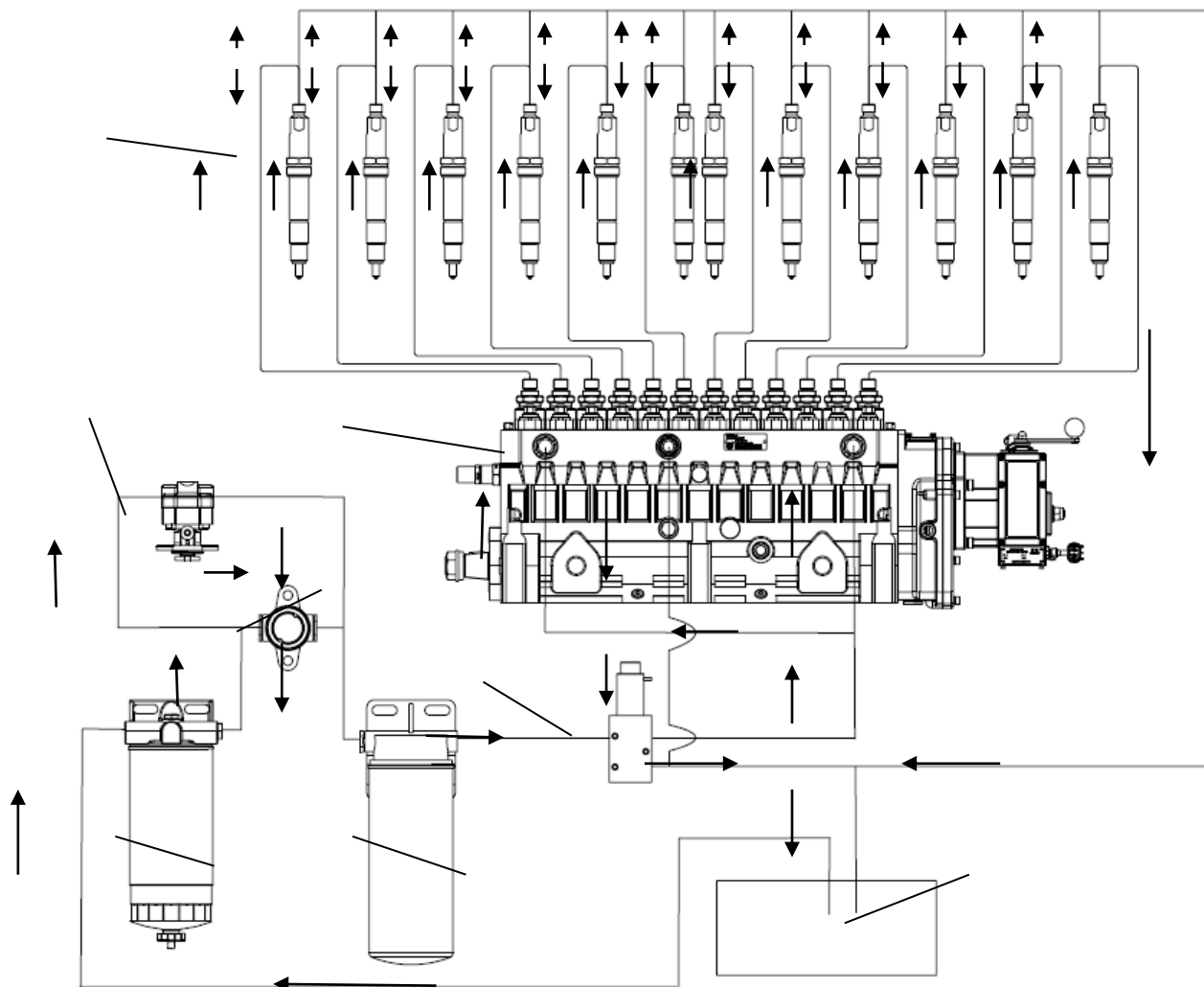


Figure 4-40 Composition diagram of fuel system

1-Fuel injector; 2-Gear fuel delivery pump; 3-Fuel injection pump; 4-Manual fuel delivery pump; 5-Fuel cutoff solenoid valve; 6-Fuel strainer; 7-Fuel strainer; 8-Fuel tank

4.7.1.1 Precautions for maintenance services

During the maintenance services for related parts of fuel system, pay special attention to the cleanliness of parts. During the disassembling and installation of parts, including high and low pressure fuel pipes, fuel filter, fuel injection pump, and fuel injector, take proper protection measures to prevent the ingress of dirt into the fuel line from blocking and wearing the high precision parts, including fuel injector nozzle, fuel injector needle valve, and fuel injection pump plunger, and from causing abnormal working of system.

4.7.1.2 Functional description

The fuel system is functioned to inject the fuel of fixed volume into the cylinder at the fixed timing so that the fuel is combusted to power the running of diesel engine. The functions of the system parts are as below:

Fuel strainer – It's functioned to filter away the impurities of large particle size from the fuel and separate the water content from the fuel.

Fuel delivery pump – It generates a negative pressure to suck the fuel from fuel tank into fuel strainer, deliver the fuel to itself via low pressure fuel pipe, and then pump the fuel filtered by the fuel strainer into the fuel fine filter.

Fuel fine filter – It's functioned to filter away the impurities of small particle size from the fuel.

Low pressure fuel pipe – It conveys the low pressure fuel among the fuel tank, fuel strainer, fuel delivery pump, fuel fine filter, and fuel injection pump.

Fuel injection pump – It compresses the low pressure fuel transmitted from the low pressure fuel pipeline to high pressure fuel as per the powering sequence of diesel engine and transmits the fuel to the fuel injectors via high pressure fuel pipeline.

High pressure fuel pipe – It conveys the high pressure fuel between fuel injection pump and fuel injectors.

Fuel injectors – They are functioned to spray high pressure fuel into cylinders as per the powering sequence of diesel engine.

4.7.1.3 Function Inspection

Please refer to the relevant contents of 3.16 and 3.19 for the daily checking of fuel system.

4.7.2 Fuel filter

Layout of fuel filter

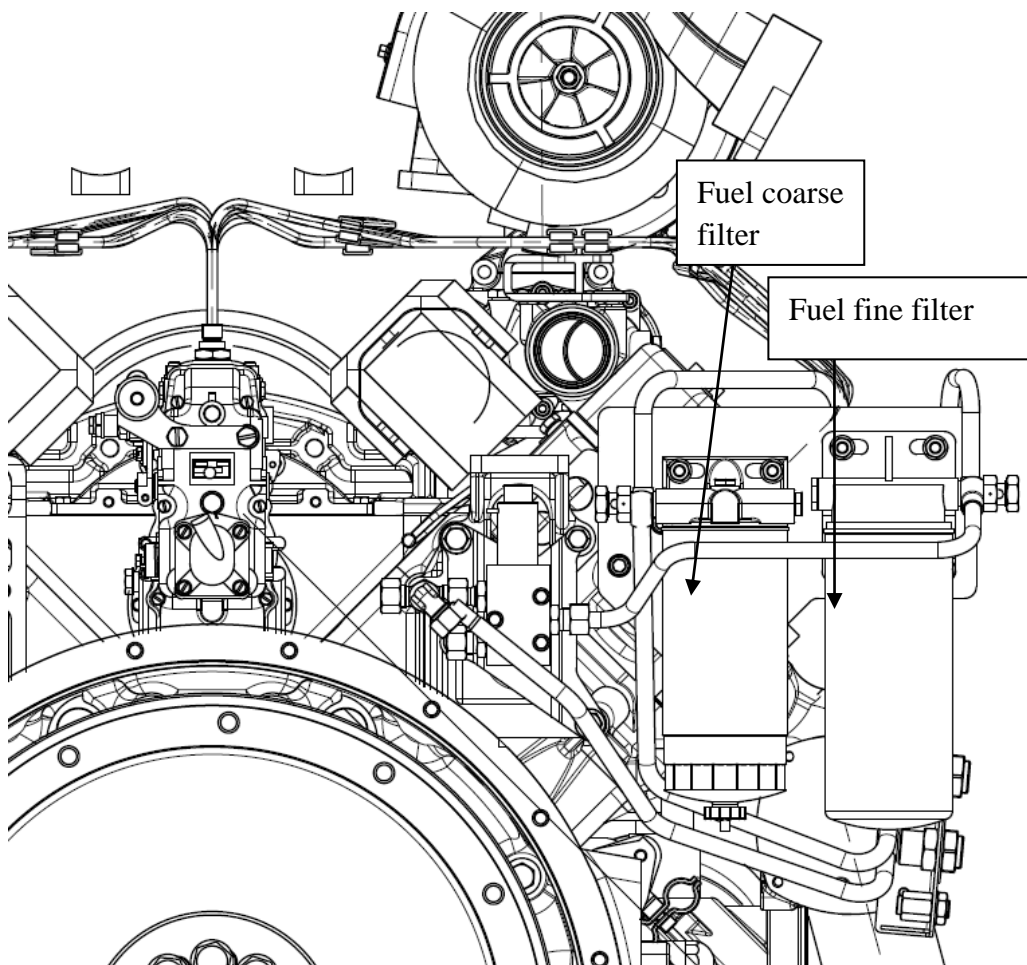


Figure 4-41 Layout of fuel filter

4.7.2.1 Parts

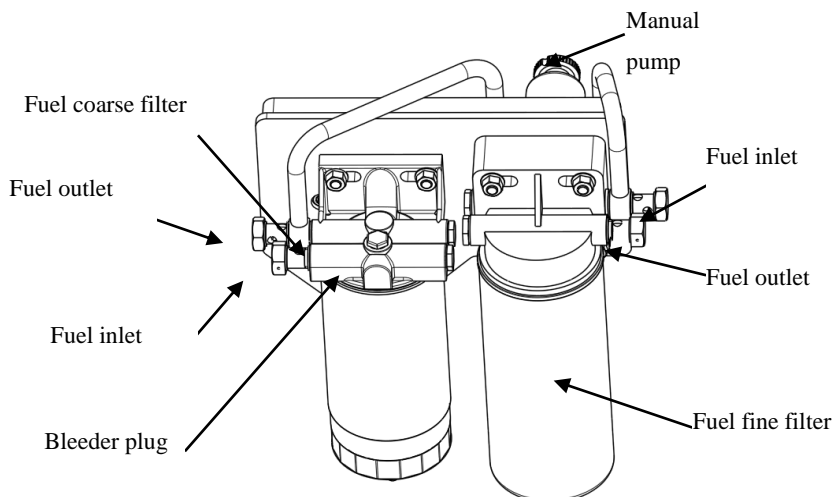


Figure 4-42 Diagram of fuel filter parts

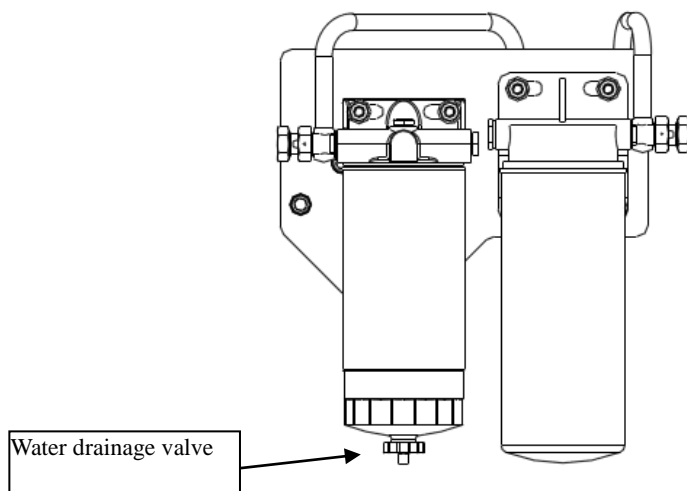


Figure 4-43 Fuel filter water drainage valve

4.7.2.2 Breakdown

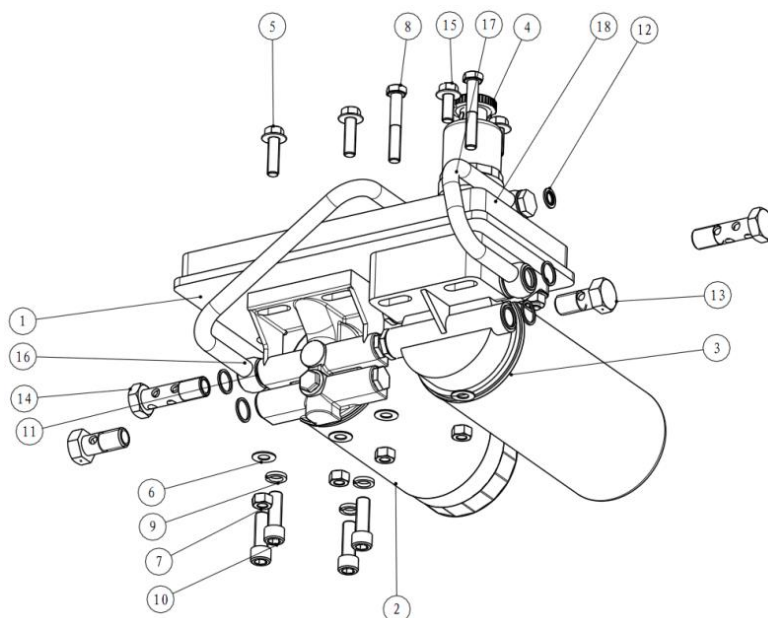


Figure 4-44 Diagram of fuel filter parts

Table 4-19 List of fuel filter

1	Fuel filter bracket	10	Hexagon socket head screws
2	Fuel coarse filter	11	Combination washer
3	Fuel fine filter	12	Combination washer
4	Manual pump	13	Hollow bolt
5	Hexagon flange bolt	14	Hollow bolt
6	Wave spring washer	15	Hexagon flange bolt
7	Hexagon nut	16	Strainer - Manual pump fuel pipe
8	Hexagon bolt	17	Manual pump - Fine filter fuel pipe
9	Spring washer		

4.7.2.3 Checking

Check the water level in the water collector of fuel strainer and drain the water once every 100 hours. Replace the fuel filter element once every 400 hours.

4.7.2.4 Assembling

- 1) Disassemble the fuel strainer element and fuel fine filter element by an appropriate wrench and clean the filter seats.
- 2) Apply engine oil to the new filter element seal gasket.
- 3) Install the filter element in place by hand in such manner that the seal ring comes into contact with the sealing surface of filter seat.
- 4) Tighten the filter element by $3/4 \sim 1$ turn by an appropriate wrench.
- 5) Loosen the bleeder plug of fuel strainer and pump the fuel by the manual pump on the fuel strainer, till the fuel flows out from the bleeder plug.
- 6) Loosen the hollow bolt at the fuel outlet of fuel fine filter, pump the fuel by the manual pump on the fuel delivery pump, till the fuel flows out from the loosened hollow bolt, and then tighten the hollow bolt.

4.7.3 Fuel pump

4.7.3.1 Parts

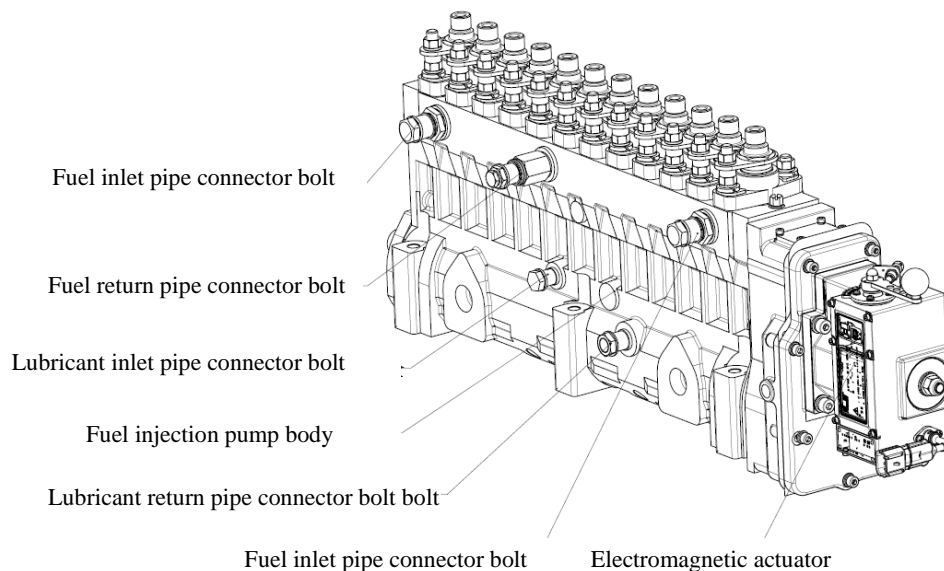


Figure 4-45 Diagram of fuel injection pump assembly parts

4.7.3.2 Breakdown

P10 fuel injection pump is an enhanced inline fuel injection pump, featuring small volume and high fuel supply and carrying capacity. It's mainly composed of pump body, pumping system, fuel volume control mechanism, and drive mechanism.

4.7.3.2.1 Pump body:

P10 pump is a suspended flange full-enclosed fuel injection pump made of die cast aluminum alloy, with full-enclosed pump body, bracket installation, and cylinder bore spacing at 40, featuring high strength and stiffness and high carrying capacity against high pump end pressure. When the forced lubrication is adopted, the pump body is fitted with lubricating oil inlet and return orifices.

4.7.3.2.2 Pumping system:

The pumping system of P10 fuel injection pump adopts the suspension structure, in which the plunger sleeve is suspended within the pump body mounting bore and the plunger, fuel outlet valve coupling, fuel outlet valve spring, and fuel outlet valve gasket are fixed in the plunger sleeve by fuel outlet valve fixing seat. The plunger sleeve is fitted with two rubber O-rings to realize low pressure sealing. The plunger sleeve is designed with kidney-shaped hole so that the rotation of plunger sleeve can adjust the non-uniform fuel volume among cylinders. The gasket is installed between plunger sleeve and pump body to adjust the fuel supply pre-travel and fuel supply angle among cylinders, in order to ensure that the cam profile is working in the best working segment. The fuel outlet valve coupling is functioned to separate the high pressure fuel pipe and the plunger chamber at the completion of plunger pumping, in order to prevent the backflow of fuel. The pressure reduction travel (relief pressure) of fuel outlet valve can guarantee an appropriate residual pressure of high pressure fuel volume and prevent the secondary and irregular injection. The plunger sleeve is fitted with fuel return orifices to reduce the fuel leakage. The fuel return orifices of the plunger sleeve are fitted with baffle screws to prevent the return fuel from impacting the pump body.

4.7.3.2.3 Fuel volume control mechanism:

The fuel volume is controlled by the pull rod and the plunger control sleeve. The pull rod is installed within the sleeve of pump body. Driven by the speed regulator, the pull rod drives the

plunger via the engaged plunger control sleeve to change the relative position between plunger and the plunger sleeve so that the change extent of the relative position is used to adjust the fuel volume.

4.7.3.2.4 Drive mechanism:

The drive mechanism is composed of the camshaft subassembly, roller body subassembly, plunger spring, and upper spring seat. The camshaft of P10 pump is fixed within the camshaft chamber of pump body by a rolling bearing without inner ring, a double-row taper roller bearing, and 1~2 intermediate bearings. The cams drive the roller body subassemblies of various cylinders as per preset sequence to reciprocate the plungers vertically. The plunger springs are functioned to move downward the plungers driven upward by the camshaft and keep the roller body assemblies non-separated from the cams.

4.7.3.2.5 Electric speed regulator

The electric speed regulator is mainly composed of electromagnetic actuator, speed controller, and speed sensor. The electromagnetic actuator is installed on the rear end of fuel pump, the speed sensor is installed on the flywheel cover, and the speed controller is generally installed within the control cabinet.

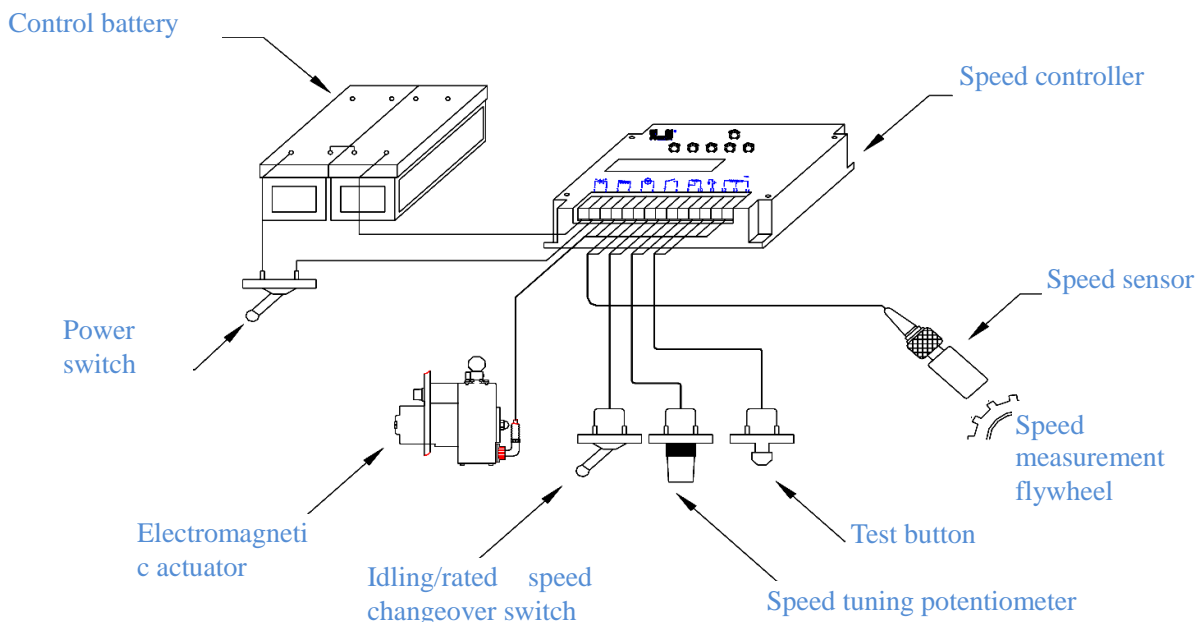


Figure 4-46 Structural diagram of electric speed regulator

4.7.3.3 Disassembling

4.7.3.3.1 Disassembling

Before the disassembling, remove the external dusts and dirt, record the adjustment data, and disassemble as per the procedure below:

1) Fix the fuel injection pump assembly on special bench or vice bench.

2) Disassemble the electromagnetic actuator.

3) Loosen the fastening nuts of plunger sleeves and take out the plunger sleeves (including the fuel outlet valve coupling, fuel outlet valve spring, and fuel outlet valve gasket installed within the plunger sleeve).

4) Loosen the pull rod locating screws, pull the pull rod till the plunger control sleeve is just beyond the pull rod slot, and take out the plunger by rotating the plunger and pulling upward the plunger. The disassembled plungers shall be placed into corresponding plunger sleeves and no interchange is allowed.

5) Take out the plunger control sleeve.

6) Rotate the camshaft and, when the roller is at bottom dead center, push down the spring seat by a metal bar. When the snap ring pops up, take out the snap ring, spring upper seat, plunger spring, and roller body subassembly.

7) Disassemble the drive end bearing cap, unscrew the intermediate bearing screws, and take out the camshaft.

8) Push out the disassembled roller body subassemblies from one end of roller pin to the other end and take out the wire retainer, roller inner ring, and roller.

9) Loosen the fuel outlet valve fastening cap from the plunger sleeve and take out the fuel outlet valve and O-ring.

4.7.3.3.2 Checking of disassembled parts:

Clean the disassembled parts by clean gasoline and check the wear and damage status of parts. Replace seriously worn and non-reusable parts and replace all seal gaskets, O-rings, oil seals, and snap rings of spring upper seat.

1) Plunger coupling

Replace the plunger upon detection of damage, wear, and discoloration in its spiral groove.

Check the sliding performance of plunger by rotating and sliding downward the plunger. Upon detection of over-fast rotation or stagnation midway, replace the plunger.

2) Fuel outlet valve coupling

Replace the fuel outlet valve and valve seat upon detection of damage or wear in their working surfaces.

3) Roller body assembly

Replace the roller upon detection of wear, damage, and surface falloff on its surface.

Replace roller pin and roller inner ring upon detection of wear or damage.

Replace roller body upon detection of wear or damage on its working surface.

4) Replace the camshaft upon detection of defect in taper area, cam surface, contact surface with intermediate bearing, or thread area.

5) Bearings

Replace the intermediate bearing upon detection of defect and replace the bearings on two ends of camshaft upon detection of wear.

6) Springs

Replace the plunger spring and fuel outlet valve spring upon detection of damage, rusting, and non-uniform wear.

7) Fuel supply pull rod and plunger control sleeve

Replace the fuel supply pull rod upon detection of bending or deformation. Replace the plunger control sleeve upon detection of serious wear at flat insertion part of plunger.

8) Pump body

Replace the pump body upon detection of cracking, wear, or thread damage.

4.7.3.3.3 Disassembling of electric speed regulator

1) Unplug the connecting cable between actuator and controller.

2) Disassemble 7 connecting hexagon socket head screws between actuator and intermediate body.

3) Drain the lubricating oil from the intermediate body housing.

4) Disassemble the connecting nut or butterfly pin between actuator and toothed bar and loosen the connection between actuator and oil pump toothed bar.

4.7.3.4 Assembling

4.7.3.4.1 Installation of fuel injection pump

1) Place the plunger sleeve on special tooling or vice, install the sealing gasket, fuel valve parts, fuel outlet valve spring, and fuel outlet valve spring seat, screw the fixing seat of fuel outlet valve, place the plunger into original plunger sleeve, and install the O-ring.

2) Assemble the roller, roller inner ring, wire retainer, and roller body together to the roller body subassembly.

3) Fix the pump body on special tooling or vice, overturn the pump body, install the roller body subassemblies into cylinder bores from bottom to top via bearing bores, press the bearings onto the journals on two ends of camshaft, and secure the snap rings on the speed regulator end. Pass the camshaft together with intermediate bearings into the camshaft chamber of pump body from one end and then tighten the fastening screws of intermediate bearings and fastening screws of front housing.

4) Press the bearings and framework oil seals into bearing caps, attach the O-rings, and install the bearing caps into the mounting bores of pump body.

5) Turn over the pump body, place the plunger spring and upper spring seat in turn, and install the snap ring of upper spring seat securely by special tool. Ensure to secure the snap ring, otherwise it will lead to accident and damage the fuel injection pump.

6) Install the pull rod into the pump body sleeve. The pull rod shall move flexibly, with the pull rod marking facing upward.

7) Rotate the camshaft. When certain cylinder is at the top dead center, the flat end of plunger will insert into the flat slot of the plunger control sleeve. While installing the plunger into the roller body, rotate the plunger control sleeve to ensure the complete engagement of its pull rod. Align the plunger sleeve installed with pumping subassembly with the plunger, install them together, and tighten fastening nuts of flange sleeve to 45~50N.m. Tighten the fixing seat of fuel outlet valve by a torque wrench to 120N.m. Check the pull rod for flexible movement, otherwise check and solve the cause. Install all other cylinders as per same method.

8) At completion of assembling, the static sliding resistance of the pull rod shall be no higher than 300g.

4.7.3.4.2 Installation of electric speed regulator

Perform the wiring and installation as per the figure below.

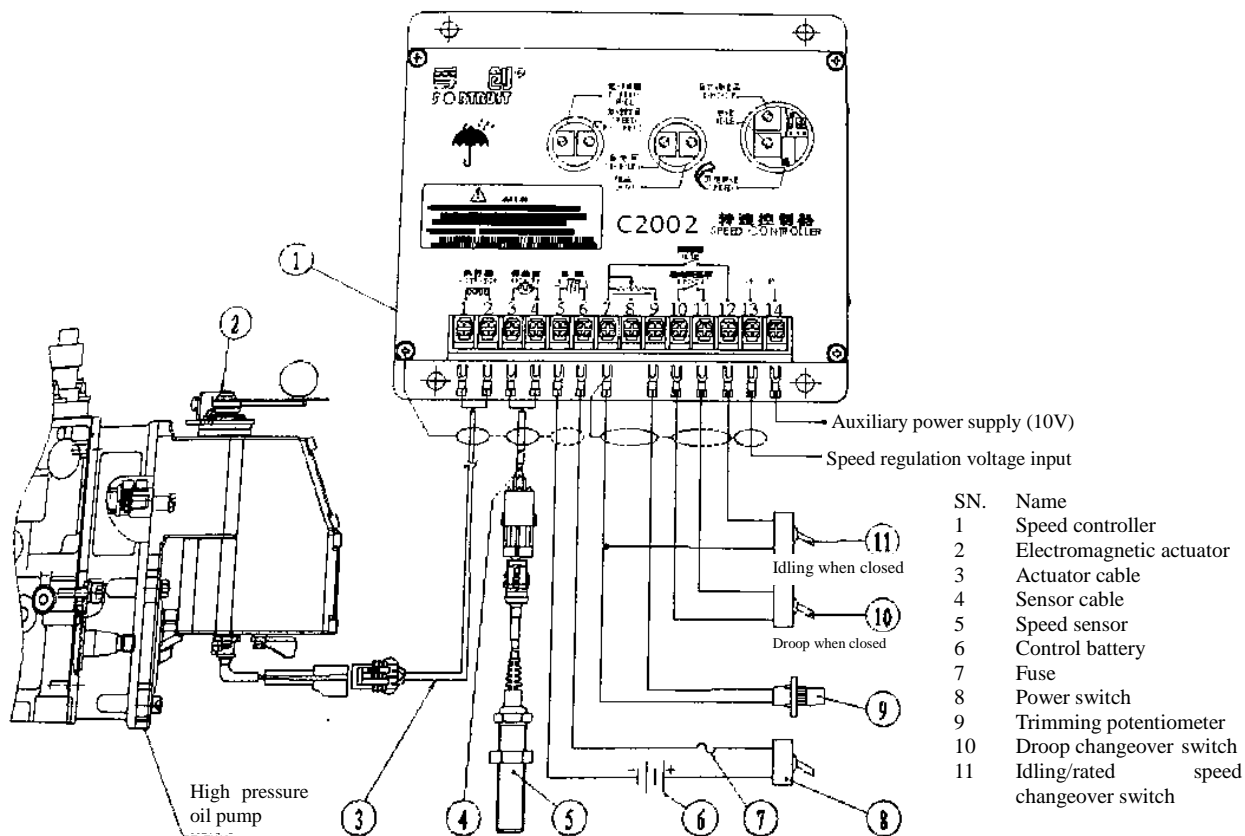


Figure 4-47 Connection diagram of electric speed regulator

4.7.3.5 Installation

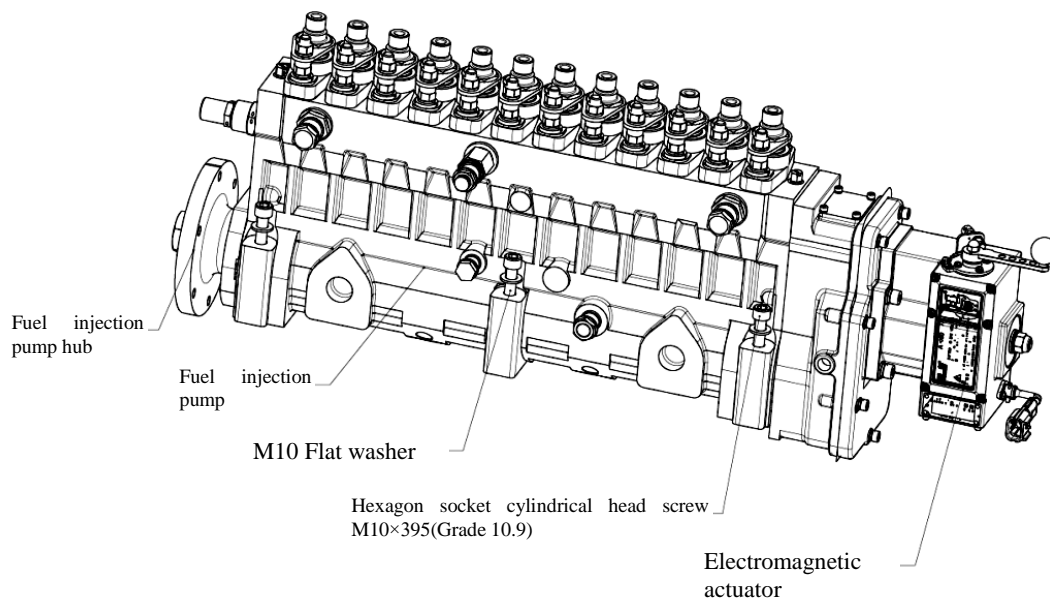


Figure 4-48 Assembly of fuel injection pump

1) Install the fuel injection pump hub onto the fuel pump, with the hub marking facing upward. Align its marking with that of fuel pump, apply sealant 242 to the threads, and tighten to (250~300) N.m.

2) At the compression top dead center of cylinder B6, tighten the fuel pump hub with coupling.

3) Turn the diesel engine to the advance angle. If the advance angle is inappropriate, loosen the connection between hub and coupling and perform fine tuning.

4) After adjustment, tighten the fuel pump hub together with coupling and fix the fuel pump onto the cylinder block by M10×95 grade 10.9 bolts.

4.7.3.6 Special tools

Special tooling for snap ring of upper spring seat of fuel pump plunger spring

4.7.3.7 Torque specification

Except the torques specified otherwise in the installation, follow the general tightening torques for conventional bolts.

4.7.3.8 Troubleshooting

1. Engine Start-up difficult

- | | |
|--|--|
| 1) Incorrect fuel supply advance angle while installing fuel pump onto diesel engine | 1) Readjust as per operation manual of diesel engine |
| 2) Air content in fuel system | 2) Bleed the air |
| 3) Working failure of fuel delivery pump | |
| A. Air leakage at fuel inlet and outlet pipe connectors of fuel delivery pump | A. Replace gaskets and tighten connectors |
| B. Failure of fuel delivery pump check valve | B. Remove dirt and grind end face of check valve |
| C. Wear of fuel delivery pump piston | C. Replace piston |
| D. Blockage of internal filter screen of fuel delivery pump fuel inlet connector | D. Clean filter screen |
| 4) Insufficient starting fuel amount | 4) Re-adjust |
| 5) Wear or blockage of plunger coupling | 5) Replace plunger coupling |
| 6) Blockage of nozzle or poor atomization | 6) Replace nozzle coupling |
| 7) Low opening pressure of nozzle | 7) Re-adjust |
| 8) Filter blockage | 8) Clean the filter element |
| 9) Insufficient power of electric speed regulator power supply (battery) | 9) Charge or replace battery |
| 10) Poor installation of speed sensor | 10) Reinstall speed sensor |
| 11) Broken cable of speed sensor | 11) Replace sensor cable |

- | | |
|--|---|
| 12) Stagnation between actuator and fuel pump rack linkage | 12) Overhaul |
| 13) Broken actuator cable | 13) Replace actuator cable |
| 2. Insufficient horsepower | |
| 1) Early or delayed fuel injection timing | 1) Re-adjust |
| 2) Insufficient fuel injection volume | 2) Readjust and repair |
| 3) Leakage of fuel injector | 3) Repair or replace |
| 4) Wear of plunger | 4) Replace plunger coupling |
| 5) Poor atomization of nozzle | 5) Repair or replace nozzle |
| 3. Unstable engine speed | |
| 1) Inappropriate adjustment of controller | 1) Adjust differential (stability) and gain potentiometers on controller |
| 2) Excessive axial clearance of camshaft | 2) Readjust clearance |
| 3) Deteriorated fuel supply volume uniformity among cylinders | 3) Adjust and repair |
| 4) High pull rod resistance | 4) Overhaul |
| 5) Large error of fuel supply angular interval among cylinders | 5) Re-adjust |
| 6) Excessive lubricating oil level within actuator | 6) Overhaul and troubleshooting |
| 4. Engine galloping | |
| 1) Low gain setting and poor flexibility of controller | 1) Reset |
| 2) Malfunction of speed controller | 2) Replace |
| 3) Mismatch of fuel supply zero position between actuator and fuel pump so that the fuel supply of fuel pump can't cut off after power-off of actuator | 3) Adjust and Overhaul |
| 4) Signal error of engine speed sensor | 4) Replace the sensor |
| 5) Blockage of pull rod | 5) Overhaul |
| 6) Breakage of plunger spring | 6) Replace |
| Notice: Upon detection of engine galloping, immediately cut off the fuel line and block the intake passage of engine to force the stop of engine. | |
| 5. Sudden stop of engine | |
| 1) Failure of electric speed regulator power supply | 1) Ensure the continuous power supply for the electric speed regulator |
| 2) Fuel supply interruption | 2) Check the fuel volume in fuel tank, the working status of fuel delivery pump, and the fuel pipeline. |
| 3) Poor contact of cable or damage of circuit | 3) Overhaul and replace |
| 4) Blockage of plunger | 4) Replace |
| 5) Seizure of fuel injector nozzle | 5) Replace |
| 6) Breakage of plunger spring | 6) Replace |

4.8 Cooling System

4.8.1 Cooling circuit

The diesel engine for land power generator only adopts the circulation of heat carrying fluid within an enclosed circuit.

The major and minor circulations of the cooling system are controlled by the thermostat:

When the temperature of coolant is low, the thermostat closes so that the coolant returns to water pump via bypass pipeline for cooling circulation, without flowing through the radiator (Minor circulation of coolant).

When the temperature of coolant is high, the thermostat opens so that the coolant completely flows through the radiator and then flows into water pump for cooling circulation (Major circulation of coolant).

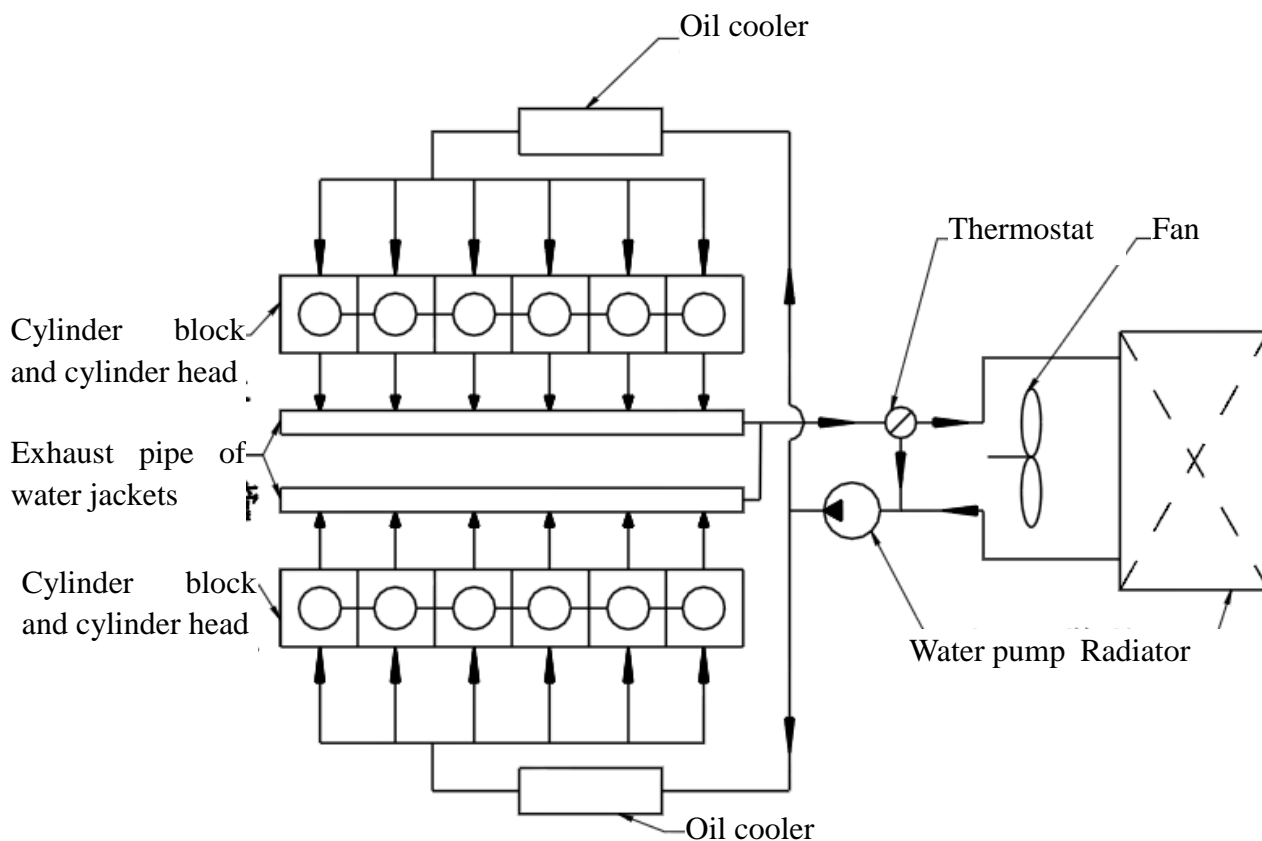


Figure 4-49 Schematic diagram of cooling system

4.8.2 Thermostat

- Thermostat subassembly

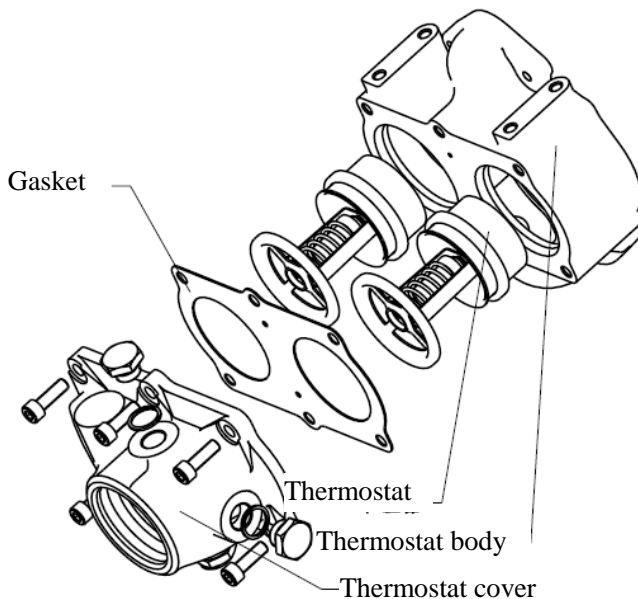


Figure 4-50 Breakdown diagram of thermostat

- Checking of thermostat

Immerse the automatic thermostat in a water container. After heating, measure the water temperature and observe the temperatures of thermostat for consistency with the temperatures listed in the table below.

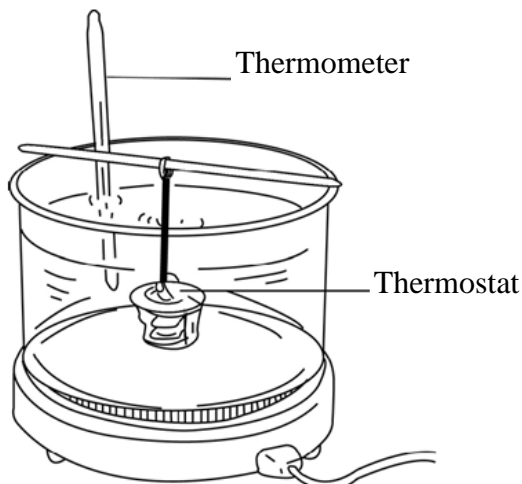


Figure 4-51 Checking of thermostat

Table 4-20 Inspection item of thermostat

Initial opening temperature (°C)	Lift height at full opening (°C)
Hata! Başvuru	≥9.5mm(87°C)

4.8.3 Water pump

The 12M26 model adopts two water pump which symmetrically arranged on both sides of diesel engine and is driven by a poly V-belt. The poly V-belt automatic tensioner is fixed on the cylinder block by brackets to keep a sufficient tension for poly V-belt.

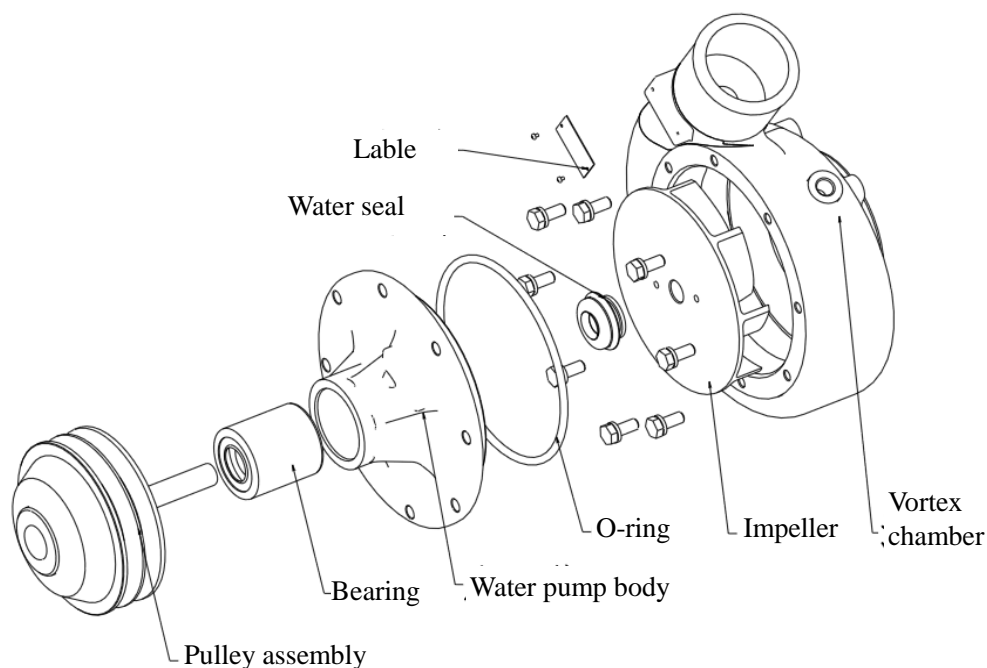


Figure 4-52 Breakdown of water pump

4.8.3.1 Disassembling of water pump

- Disassemble the small alternator.
- Disassemble the fan, poly V-belt, and pulley.
- Disassemble the cooling pump.
- Disassemble the thermostat.

4.8.3.2 Precautions

- 1) Check the bearings of cooling pump for abnormal noise, blockage, swing, and water leakage.
- 2) Replace the O-ring of water pump with new one.

4.8.4 Fan

The 12M26 series diesel engine for power generator adopts the steel fan with rigid drive mode. Depending on the needs of diesel engine for power generator, the reverse fan is adopted to

guarantee the cooling effect.

4.8.4.1 Parts

The fan parts are as below:

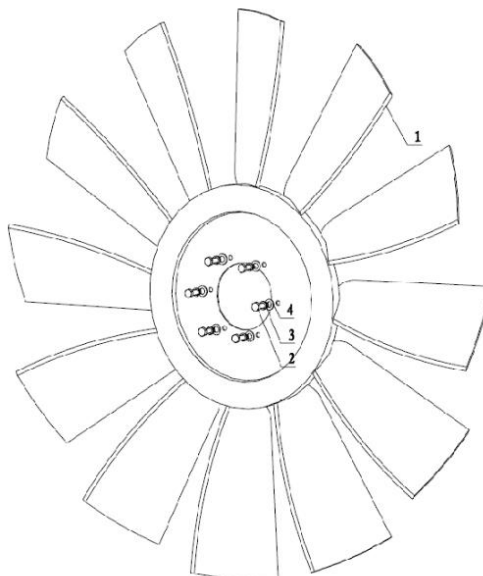


Figure 4-53 Diagram of fan

Table 4-21 List of fan

SN.	Chinese name	Number of units
1	Fan	1
2	Hexagon bolt	1
3	Standard spring washer	6
4	Flat washer	6

4.8.4.2 Disassembling

14mm open-end wrench

Unscrew six hexagon head bolts and take out the fan.

The installation is in reverse order:

Tighten six hexagon head bolts in turn. The required tightening torque is as below.

Table 4-22 Bolt tightening torque

Bolt size	Rating	Tightening torque
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		specification
M14	10.9	190N·m

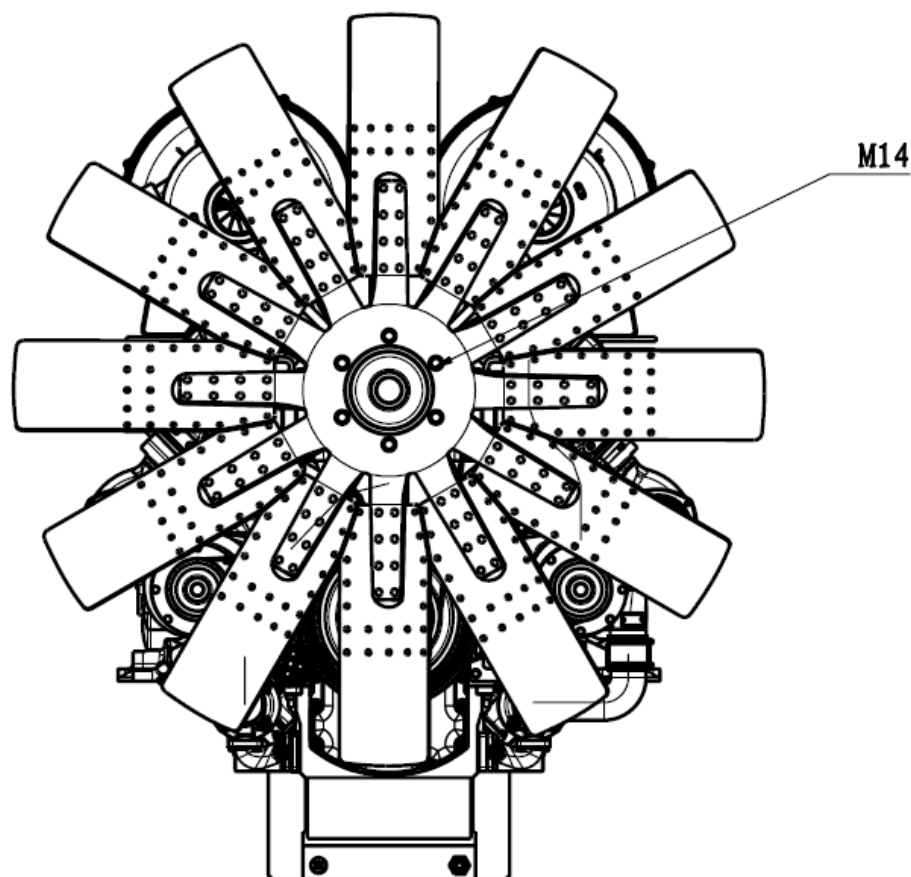


Figure 4-54 Diagram of fan

4.8.4.3 Checking

4.8.4.3.1 Checking of fan

Check the fan rivets for looseness, check the fan blades for bending, and ensure the normal working of fan.

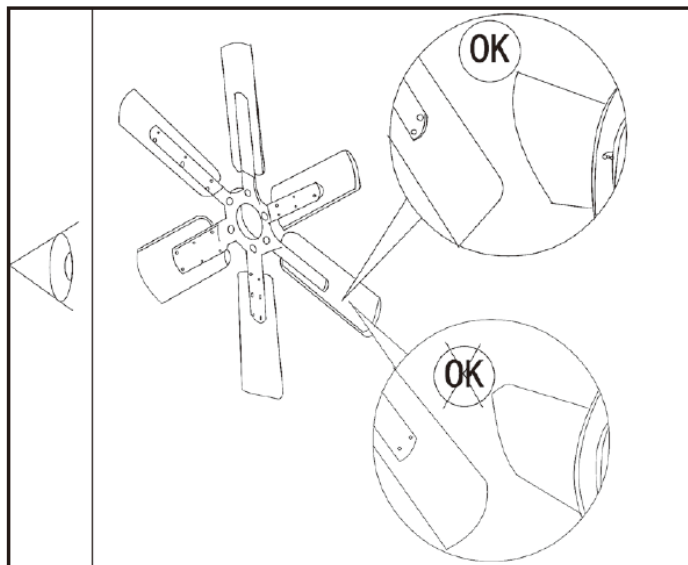


Figure 4-55 Checking of fan

4.8.4.3.2 Check the poly V-belt

Visually observe the poly V-belt for cracking and scratch and when necessary replace.

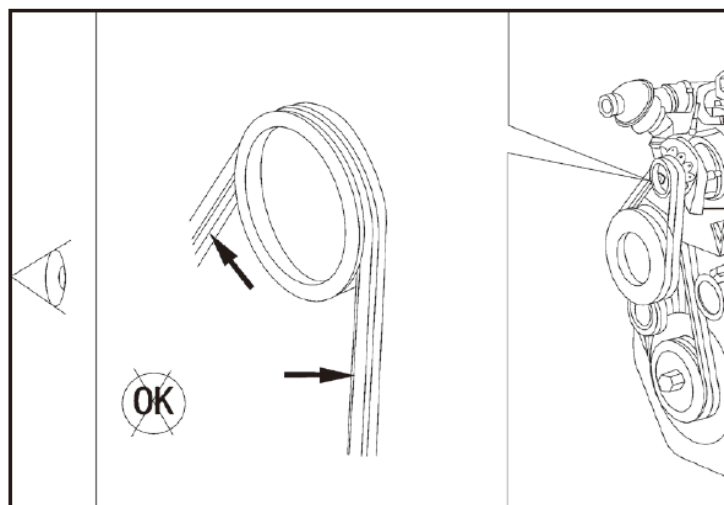


Figure 4-56 Checking of poly V-belt

4.9 Lubrication System

4.9.1 Lubrication System

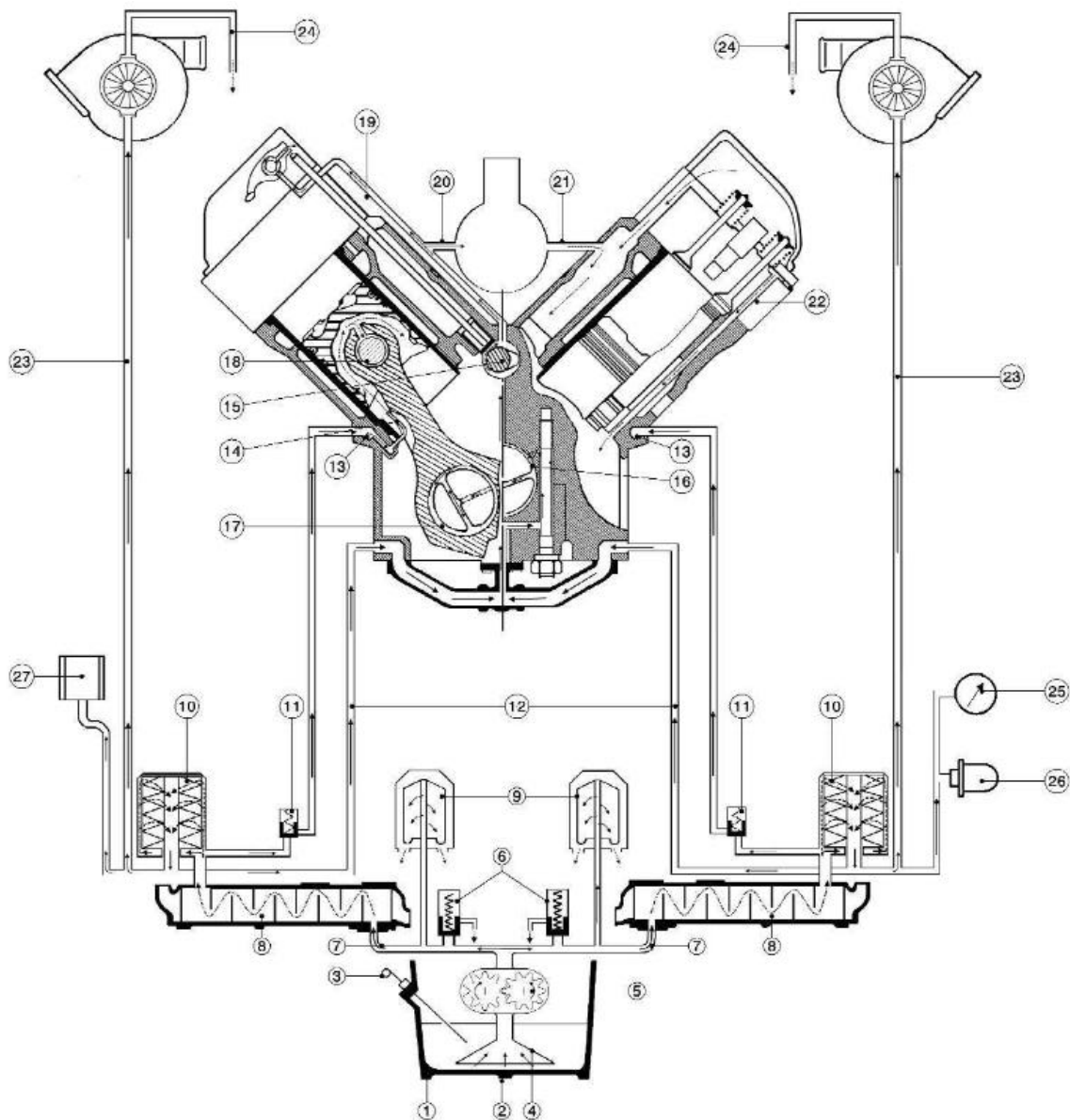


Figure 4-57 Diagram of lubrication system

Table 4-23 List of lubrication system

1	Oil sump	2	Drain plug
3	Oil dipstick	4	Strainer
5	Oil pump	6	Pressure limiting valve
7	Oil pipe	8	Oil cooler
9	Centrifugal engine oil filter	10	Filter
11	Pressure regulating valve	12	Oil pipe
13	Oil pipe	14	Piston cooling nozzle
15	Camshaft bushing	16	Main bearing shell
17	Connecting rod bushing	18	Connecting rod bushing

19	Rocker lubricating oil pipe	20	Oil inlet pipe of fuel injection pump
21	Oil return pipe of fuel injection pump	22	Oil return pipe
23	Turbocharger oil inlet pipe	24	Turbocharger oil return pipe
25	Pressure gauge	26	Pressure sensor
27	Pressure switch		

4.9.1.1 Oil line:

The engine is fitted with pressurized lubrication system. The gear oil pump is located on the bottommost place of the engine. This oil pump is driven by the valve mechanism on the front of crankshaft. All lubricating points and accessories requiring lubrication are connected by the pipeline or conduit in the pressurized lubrication system. The splash lubrication mode is adopted to lubricate the timing gear. The lubricating oil is splashed to the pistons for continuous cooling.

4.9.1.2 Engine oil pump subassembly

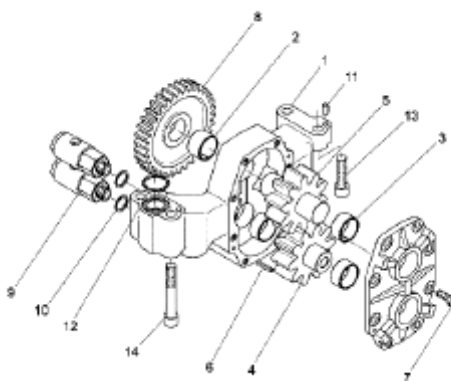


Figure 4-58 Diagram of engine oil pump parts

Table 4-24 List of engine oil pump parts

1	Oil pump assembly
2	Bushing
3	Bushing
4	Pin
5	Shaft and gear assembly
6	Shaft and gear assembly
7	Hexagon bolt
8	Drive gear
9	Safety valve
10	Copper gasket
11	Straight pin
12	Rubber O-ring
13	Hexagon socket cylindrical head screw
14	Hexagon socket cylindrical head screw

During installation, the backlash of engine oil pump with the crankshaft gear is (0.15~0.2) mm.

The fastening bolts of the engine oil pump are in specification of M12 (grade 10.9). During installation, apply Loctite 242 to the thread surfaces to prevent vibration looseness and tighten to $110\pm 5\text{N.m}$.

Notice: After the installation of engine oil pump, check the engine oil pump for smooth rotation. If the rotation of the engine oil pump is tight, the oil pump will be probably burnt during running of engine.

4.9.1.3 Adjustment of oil pressure

1) Safety valve

Two safety valves are arranged on the right side of the oil sump and can be maintained by the access panel of the cylinder 6. When the oil is start under cold status, the above-mentioned valves can carry the pressure of 10 bar and are functioned to limit the oil pressure of engine circuit.

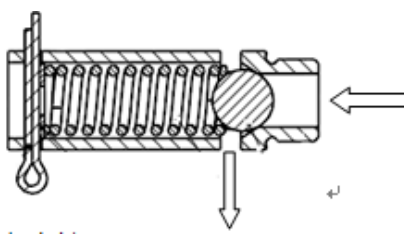


Figure 4-59 Diagram of safety valves

2) Control valve

The oil pressure control valve is located on the engine oil filter bracket. The oil pressure control valve is used to keep constant the oil pressure in the circuit and the opening pressure of this valve is 0.2MPa. In addition, the oil displacement of these valves is the fuel supply volume of the cooling pump beneath the piston head.

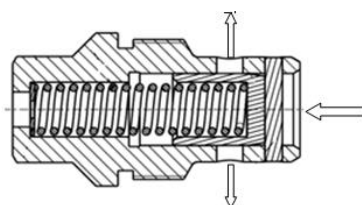


Figure 4-60 Diagram of control valve

4.9.1.4 Centrifugal engine oil filter

This engine is fitted with two centrifugal filters, which are installed near the lubrication

circuits respectively. The engine oil filter is located on the side face of oil sump.

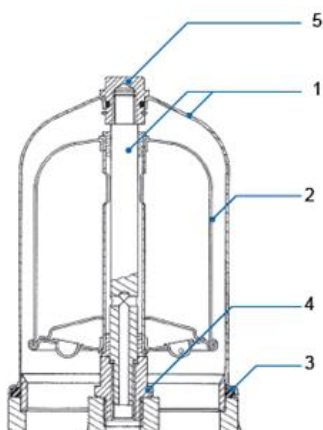


Figure 4-61 Diagram of centrifugal engine oil filter

- Replace the centrifugal filter element.
 - a. Loosen the top nut 5.
 - b. Take out the intermediate filter cup 1.
 - Warning: If the nut 4 on the filter cup is loosened please disassemble this nut. Tighten it to the fixing seat during reassembling.
 - c. Disassemble the filter element 2 and sealing gasket 3.
 - d. Clean the filter cup and fixing seat.
 - e. Install new filter element and use the sealing gasket 3 attached in new filter element.
 - f. Reinstall the filter cup, tighten to 20N.m, and ensure that the filter cup is free of distortion.

4.9.1.5 Oil filter

Both engine oil filters adopt one-time full-flow filter element. If the engine oil filter is blocked, the safety device on the filter element is used. This means that the lubrication is maintained even when the filter element is blocked. Periodically replace these filter elements during maintenances.

Replace the Oil filter

Replace the filter element during each replacement of engine oil. Before disassembling the engine oil filter, remove the dirt from its surrounding area.

A one-time engine oil filter element is installed on each side of the engine. Loosen the filter element by an engine oil filter wrench during replacement.



Figure 4-62 Installation of engine oil filter

- a. Clean the engine oil filter base.
- b. Apply engine oil (instead of lubricating grease) to the sealing gasket.
- c. Tighten the engine oil filter by hand (instead of tool) and rotate by approximately 3/4 turn.

Check the engine oil level and pre-lubricate the engine. Re-check the oil level and when necessary add sufficient oil. Ensure that the engine oil filters are free of oil leakage.

4.9.1.6 Engine oil

4.9.1.6.1 Engine oil type

Use CD15W/40 or above engine oil as specified by GB11122.

4.9.1.6.2 Oil capacity:

The capacity of the standard oil tank for 12M26.2 horizontal engine is 113L.

4.9.1.6.3 Replace engine oil

- 1) After the stop of engine, use the manual pump for the replacement of engine oil.
- 2) Place the three-way connector to the place shown in figure below.

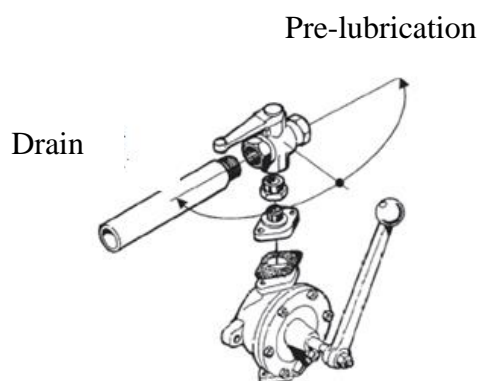


Figure 4-63 Diagram of manual oil pump

- 3) Check whether the three-way valve is placed at the position “Drain” shown in the figure below.
- 4) Check whether the pump switch is place at position 1.
- 5) Place the “Drain” changeover switch of operation box to “ON”, till the engine is fully drained.
- 6) At completion of the drainage, place the “Drain” changeover switch of operation box to “OFF”.
- 7) Adjust the three-way valve to position “Pre-lubricate”.
- 8) Add engine oil into the engine oil tank.

Notice: Add clean engine oil into diesel engine oil tank, till the oil level reaches the upper

marking of oil dipstick. Start and idle the engine and check the engine oil filters and drainage plug for oil leakage. Stop the engine, wait for approximately 5min for the engine oil to return from upper parts into oil sump, and check the oil level once again. When necessary, add engine oil, till the engine oil reaches the upper marking of oil dipstick.

4.9.2 Oil cooler

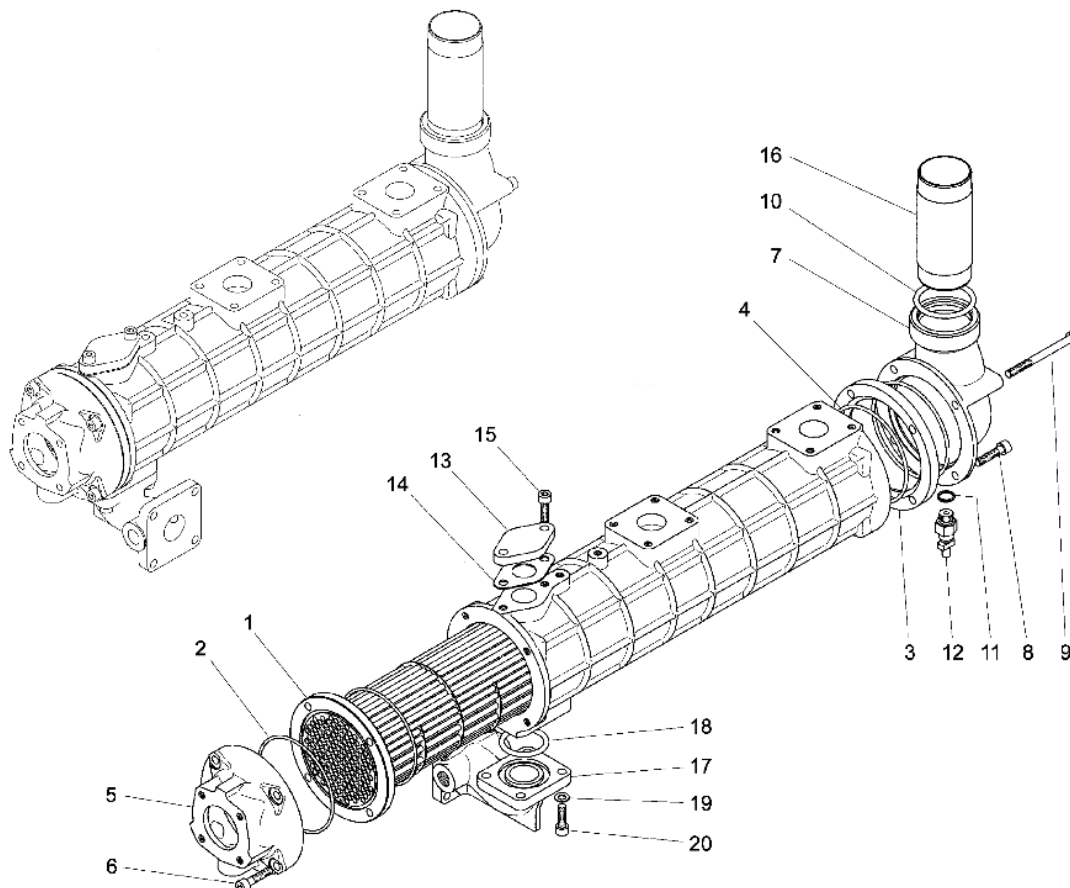


Figure 4-64 Diagram of engine oil cooler parts

Table 4-25 List of engine oil cooler

1	Oil cooler element	2	Rubber O-ring
3	Support block	4	Rubber O-ring
5	Water inlet port cap	6	Hexagon socket cylindrical head screw
7	Coolant outlet	8	Hexagon socket cylindrical head screw
9	Hexagon socket cylindrical head screw	10	Rubber O-ring
11	Seal ring	12	Water drainage valve
13	Flange	14	Gasket
15	Hexagon socket cylindrical head screw	16	Connecting pipe
17	Fuel inlet bend	18	Rubber O-ring
19	Gasket	20	Hexagon socket cylindrical head

			screw
--	--	--	-------

The engine is fitted with two engine oil cooler, which located on the both sides of the engine. The engine oil is circulated by cooler and is cooled by engine coolant before being filtered.

Replace the engine oil cooler core:

- 1) Loosen 4 M8 connecting screws of water inlet pipe on the water inlet port cap of engine oil cooler by a wrench and disassemble the connecting water pipe. (Drain the coolant from engine before disassembling)
- 2) Disassemble 4 bolts of engine oil cooler water inlet and outlet port caps by an Allen wrench and disassemble the water inlet port cap and the engine oil cooler housing.
- 3) Clean the water inlet and outlet port caps and the sealing junction surface of engine oil cooler housing.
- 4) Disassemble the engine oil cooler core and clean the inside of housing.
- 5) Replace and install new engine oil cooler core.
- 6) Reinstall the water inlet and outlet port caps of engine oil cooler and tighten the screws.
- 7) Reinstall the water inlet pipe of engine oil cooler and tighten the screws.

Note: Apply Loctite sealant 242 to the threads before tightening the bolts.

4.10 Startup system

4.10.1 Start-up system

The starter system is composed of battery (to be provided by the user), starter motor, starter switch, and wires.

4.10.1.1 Precautions for maintenance services

- Before start of engine

Ensure that there is no person around the engine before start.

Ensure that all protective plates are properly seated.

Ensure that all engine parts are free of contact with any object: Splash danger.

Take necessary protection measures during operations around motion parts.

Never disable the automatic stop circuit.

Above measures are intended to prevent the personal injuries and machine damage.

Before starting a new engine or a recently repaired engine, operate the acceleration and stop

control levers on the fuel injection pump to ensure flexible motions.

Before start, rotate the crankshaft of diesel engine for several turns. After the rotation without obstruction is confirmed, place the speed control lever of fuel injection pump in the middle position and turn on the power switch.

Start the diesel engine only after the safety of the equipment and the environment is ensured.

- Take the necessary measure for emergency cutoff of fuel or air supply, in order to prevent the initial speed risk.

Check circuit for cleanliness.

Check for non-obstructed exhaust gas in the exhaust pipeline.

If the engine is stopped for ≥ 24 hours, perform the pre-lubrication before restart. If the engine is stopped for less than 24 hours, the pre-lubrication is not especially required.

Check the electric supply system.

Check and ensure that all other parts driven by the engine work normally.

- Engine with manual pre-lubrication pump

Ensure that the three-way valve is placed at the position “Pre-Lubrication” as shown in figure below.

After the stop of engine, pre-lubricate the engine by manual drainage pump.

Ensure that the transmission linkage is already disengaged.

Ensure that all drive parts at neutral position.

Ensure that the accelerator control lever is at position “Idling”.

Rotate the key to position “Start” on the instrument panel to start the engine.

Alternatively, start the engine from the cabinet of the machine room. If the “Start” switch is at position “ON”, press the “Start” button.

 Notice

After the start of diesel engine, idle the engine for 2~3min. The engine oil pressure shall be no less than 200kPa. If insufficient, stop the engine immediately for checking, in order to prevent damaging the diesel engine. When the coolant temperature is less than 60 °C, do not run the engine at high speed under heavy load suddenly, otherwise it will deteriorate the wear resistance and reliability of the diesel engine.

Do not idle or run the diesel engine under unloaded condition for a long time.

4.10.1.2 Function and operation descriptions

12M26 series diesel engine for power generator is started by electric starter motor. Under normal working condition, the starter motor converts the electric energy stored in the battery into mechanic energy to drive the running of engine at a speed high enough for successful start of the engine.

4.10.1.2.1 Startup of Diesel Engine

- Control panel

Turn off the master circuit.

Rotate the key to position “1” to power on the control panel.

“Engine oil pressure warning lamp” automatically turns on for 10s (test of ultimate low engine oil pressure safety line)

It’s recommended to test the indicator lamps, bulbs, and buttons once (by pressing the touch button 10 on the control panel).

Rotate the key to position “START” to start the engine and then release the key. The key automatically returns to position “1”.

At the start of diesel engine, if the diesel engine fails to start within 10s, immediately release the button and wait for 1min before retry.

If the engine can’t be started by three consecutive attempts, stop the attempt and find out and solve the malfunction before retry.

During the working of engine, both “oil pressure warning lamp” and the “battery power” indicator lamps are off.

All indicator lamps are off during normal running of engine.

In event of abnormality, the “horn” will issue warning tone.

When the engine is running.

The adjustment and repair are prohibited during the running of the engine.

For the purpose of safety, all persons and objects shall keep away from motion parts.

 Notice

Do not wear loose clothing or wear bracelet or necklace. Otherwise, such articles will be probably blocked into engine parts.

4.10.1.2.2 Stop of Diesel Engine

Avoid the stop of engine under full load.

Before stopping the engine, reduce the load and speed and run the engine under idling or low-load condition for 3~5min to cool down the pistons, cylinder sleeves, bushings, shaft sleeves, and turbocharger for a sufficient time, in order to prevent the scuffing and bushing scratch.

Rotate the key switch to position “OFF” or press the stop button to stop the running of engine, till the flywheel stops rotation or the speed indication on the instrument panel is zero.

If the diesel engine circulating water is not added with antifreeze, ensure to drain the coolant after stop in cold days, in order to prevent the frozen damage of diesel engine. The water drainage valve is located beneath the oil cooler. Rotate the water drainage valve switch to drain the water from diesel engine. At the same time, disassemble the water drainage plug from the radiator to drain the coolant from the radiator.

4.10.1.3 Malfunction diagnosis

1. The starter motor is not working, even when the switch of starter motor is turned on.

	Cause	Troubleshooting
1	Insufficiently charged battery	Check and charge or replace battery
2	Poor contact of connecting wires	Look up and tighten wiring posts
3	Burnt fuse	Replace fuse
4	Poor contact of electric brush	Clean electric brush surfaces or replace electric brush
5	Short-circuit of starter motor	Check and repair motor or replace assembly

2. The drive gear is engaged, but the engine is not running – Weak starter motor

	Cause	Troubleshooting
1	Insufficiently charged battery	Check and charge or replace battery
2	Wear of bearing bushing	Replace assembly
3	Loose weld of wire ends	Re-weld
4	Poor contact of switch	Check and repair switch

3. The drive gear moves forward, but can't engage with ring gear.

	Cause	Troubleshooting
1	Insufficient movement distance of starter motor gear	Check motor or replace assembly
2	Tooth collision of starter motor or flywheel ring gear	Replace starter motor or flywheel ring gear

4. After the start of engine, the starter motor doesn't stop rotation when the starter motor switch is turned off.

	Cause	Troubleshooting
1	Return failure of switch	Check and repair switch
2	Return failure of starter motor gear	Check and repair motor or replace assembly

4.10.1.4 Main data and technical specification

The DC starter motor is in voltage of 24V, with right-hand rotation direction and 12 teeth. The circuit diagram of starter motor is shown in figure below. The internal circuit of the starter motor is already connected.

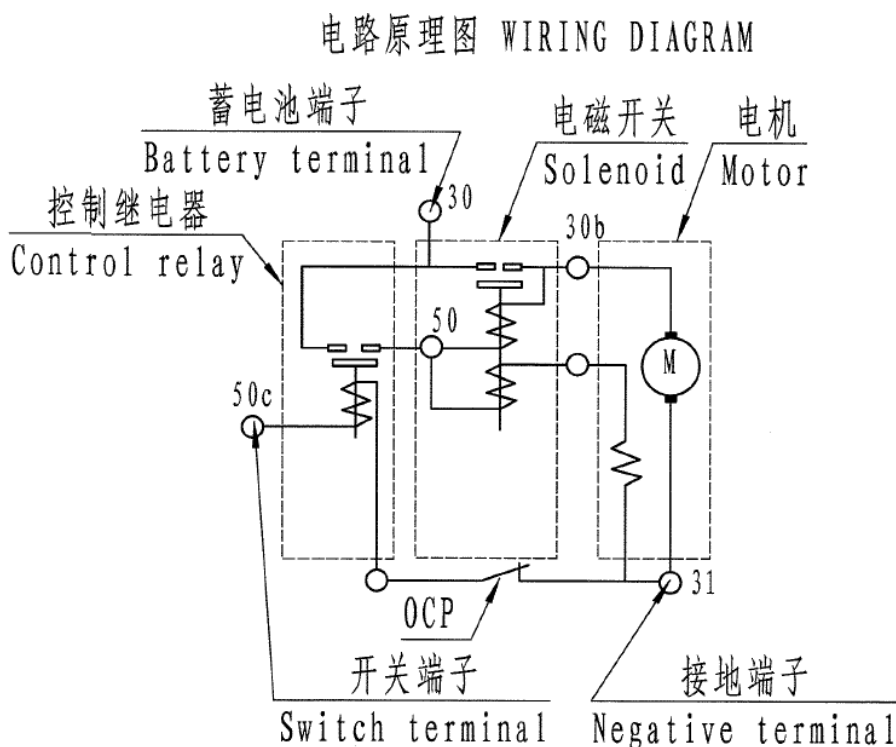


Figure 4-65 Circuit diagram of starter motor

4.10.2 Starter

4.10.2.1 Overview of starter motor

4.10.2.1.1 Function and basic structure

The starter motor is one of the core parts of vehicle starter system and is functioned to convert the electric energy of battery to electromagnetic torque and, via the gear and ring gear mechanism, drive the rotation of engine to start the engine. The starter motor is mainly composed of DC motor, one-way clutch, starter pinion (or reduction gear train), electromagnetic switch, and starter relay.

4.10.2.1.2 Model and classification

In accordance with the regulations of the industry standard QC/T73-93 Preparation Method of Product Model for Automotive Electric Equipment of the People’s Republic of China, the composition of model number for the automotive starter motor is as below:

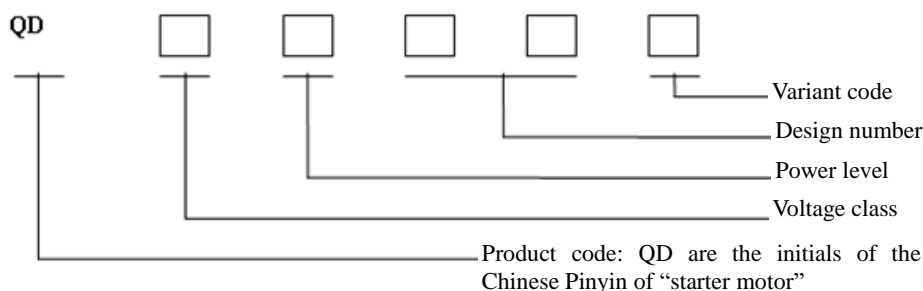


Figure 4-66 Model designation of starter motor

QD denotes starter motor; QDJ denotes reduction starter motor; QDY denotes permanent magnet starter motor (including the permanent magnet reduction starter motor).

Voltage grade code: 1 denotes 12V and 2 denotes 24V.

Power grade code: As listed in Table 4-26.

Table 4-26 - Power grade code

Power level code	1	2	3	4	5	6	7	8	9
Power / kW	<1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8

At present, the starter motor equipped on our products adopts the electromagnetically driven flexible engagement mode and can be divided by drive gear engagement mode to armature motion starter motor and shifting fork gear motion starter motor (of which the latter accounts for a high proportion) and by drive mechanism to direct drive starter motor (Equal speed for starter motor rotor and starter motor gear) and reduction starter motor (The speed of starter motor gear is less than rotor speed).

4.10.2.2 Installation specification of starter motor

4.10.2.2.1 Installation of starter motor

Before the assembling of starter motor, check the status of junction surface between starter motor and flywheel cover. The junction surface shall be free of burr, oil mist, and knocking damage.

Screw three M10×25 studs into flywheel cover by stud tooling and tighten the studs (As shown in Figure 1). Put the ring washer on the starter motor and place the starter motor vertical to the installation hole, pass the starter motor through the studs and install to the flywheel cover, and ensure the correct engagement of starter pinion (As shown in Figure 2). Use three M10 type 1 hexagon nuts attached with standard spring washer install the starter motor loosely to the flywheel cover and tighten the nuts symmetrically to 64N.m~76N.m (As shown in Figure 3) by a 16mm open-end wrench.

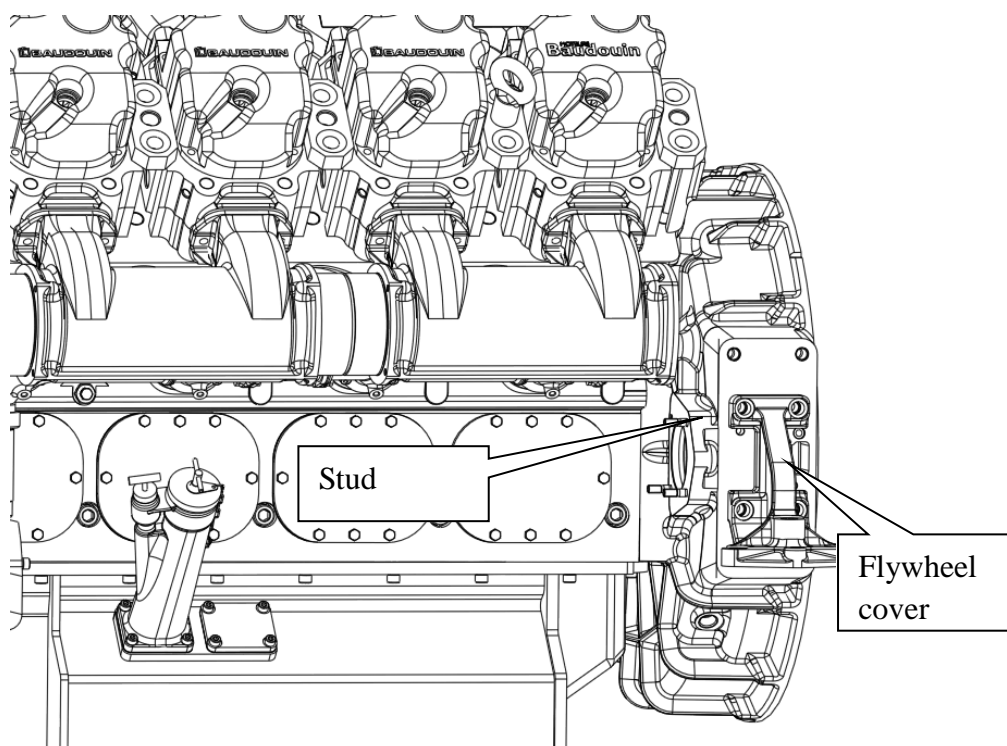


Figure 4-67 Installation of studs

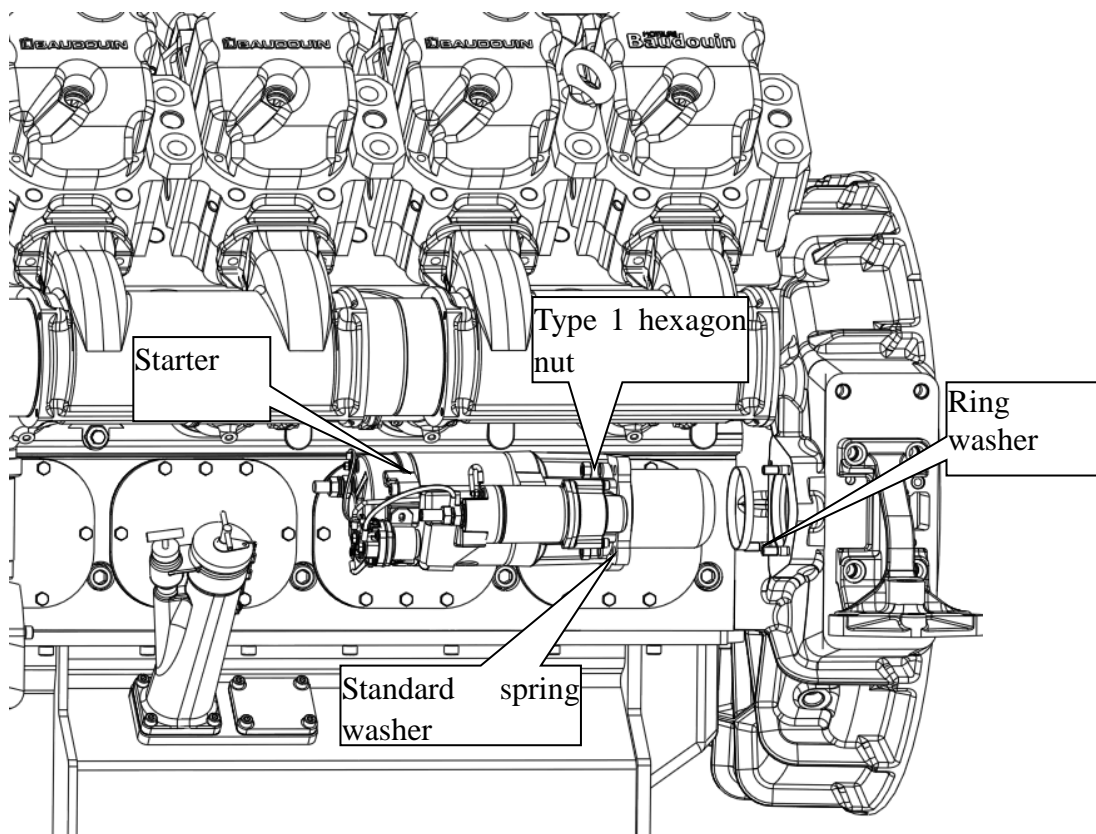


Figure 4-68 Loose installation of starter motor

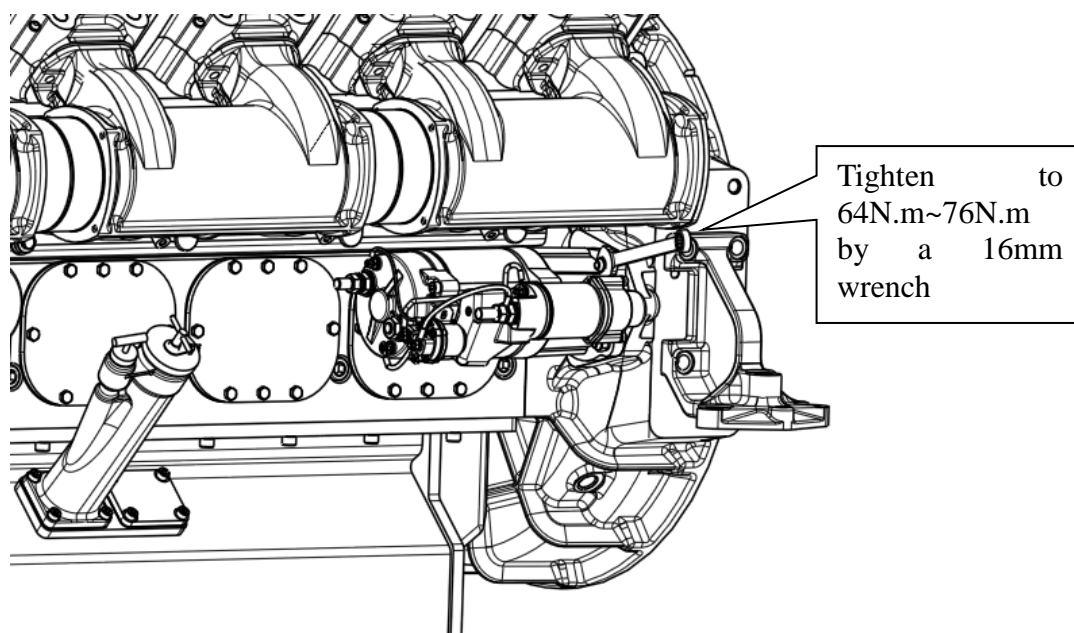


Figure 4-69 Tighten bolts as per specification

4.10.2.2.2 Wiring of starter motor

The wiring of starter motor must be correct, secure, and safe. The tightening torques are listed in the table below.

Table 4-27 Tightening torques

Screw specification	Tightening torque (N.m)	Screw specification	Tightening torque (N.m)
M5	2~2.5	M10	13.5~15.8
M8	8.4~10.5	M12	24.7~27.5

4.10.2.2.3 Disassembling of starter motor

To disassemble the steering pump, disassemble the bolts by a 16mm wrench, take out the nuts and washers, and lightly knock the housing by a rubber hammer (never knock by a hard object) to disassemble the starter motor.

4.10.2.3 Common Malfunction Diagnosis and Troubleshooting of Starter Motor

4.10.2.3.1 Start failure

Symptom 1: The starter motor doesn't rotate at the time of start, without any sound.

Cause 1: Malfunction of starter switch

Checking: Check the starter master switch and the starter control relay for normal functioning.

Troubleshooting: Replace malfunctioned part.

Cause 2: Burnt starter circuit fuse

Checking: Check the starter circuit fuse.

Troubleshooting: Replace the fuse. If the fuse is burnt once again at the next start, check the circuit for presence of short-circuit point and solve the short-circuit. If the external circuit is normal, the starter motor is internally short circuited and needs to be replaced.

Cause 3: Locking of starter circuit.

Checking: Check whether the transmission is at neutral gear and whether the safety switch is normal.

Troubleshooting: Shift the transmission to neutral gear and ensure the normal safety switch.

Cause 4: Open-circuit of starter motor

Checking: Check the switching motor terminals of starter motor for voltage to ground. If the voltage to ground is zero at the time of start, the internal circuit of starter motor is open circuited.

Troubleshooting: Replace starter motor.

Symptom 2: The starter motor is not rotating, but a clear and short “click” sound can be heard.

Cause 1: Low voltage of battery.

Checking: Under the stop state of engine, turn on the headlamp for 1~3min and then measure the battery voltage. If the measurement is less than 24V, it indicates the low power of battery.

Troubleshooting: Connect an external power supply to charge the battery, or replace the battery, or start the engine by an external power supply via cables.

Cause 2: Excessive voltage drop at start due to excessive internal resistance of starter circuit.

Checking: Compare the terminal voltage of battery with the terminal voltage to ground of starter motor. The voltage difference shall be no higher than 1V. Measure the control terminal voltage and the battery terminal voltage. The voltage difference shall not be higher than 1V.

Troubleshooting: Increase the sectional area of wires to reduce the internal resistance. The recommended sectional area is at least $1.5 \text{ mm}^2 \sim 2 \text{ mm}^2$.

Cause 3: Occurrence of “tooth collision” symptom (The drive gear of starter motor comes into contact with end face of flywheel ring gear).

Troubleshooting: Disassemble the starter motor and check the drive gear and flywheel ring gear end face for excessive wear.

Troubleshooting: Replace the drive gear or isolator of starter motor and replace flywheel ring gear.

Cause 4: Internal malfunction of starter motor. The possible causes include short-circuit of armature and excitation winding, surface oxidizing, ablation, or oil dirt of commutator, poor contact of electromagnetic switch, wear of electric brush, and insufficient pressure of electric brush spring.

Checking: Disassemble the starter motor and test the functioning of starter motor by an external normal circuit.

Troubleshooting: Disassemble the starter motor for checking and repair by professional repair personnel of starter motor.

Symptom 3: High noise, abnormal sound, or intermittent running

Cause 1: Abnormal starter motor installation and damaged starter motor gears.

Checking: Disassemble the starter motor, check the starter motor gears and flywheel ring gear, and analyze for correct installation.

Troubleshooting: Correctly install the starter motor. If the starter motor gears are damaged, replace the starter motor.

Cause 2: Excessive depletion of battery.

Checking: Under the stop state of engine, turn on the headlamp for 1~3min and then measure the battery voltage. If the measurement is less than 24V, it indicates the low power of battery.

Troubleshooting: Connect an external power supply to charge the battery, or replace the battery, or start the engine by an external power supply via cables.

Cause 3: Turn-to-turn short-circuit of relay coil, poor contact of relay contact, and turn-to-turn short-circuit of electromagnetic switch coil.

Checking: Replace relay and restart starter motor. If the starter motor can work normally, the original relay is damaged.

Troubleshooting: Replace with new relay.

Symptom 4: Idling of starter motor.

Cause 1: Deformation of shifting fork or loose shifting fork linkage.

Checking: Disassemble the starter motor, power on the starter motor by an external circuit, and observe the starter motor gears for presence of protrusion.

Troubleshooting: Replace starter motor.

Cause 2: Serious damage of certain segment due to breakage or excessive wear of ring gear and slip or damage of one-way clutch.

Checking: Disassemble the starter motor and observe the wear extent of starter motor gear and flywheel ring gear.

Troubleshooting: Repair by welding or replace the flywheel ring gear. If the starter motor is still idling, replace the starter motor (The one-way clutch is damaged).

Symptom 5: Constant rotating of starter motor.

Cause 1: Return failure of ignition switch.

Checking: Replace ignition switch and perform start test.

Troubleshooting: Replace ignition switch.

Cause 2: Ablation of relay contact and disqualified breaking voltage of contact.

Checking: Replace starter motor and perform start test.

Troubleshooting: Check, repair, adjust and replace.

Cause 3: Ablation of starter motor contact or damage of contact coil spring and soft or broken return spring of drive fork.

Checking: Replace starter motor and perform start test.

Troubleshooting: Replace starter motor.

4.10.2.3.2 Judge malfunction points on vehicle

Check appearance of starter motor for obvious abnormality, such as ablation, looseness, deformation, and damage.

Firstly, check the battery voltage and all switching voltages.

Start by using the auxiliary starter switch and verify the normal start control system. Operation method of auxiliary starter: Shift the transmission to neutral gear, place the ignition switch to “ON”, open the engine hood, and press “Start”. After the engine is started, immediately release the button to complete the start by using the auxiliary starter.

Replace the starter motor. If the malfunction disappears after the adoption of measure c), the malfunction exists in the start control circuit. If the malfunction still exists, further judge the malfunction source by replacement method. Replace the malfunctioned starter motor by a good one or disassemble the wires of starter motor, connect the battery and starter motor directly by auxiliary wires, and observe the start effect. If the start is normal, the malfunction exists in the start control circuit. Otherwise, the starter motor is the malfunction source.

4.10.2.3.3 Malfunction judgment of starter motor parts

Manual rotation of isolator in both directions

Discoloration of drive shaft

Ablation or damage of electromagnetic switch

4.10.2.3.4 Replacement criterion of starter motor parts

The residual length of the worn electric brush is less than half of its original length.

Original length of M90 series electric brush: 18

Original length of M93 series electric brush: 20.5

Original length of M105 series electric brush: 21.5

The wear of armature commutator is higher than 1mm.

The original diameter of M90 series commutator is $\varnothing 39$.

The original diameter of M93 series commutator is $\varnothing 35$.

The original diameter of M105 series commutator is $\varnothing 39$.

The electromagnetic switch and the starter relay are used continuously for 2 years (20,000 start cycles).

4.10.2.4 Daily maintenances of starter motor

Check the starter motor for secure installation and wiring.

Remove the surface oil dirt of starter motor.

Check the drive gear and flywheel ring gear.

Remove the surface oil dirt of drive shaft.

Clean the terminals of battery.

The starter motor is a short-time working unit. The start time shall not exceed 15s each time and the interval between two consecutive starts shall be $>30s$.

When the temperature is below -5°C in winter, preheat the engine before start.

To start the diesel engine in winter or under low temperature condition, take the thermal insulation measure for the battery.

Once the engine is started, Immediately release the starter switch to disengage the starter motor drive gear from flywheel ring gear.

4.10.3 Malfunction diagnosis and troubleshooting of charging system

4.10.3.1 Charging failure

Malfunction 1: Charging failure		
Vehicle symptom	Failure detection	Troubleshooting
(1) The charging indicator lamp fails to turn on after turn-on of key switch.	a. Check charging indicator lamp. b. Check the excitation circuit for presence of open-circuit.	① Check alternator indicator lamp for presence of voltage to ground. If not, replace indicator lamp or check circuit. ② If yes, it indicates that the alternator regulator or rotor is malfunctioned. Repair or replace alternator.
(2) The charging indicator lamp fails to turn off	a. Low power of indicator lamp or loose parallel excitation resistor. b. Low idling	① Use recommended 2~6W lamp bulb or repair circuit. ② Adjust idling speed of the engine.

<p>during idling of engine and turns off during high-speed running of engine.</p>	<p>speed of engine.</p>	
<p>(3) The charging indicator lamp fails to turn off while the engine is running.</p>	<p>a. Check whether the voltage to ground of the alternator exciting terminal is within 1~3V.</p>	<p>① If the alternator indicator lamp terminal voltage is really low, it indicates low power of excitation line indicator lamp or loose connection in circuit. Adjust the indicator lamp power or check the circuit connectors and connection points. ② If the alternator indicator lamp terminal voltage is zero, it indicate the presence of short-circuit to ground at the excitation circuit alternator terminal. In such case, check the circuit. ③ If the alternator indicator lamp terminal voltage is the battery voltage, it indicates the presence of malfunction in vehicle excitation circuit and that the alternator regulator and excitation tube may be damaged. In such case, make sure to correct the excitation circuit and then repair the alternator.</p>
	<p>b. Check whether the voltage to ground of the alternator output terminal B+ equals to battery voltage of approximately 24V.</p>	<p>① If the B+ voltage to ground is zero, check whether both the positive and negative wires between alternator and battery are under continuity status. ② If the B+ voltage to ground is significantly below the battery voltage, check the connecting points of positive and negative wires between alternator and battery for presence of looseness or check the battery for damage. Recommended measurement method: Jumper connect one 2W indicator lamp between alternator output terminal B+ and excitation terminal D+/L and observe the working status of indicator lamp. Troubleshooting: ① The lighting intensity of indicator lamp is normal, the indicator lamp turns off after the engine is started, and the alternator output voltage is 27~28.5V. The vehicle excitation circuit is malfunctioned and needs checking and repair. ② The lighting intensity of indicator lamp is normal, the indicator lamp turns on constantly after the engine is started, and the alternator output voltage is 27~28.5V. The alternator</p>

		<p>regulator is malfunctioned and needs to be replaced.</p> <p>③ The lighting intensity of indicator lamp is normal, the indicator lamp turns on constantly after the engine is started, and the alternator output voltage is the battery voltage. The alternator regulator, rectifier bridge, stator, or internal connection may be malfunctioned and need repair or replacement.</p>
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4.10.3.2 Low charging voltage

Malfunction 2: Low charging voltage		
Vehicle symptom	Failure detection	Troubleshooting
The battery is frequently charged insufficiently, with low charging voltage, and its voltage drops significantly when being loaded.	Understand whether the alternator output power is reasonably matched with the electric devices of vehicle.	The measurement of alternator terminal B+ voltage shall be at 27.8~28.4V. If the voltage is normal, it indicates that the voltmeter or voltmeter sampling point is malfunctioned and needs to be repaired or replaced.
	a. Check voltmeter for damage.	① It's recommended that the no-load idling speed of alternator is higher than 1600RPM. ② When the alternator is working under high power load condition (for instance, the air conditioner is switched on), the alternator speed shall be $\geq 2000\text{rpm}$ or the voltage shall be approximately 27V.
	b. Check the alternator speed.	
	c. Check the drive belt quality and tension for alternator and related gear system.	① Check the quality of belts for alternator and relevant pulley systems and replace any burnt, ruptured, distorted belt or the belt with tooth breakage or the belt dropping to the bottom of groove. ② Re-tension the alternator and relevant pulley systems. ★ Notice: For the systems with double drive belt, replace both belts in event of replacement.
	d. Check alternator pulley.	Tighten if loosened.
e. Check wires for reasonable use and measure voltages at alternator and battery terminals.	① If the voltage difference is higher than 1V (high voltage drop due to thin wires) under heavy-load condition, replace the wires. if $\leq 35\text{A}$, then $S \geq 6\text{mm}^2$; if $\leq 70\text{A}$, then $S \geq 12\text{mm}^2$ if $\leq 100\text{A}$, then $S \geq 20\text{mm}^2$; if $\leq 150\text{A}$, then $S \geq 25\text{mm}^2$ ② If the wire or connector has clear temperature	

		rise under heavy-load working condition, replace the wire or connector.
	f. Check for presence of high temperature due to looseness, oxidation, or loose connection at the joint between wire and bolt of charging system.	① Grind the wire lugs with oxidized surfaces and the housing surface for installation of grounding bolt and reinstall. ② Retighten any loose nut and wire lug and re-insert the connectors. ★Notice: Run the reinstalled or re-tightened portions for 3~5min when the alternator is under heavy-load and then check for the presence of high temperature.
	g. Check the phase output voltage of alternator (This voltage shall be approximately one half of B+ output voltage.)	If there is high difference between phase terminal (W/R/AC) output voltage and normal output, the alternator rectifier bridge or stator is malfunction and the checking and replacement shall be considered.
	h. Check the battery for normal charging.	The charging current shall drop to approximately 10A after 10min charging. If the charging current is at 30~90A constantly, the battery is damaged and needs repair or replacement.

4.10.3.3 High charging voltage

Malfunction 3: High charging voltage		
Vehicle symptom	Failure detection	Troubleshooting
The voltmeter indicates high voltage	a. Check voltmeter for damage.	The measurement of alternator B+ terminal voltage generally shall be at 27~28.4V. If the voltage is normal, it indicates that the calibration error of voltmeter is high and the voltmeter needs to be repaired or replaced.
	b. Check the wires and connections of the charging system, check the connection bolts for presence of looseness, loose connection, and high temperature, and check for presence of short-circuit between wires	① In event of poor contact or loose connection, retighten or re-insert the connectors. ② In event of short-circuit, re-connect the wires.

	and alternator housing.	
	c. Check battery for normal working status.	<p>① Observe during the charging of battery whether the charging current varies greatly within a short period (from 50A to below 10A). If not, the replacement of battery as soon as possible shall be considered.</p> <p>② Observe the battery surfaces for cleanliness and dryness and check whether the wiring terminals and clamps are in good fit. Replace as soon as possible in event of any damage.</p>
	d. Check the phase terminal output voltage of alternator (This voltage shall be approximately one half of B+ output voltage).	If there is high difference between phase terminal (W/R/AC) output voltage and normal output and the voltage drop is high when the alternator is loaded, the alternator rectifier bridge or stator is malfunctioned and the checking and replacement shall be considered.
	e. The malfunction symptom is not solved after above checking.	Replace alternator regulator, rotor, or whole alternator.

4.10.3.4 Unstable charging voltage

Malfunction 4: Unstable charging voltage		
Vehicle symptom	Failure detection	Troubleshooting
The voltmeter indicates the charging during normal running of engine, but the pointer fluctuates and the reading can't be read (or the charging indicator lamp turns off occasionally).	a. Loose belt or belt run-out for alternator or related pulley systems.	Tension belts for alternator and related pulley systems.
	b. Looseness or poor contact at connections of charging circuit	Check and tighten connections of charging circuit
	c. Contamination of collector ring, excessive wear of electric brush, or softening or breakage of electric brush spring	Remove contaminants or replace electric brush or electric brush spring
	d. Damage of regulator	Replace the regulator.

4.10.3.5 Alternator noise

Malfunction 4: Unstable charging voltage		
Vehicle symptom	Failure detection	Troubleshooting
There is an abnormal noise during running of alternator.	a. The fixing bracket of alternator is deformed or is too close to other external housings.	Improve strength of fixing bracket and adjust installation status.
	b. Looseness or slip of alternator belt	Replace engine belt.
	c. Loose alternator pulley	Tighten pulley.
	d. Oil shortage or damage of alternator bearings	Replace alternator bearing
	e. Low noise within alternator	The stator coil is short circuited. Replace it.
	f. Speed-dependent squealing within alternator	This is the noise generated by the vibration of stator iron core. If necessary, replace stator subassembly.

4.10.4 Generator

4.10.4.1 Basic operation rule of alternator

4.10.4.1.1 Secure installation

The alternator shall be installed on the engine or vehicle correctly, securely, and reliably. The mounting bolts must match with mounting holes of alternator and must be tightened. The grooves of the pulley shall be within same plane with those of drive pulley.

★ Recommendation: Immediately tension the belt after 20km mileage or 20min engine running time for a new vehicle. Periodically check the belt for proper seating within the grooves. The mounting bracket for the alternator must ensure the necessary strength and stiffness requirements.

4.10.4.1.2 Appropriate tension of belt

The appropriate belt tension is generally in such manner that the belt deflection is 10~20mm when a 150N (15kgf) force is applied onto the belt in the middle point between two pulleys (or that the belt is free of obvious vibration during loaded running). Check the belt tension once every 2 months.

★ **Warning:** The loose belt will lead to “speed loss” of the alternator and cause the malfunctions such as insufficient power generation, battery depletion, stator burnout, and bearing damage. A new replacement belt must be re-tensioned after 5min running.

Recommendation: Appropriately adjust the adjustment arm to ensure the appropriate belt tension and tighten all fastening nuts of motor to specified torque.

4.10.4.1.3 Correct and secure wiring

1. Description of alternator wiring terminals. Never connect the terminals incorrectly, in order to prevent burning the vehicle harnesses and damaging the alternator units.

B+: Positive terminal, to battery and other loads (with battery motor).

B-: Negative output, to circuit (double wire system motor).

E: Negative grounding terminal.

N: Neutral terminal.

W/AC/R: Phase output terminal.

IG/WL/D+/L: Charging indicator lamp terminals (sometimes also with excitation function. The 2W indicator lamp is recommended. The terminals D+/WL can output $\leq 1A$ current.

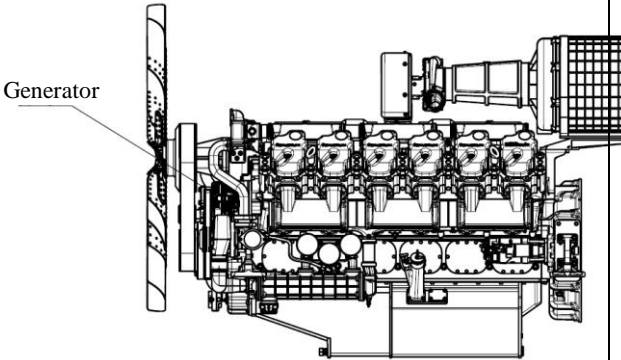
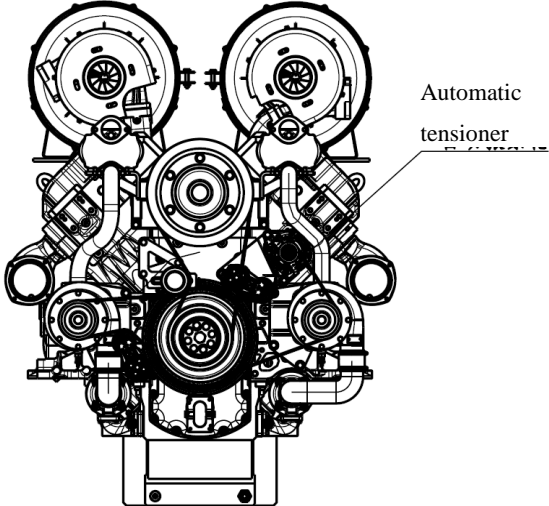
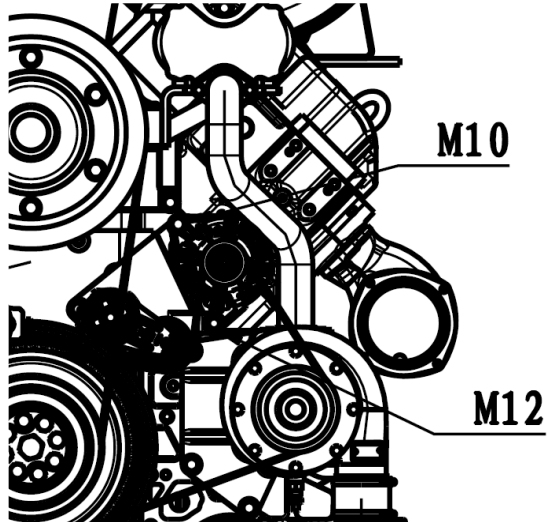
2. For an alternator without battery application, there are special wiring requirements. Please refer to the operation instruction of alternator without battery application.

★ **Warning:** Ensure to periodically check the fastening status for the nuts (bolts) and wiring plates. Looseness (loose connection) will lead to insufficient power generation and generate electric spark at loose point to bring about major potential dangers for the operation safety of the vehicle (especially the high-power motors). It's prohibited to bind up the output wires of alternator with the high pressure gas pipe of the vehicle or the engine or the oil pipes.

3. Before the disassembling/assembling of alternator and electric welding of vehicle, ensure to disconnect the wires of battery and alternator.

★ **Special notice:** Disconnect the negative wire before positive wire for disassembling and connect positive wire before negative wire for installation.

4.10.4.2 Disassembling and installation method of alternator

<p>Generator installation position.</p> 	<p>2. Loosen the automatic tensioner and disassemble the poly V-belt from alternator pulley.</p> 
<p>3. Disassemble the M12 and M10 mounting bolts of alternator.</p> 	<p>4. The installation sequence for the alternator is in reverse order of the disassembling sequence.</p>

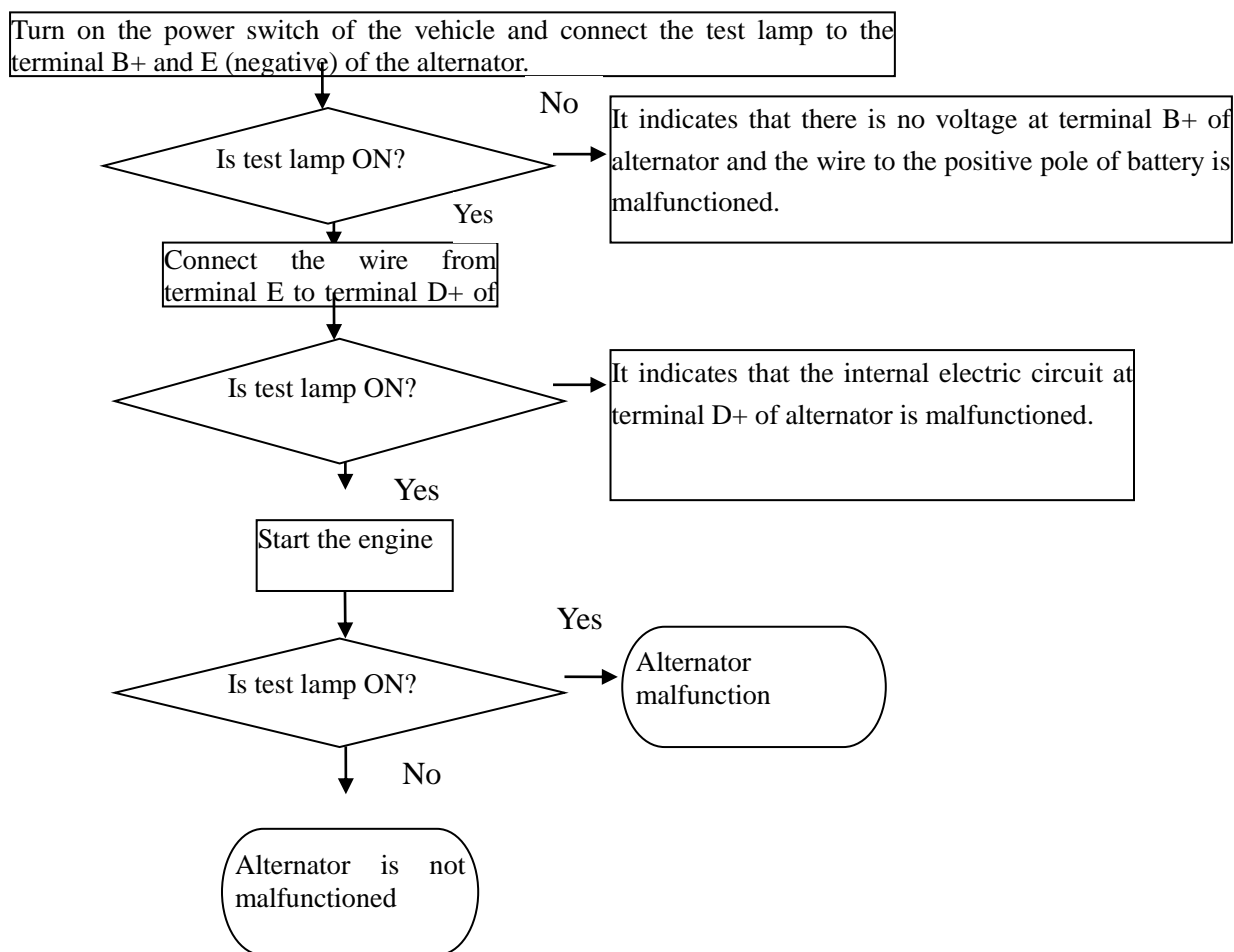
★ Notice: The alternator must be disassembled, assembled, and repaired by professionals. During installation, check all insulation gaskets and sleeves for intactness and ensure to replace any damaged one. The positive terminal of alternator can't be short circuited with the housing; otherwise it's prohibited to install the alternator onto the vehicle to prevent causing serious vehicle accidents.

4.10.4.3 Malfunction diagnosis and maintenance of alternator

4.10.4.3.1 Procedure for judgment of alternator malfunction

During the warranty service for the user, firstly test on the vehicle to judge whether the

alternator is malfunctioned. Tool: Test lamp. The procedure is shown in figure below.



Flowchart for judgment of alternator malfunction

4.10.4.3.2 Maintenances of alternator

The timely and correct maintenances are effective means to prolong the service life of alternator and improve the operation efficiency of whole vehicle. Therefore, the systematic and standardized maintenances are required for the alternator.

Main maintenance items;

Check the wear and slip status of belt.

Check wires for broken ends and damage.

Check all fasteners of alternator and all wiring post nuts of alternator. Check the terminal nuts of all electric devices for looseness and retighten all fasteners to prevent the vibration of alternator from causing hitching of bracket and alternator or prevent the loose connecting nuts from causing flow-through of high current and damage of regulator.

Timely remove the dusts and oil dirt from alternator.

Periodically check the wear status of alternator carbon brush and slip ring and when necessary remove the dusts adhered onto the slip ring by sand paper.

Check the fan blades for damage and when necessary replace with new fan.

Maintenance-free for full-sealed heavy-duty bearings.

Annex A Recommended Torque for Standard Bolts

Recommended Torques for Standard Bolts

Friction coefficient	0.125 (zinc plated)				0.14 (polished)			
	6.9	8.8	10.9	12.9	6.9	8.8	10.9	12.9
Strength grade	6.9	8.8	10.9	12.9	6.9	8.8	10.9	12.9
Bolt size	Recommended torque (N·m)							
M4	2.3	2.7	3.8	4.6	2.4	2.9	4.1	4.9
M5	4.7	5.5	8.0	9.5	5.0	6.0	8.5	10
M6	8.0	9.5	13.0	16.0	8.5	10	14.0	17
M8	19	23	32	39	21	25	35	41
M10	39	46	64	77	41	49	69	83
M12	67	80	110	135	72	86	120	145
M14	105	125	180	215	115	135	190	230
M16	165	195	275	330	180	210	295	355
M18	225	270	390	455	245	290	405	485
M20	325	385	540	650	345	410	580	690
M22	435	510	720	870	465	550	780	930
M24	560	660	930	1100	600	710	1000	1200
M27	830	980	1400	1650	890	1050	1500	1800
M30	1100	1350	1850	2250	1200	1450	2000	2400
M8×1	21	25	35	42	23	27	38	45
M10×1.25	41	49	66	82	44	52	73	88
M12×1.25	74	88	125	150	80	95	135	155
M12×1.5	70	83	115	140	76	90	125	150
M14×1.5	115	140	195	235	125	150	210	250
M16×1.5	175	210	295	350	190	225	315	380
M18×1.5	255	305	425	510	275	325	460	550
M20×1.5	360	425	600	720	385	460	640	770
M22×1.5	480	570	800	960	520	610	860	1050
M24×1.5	610	720	1000	1200	650	780	1100	1300
M27×1.5	890	1050	1500	1800	970	1150	1600	1950
M30×1.5	1250	1450	2050	2500	1350	1600	2250	2700

Annex B Recommended Torque for Hollow Bolts

Recommended Torques for Hollow Bolts

Specification	Head type	Recommended tightening torque (Nm)
M8×1	Hexagon head	7±1
M10×1	Hexagon head	17±2
		13±2 (Copper bolt and small combination washer)
M12×1.5	Flange bolt	20±3
	Hexagon head	22±3
M14×1.5	Flange bolt	28±3
	Hexagon head	27±3
M16×1.5	Flange bolt	32±3
	Hexagon head	30±3
M18×1.5	Flange bolt	36±3
	Hexagon head and flange bolts	60±5

Appendix C Fit Clearances for Main Parts of Diesel Engine

SN.	Item	Theoretical
1	Main bearing clearance	0.122~0.202
2	Connecting rod bearing clearance	0.093~0.167
3	Crankshaft endplay	0.1~0.346
4	Connecting rod axial clearance	0.26~0.452
5	Clearance between connecting rod small end and piston pin	0.031~0.081
6	Working clearance of piston ring opening in cold state	
	1st ring	0.45~0.6
	2nd ring	0.75~1
	Oil ring	0.45~0.7
7	Clearance between piston pin and piston pin seat	0.01~0.024
8	Clearance between intake valve stem and valve guide	0.04~0.07
9	Clearance between exhaust valve stem and valve guide	0.06~0.09
10	Indentation of intake valve bottom with respect to cylinder end plane	0.60~1.10
11	Indentation of exhaust valve bottom with respect to cylinder end plane	1.20~1.70
12	Protrusion of cylinder sleeve shoulder with respect to top plane of cylinder block	0.07~0.13
	Indentation of cylinder sleeve shoulder with respect to top plane of cylinder block	0.39~0.5
13	Camshaft axial clearance	0.1~0.25
14	Camshaft bearing clearance	0.055~0.128
15	Camshaft bearing clearance (thrust bearing)	0.06~0.119
16	Clearance between tappet and tappet hole	0.025~0.066
17	Clearance between outside diameter of cylinder sleeve and cylinder sleeve bore of engine block (upper portion)	0.014~0.079
	Clearance between outside diameter of cylinder sleeve and cylinder sleeve bore of engine block (lower portion)	0.03~0.095
18	Clearance between rocker sleeve and rockshaft	0.017~0.043

19	Valve clearance Intake/exhaust (cold state)	0.3 ± 0.03 $/0.3 \pm 0.03$
20	Axial clearance of rocker	0.4~0.6
21	Backlash between crankshaft gear and camshaft gear	0.09~0.20
22	Backlash between camshaft gear and fresh water pump gear	0.09~0.15
23	Backlash between fuel injection pump intermediate gear and fuel injection pump gear	0.08~0.125
24	Backlash between crankshaft gear and engine oil pump gear	0.20~0.25
25	Protrusion of fuel injector	1.87~2.68
26	Clearance between crankshaft speed sensor and flywheel	0.5~1.5