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FAWDE

Operation & Maintenance Manual For 4DW (485, 490) Series Diesel Engines

质量安全

FAW JIEFANG AUTOMOTIVE COMPANY LTD.
WUXI DIESLE ENGINE WORKS

FOREWORD

4DW series diesel engines (code: 800) have two options of cylinder bores (i.e., 85 and 90) and strokes (i.e., 95 and 100). Aspiration modes of 4DW series are natural aspiration, supercharge and supercharge inter-cooled etc. 4DW series have two options of speed, i.e., 3000 r/min and 3200 r/min. Power of 4DW series diesel engines ranges 34kW～62kW, maximum torque ranges 124.3N • m～230N • m, and speed (at max. torque) ranges 1800 r/min～2200r/min .

In this Manual, only natural aspiration type diesel engines, of which power ranges 34kW～46kW, are described. 4DW series diesel engines with a natural aspiration mode are suitable for use as power, completed for light-duty automobiles, 0.75-2t agriculture-use transport vehicles, small-size construction machinery, tractors, combines, electric generator sets etc.

This Manual describes main specification, adjusting methods, operation and maintenance requirements etc of 4DW series diesel engines. Correctly using and maintaining the diesel engines are extremely important to both travel safety and their longer service life. Users are kindly requested to read carefully this Manual and operate and maintain the diesel engines complying with its requirement.

As this series engine is in the process of ceaseless improvement and modification, the diesel engine you purchase in the future may somewhat deviate from this Manual.

When ordering engine accessories, please tell us the Model, declared power and speed, order No., month and year of manufacture, and serial No. of the diesel engine(s) you purchased, so that our company can provide you with correct accessories.

FAW Jiefang Automotive Company, Ltd.
Wuxi Diesel Engine Works
August 2006

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To Users

Dear Users :

When new diesel engines or engines just subjected to an overhaul (e.g., main parts such as piston, crankshaft or connecting rod etc are replaced) are used on automobiles, the automobile must not run at normal or heavy-load condition until it has run for a wear-in distance of 2000 km, in which engine speed should be no more than 2200 r/min and power should be 70% of full-load. This is very important to the reliability and after-overhaul service life of the engine. 4DW engines will bring you more economic effectiveness if you timely maintain them as per this Manual.

Contact phone numbers of our Works are as follows:
Sales Company: 0510-85013436 (fax)
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FAW Jiefang Automotive Company, Ltd.
Wuxi Diesel Engine Works
August 2006

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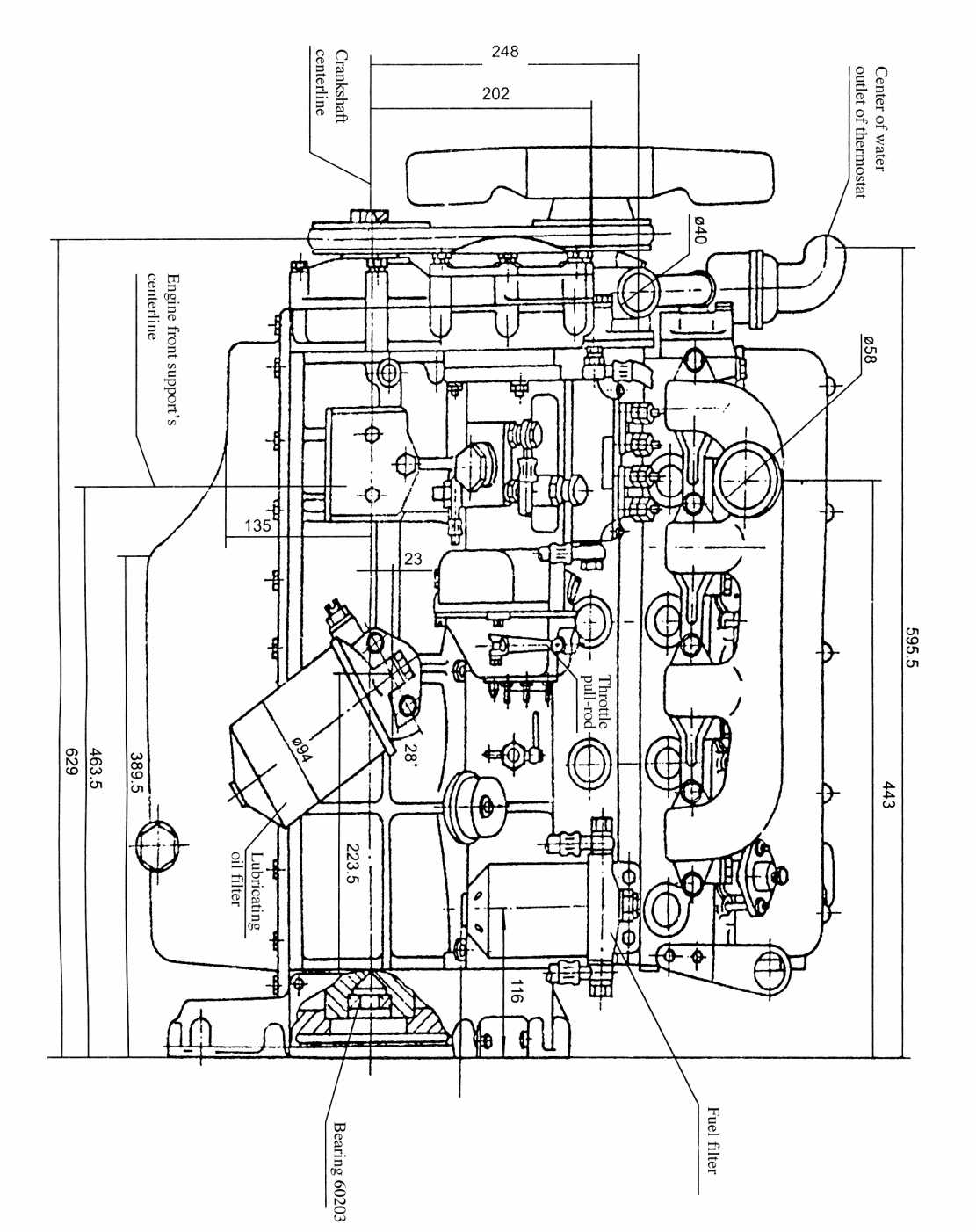
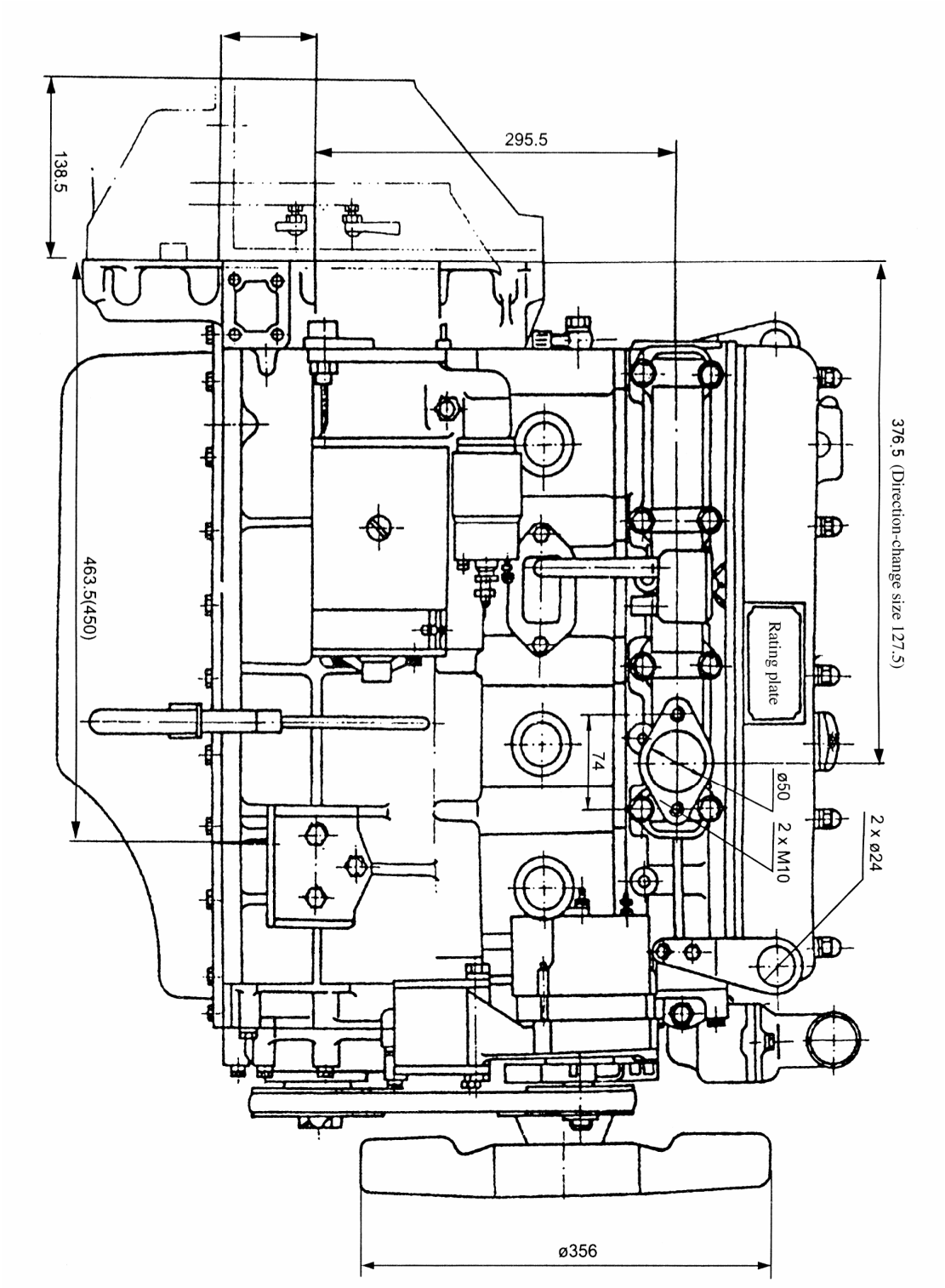
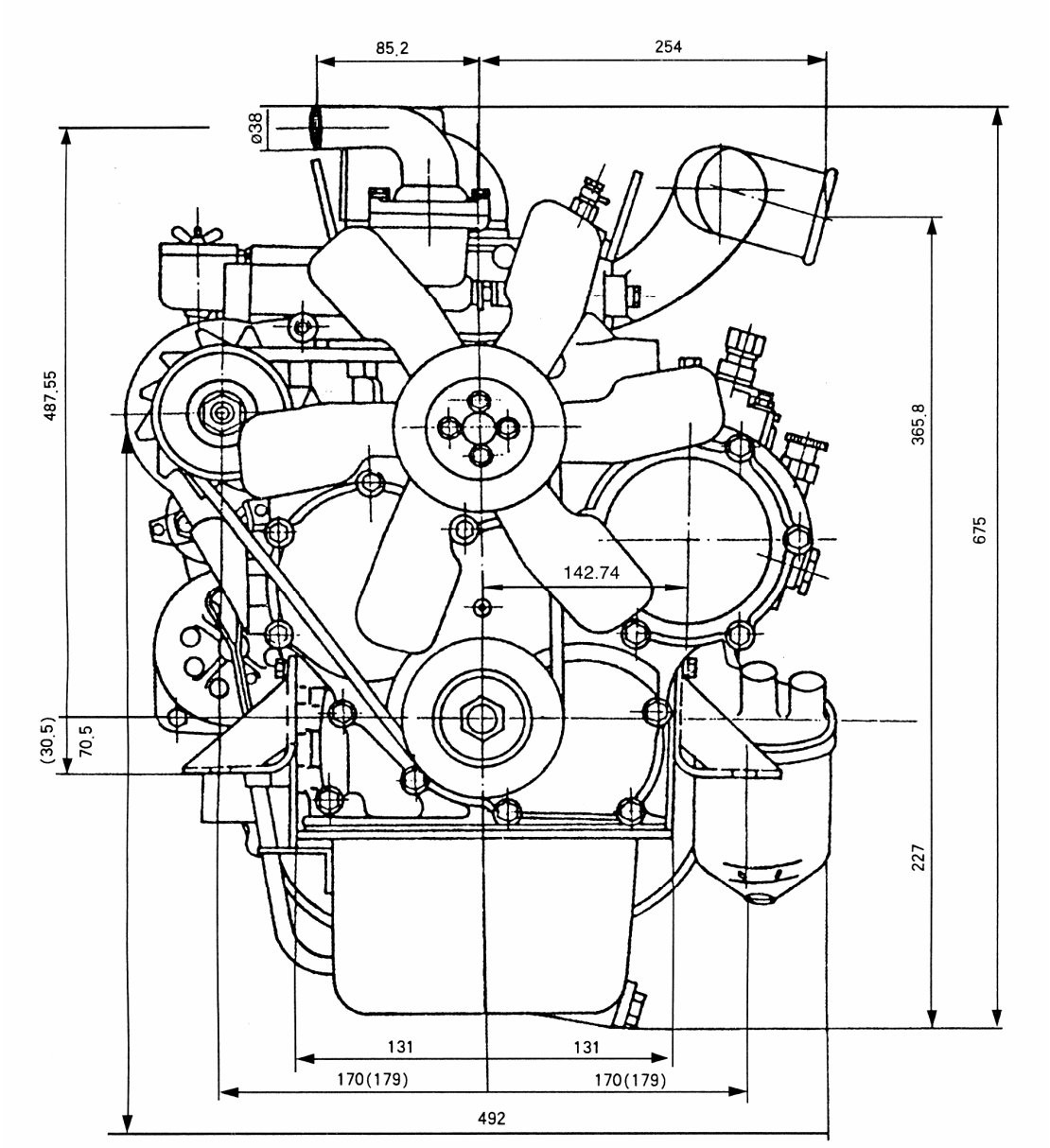


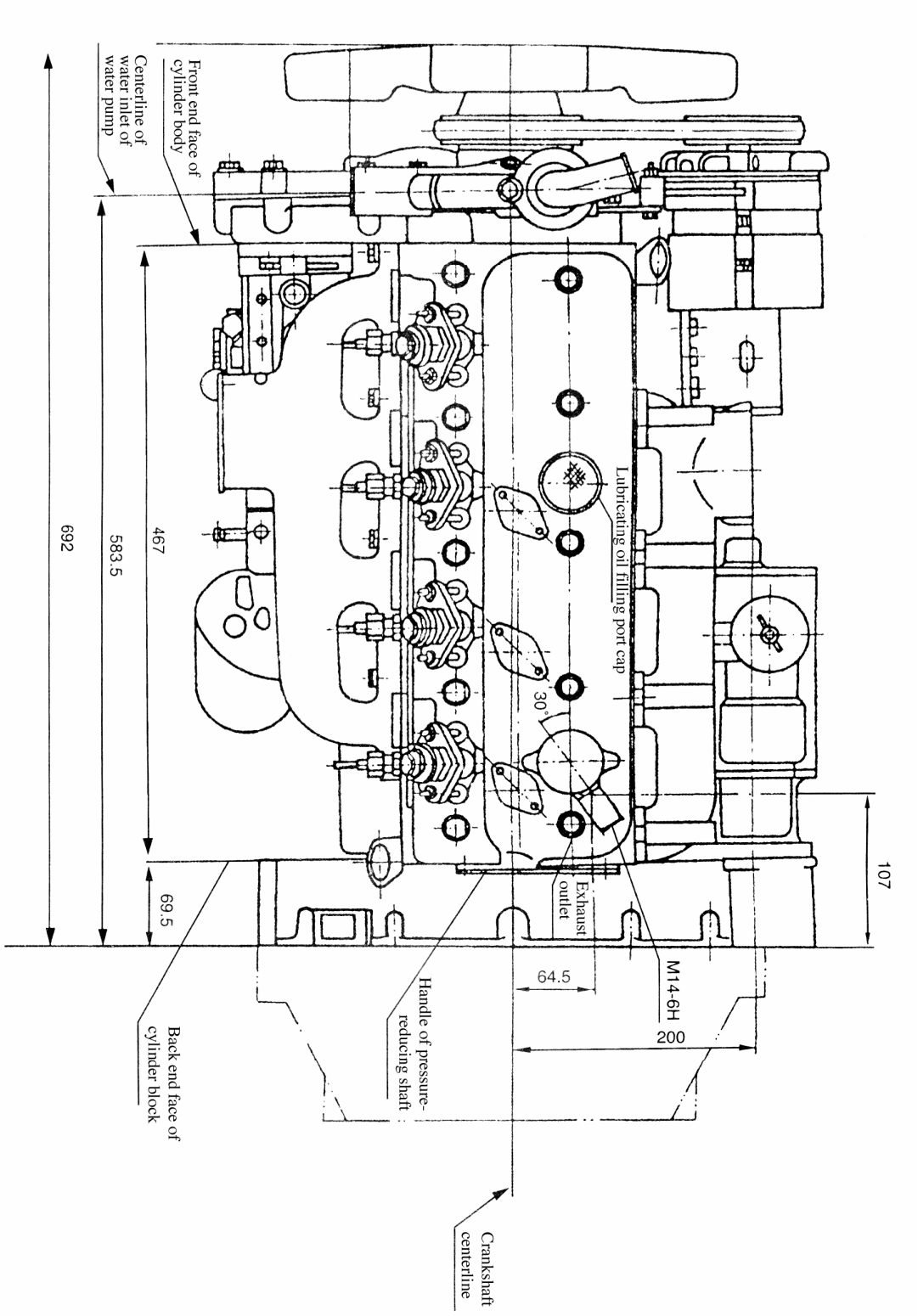
(I) Right view of 4DW81-46 diesel engine



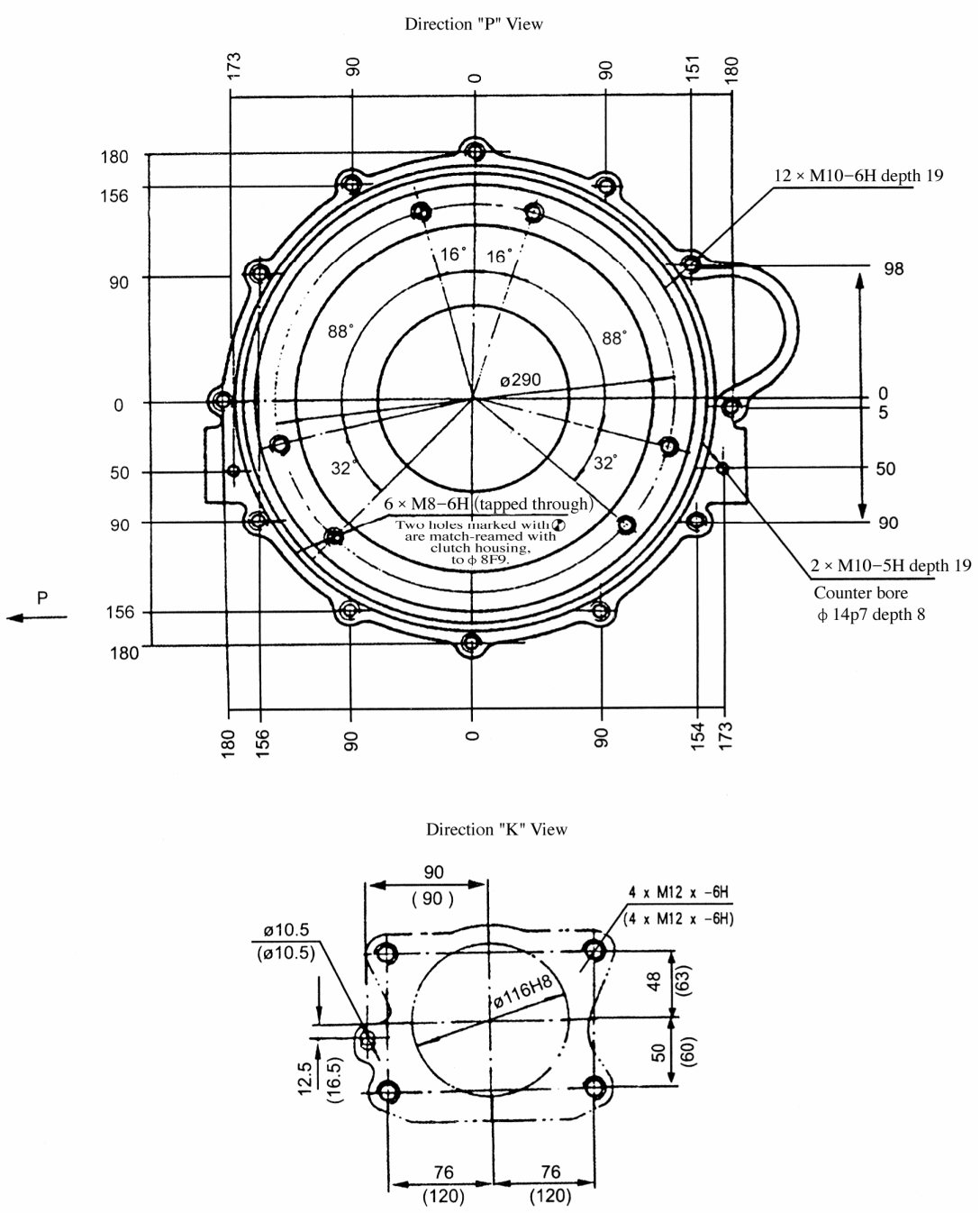
(II) Left view of 4DW81-46 diesel engine



(III) Front view of 4DW81-46 diesel engine



(IV) Vertical view of 4DW81-46 diesel engine



NOTE: In Direction "K" View, values in parentheses are suitable for NJ130, and values without parentheses are suitable for BJ130.

(V) Power output end of 4DW81-46 diesel engine

Chapter I　Technical Characteristics

I.　Technical parameters for 4DW(B00) diesel engine & its variants

1	Model/designation	4DW81-46/B01	4DW81-50/B05	4DW81-49/B71	DW91-63/B41	4DW91A63/B45
2	Type	4-cylinder, in line, 4-stroke, water-cooled, direct-injection				
3	Aspiration mode	Natural air-suction				
4	Ignition sequence	1-3-4-2				
5	Cylinder diameter (mm) × piston stroke (mm)	85×95		85×100	90×100	
6	Piston total displacement (L)	2.16		2.27	2.54	
7	Rated power (kW)	34	37	36	46	
8	Rated speed (r/min)	3000	3200	3000	3200	
9	Max. torque (N • m)	124.3		131	155	
10	Speed at max. torque (r/min)	2200		1900	2100	
11	Minimum steady idling speed (r/min)	800 ± 50				
12	Steady regulation rate (%)	≤ 10				
13	Minimum fuel consumption at full load (g/kW·h)	≤ 235				
14	Consumption ratio of engine-oil to fuel-oil (%)	0.8				
15	Maximum smoke at full load (Bosch)	≤ 3.5				
16	Free acceleration smoke (Bosch)	≤ 3.0				
17	Crankshaft rotation direction (viewing towards flywheel)	Anticlockwise				
18	Lubrication mode	Pressure lubrication & splash lubrication				
19	Starting mode	By electricity				
20	Overall dimensions (excluding clutch housing) L × W × H (mm)	696 × 492 × 650				
21	Net weight (kg)	205				

Note: Declared power denotes the power, under atmospheric pressure of 100kPa (750 mmHg), ambient temperature of 25℃ and relative humidity of 30%, and without air filter and muffler,. When atmosphere condition is different from standard atmosphere, check-calculation should be made as per GB/T6072.1-2001 《Performance of Reciprocating Internal Combustion Engine, Part 1: Declaration and Testing Methods of Standard Basic Information, Power, Fuel and Engine Oil Consumption》.

II. Main technical data

1. Valve timing

Intake valve opens	12°±2° before T.D.C.
Intake valve closes	38°±2° behind B.D.C.
Exhaust valve opens	50°±2° before B.D.C.
Exhaust valve closes	12°±2° behind T.D.C.
Valve lash (at cold state)	Intake valve: 0.28-0.33 mm
	Exhaust valve: 0.28-0.33 mm

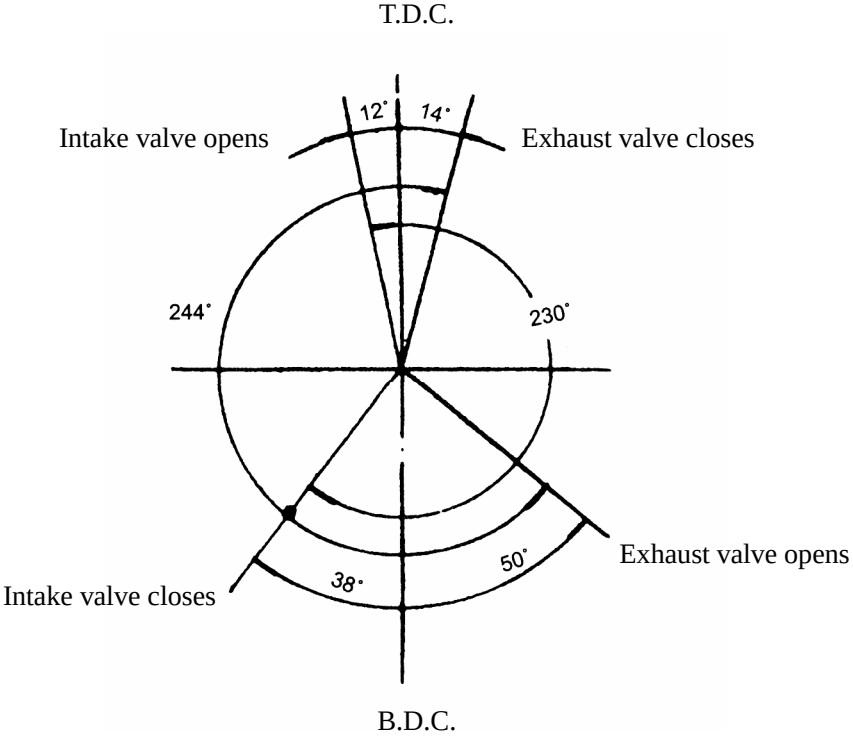


Fig. 1 Valve timing diagram

2. Fuel-supply advance angle 16° ±1° before T.D.C.

3. Temperature and pressure values of the engine

(1) Exhaust temperature (℃)

At 15-minute rated power	≤ 620
At one-hour rated power	≤ 550
At 12-hour rated power	≤ 500

(2) Engine-oil temperature (℃) ≤ 95

(3) Water-out temperature (℃) 70～90, maximum.≤ 95

(4) Main oil-duct engine-oil pressure

(at declared working condition) 196 ～ 441 (2 ～ 4.5) kPa

Engine-oil pressure when idling (kPa) no less than 98

4. Tightening torque for important bolts (N • m or kgf • m)

(1) Bolts on connecting rod 60～70 (6 - 7)

(2) Bolts on cylinder head 118～137 (12 - 14)

(3) Bolts on main bearings 120～140 (12 - 14)

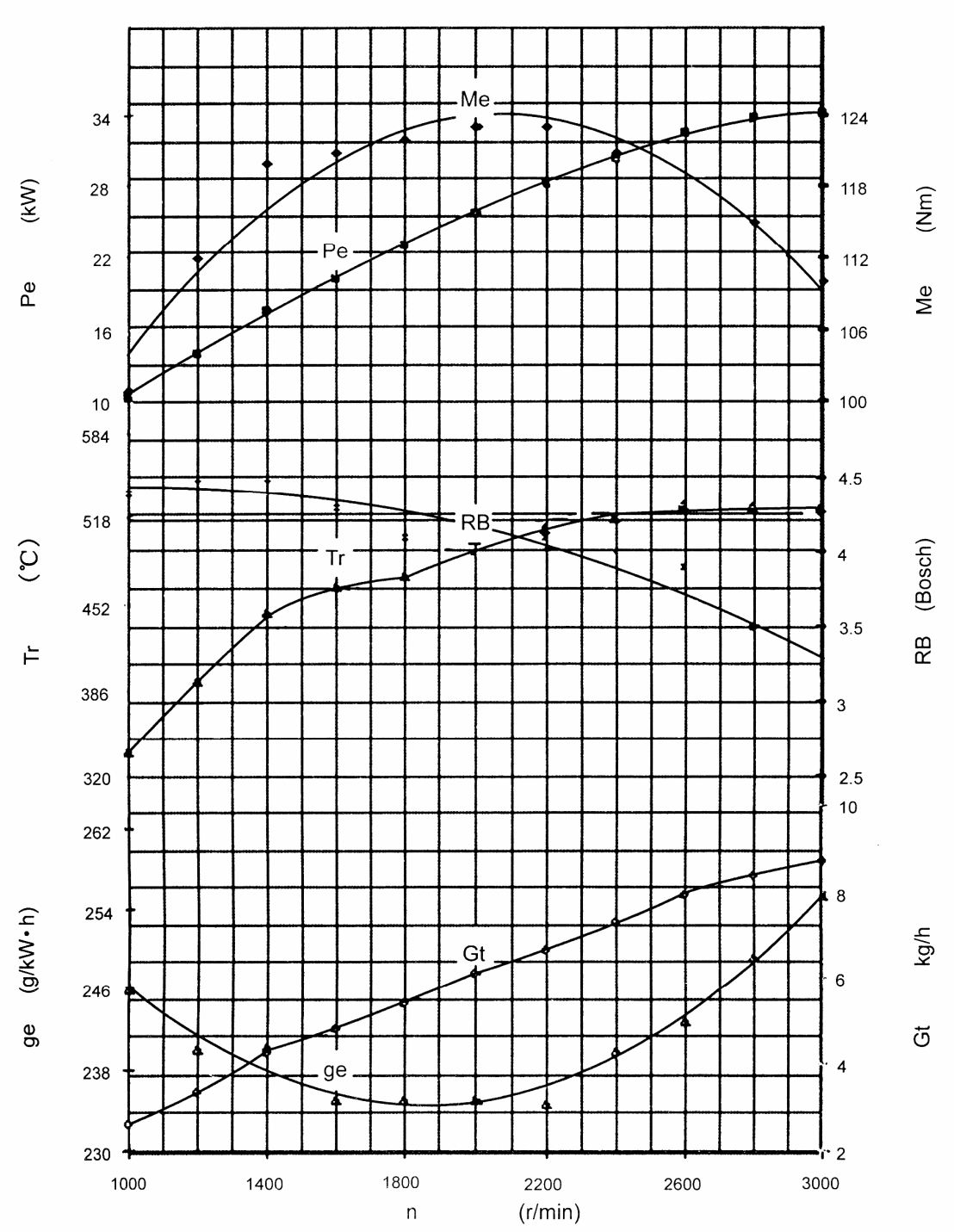
(4) Bolts on flywheel 110～130 (10 - 12)

(5) Starting bolts 110～130 (10 - 12)

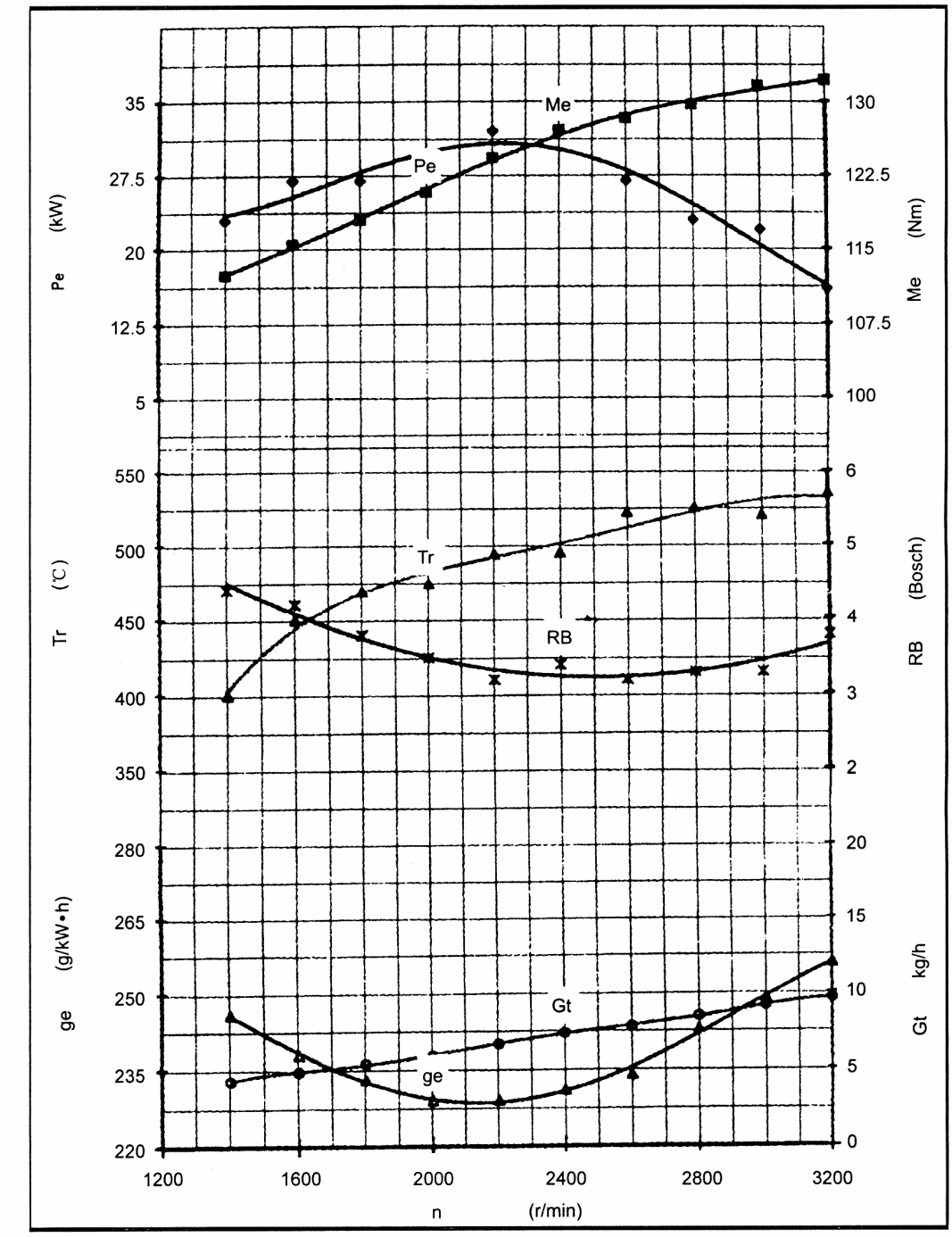
5. Lube oil capacity (L) ≈ 7

III. External characteristic curve of 4DW engines

1. External characteristic curve of 4DW81-46 (B01)



2. External characteristic curve of 4DW81-50 (B05) (37kW, 3200 r/min)



Chapter II Operation

I. Precautions

1. When using the diesel engine, it is necessary to make adjustment and maintenance as per this Manual.

2. When the engine is cold-started, pre-heating is necessary. Pre-heating time should be 20s～30s, and no more than 40s.

3. The starting motor should be used at one time no more than a duration of 5s. Interval between every two starting operations should be more than 2min.

4. New diesel engines or engines just subjected to an overhaul must not work at high speed or at full load, until they have worked for a wear-in period of 50～100h, during which they run at a low speed (no more than 2200 r/min) or less load (no more than 70% of full-load).

5. Fuel oil for the engines must be clean. Before use, the fuel oil must at least be precipitated for more than 4 days or filtered with silk cloth.

6. Normal water temperature (75～90℃) should be kept. Normal engine oil pressure, when the engine is running at a medium speed, should be 196～392 kPa.

II. Operation

1. Fuel oil, engine oil and cooling water

(1) Diesel oil specification

The diesel oil should have a sulfur content of less than 0.5%. Diesel oil with low freezing point should be used in winter. Diesel oil brands should be selected basically as per ambient temperature conditions (see Table 2-1). For example, #-35 diesel oil should be used for ambient temperature of -29℃.

Table 2-1 Relations between diesel oil brands and suitable lowest temperature

Diesel oil brand	#10	#0	#-10	#-20	#-35
Sulfur content (%)	0.2	0.2	0.2	0.2	0.2
Cetane value	45	45	45	45	45
Freezing point (℃)	10	0	-10	-20	-35
Suitable lowest temperature (engine's operating ambient temp.) (℃)	18	4	-5	-14	-29

Diesel oil must be kept highly clean, free of pollution by dust or impurities. Before being injected into the fuel tank, the diesel oil should be kept still for more than 27h. Then upper part/layer of diesel oil should be taken for use. This is extremely important for preventing the fuel injection pump and plunger from being earlier worn off.

(2) Engine oil specification

Correct selection of engine oil directly helps ensure reliable working and prevention of parts from being abnormally worn-off. A natural air-intake type engine should use oil of Class CC (or Class CD), while a supercharge type engine should use oil of Class CD. In addition, selection of engine oil brands also bases on engine's operating ambient temperature (see Table 2-2). For example, 15W/40# oil should be selected for Class CC or CD, when ambient air temp is -15℃.

If ambient temperature occasionally exceeds its limit, only starting performance will be affected, and the engine itself will not be damaged. Engine oil should be kept clean, free of pollution by dust or impurities. After the engine oil is added, it is necessary to inspect the oil level inside the crankcase sump as follows: pull out the oil dipstick and clean it with gauze, then insert it back; pull it out again and inspect if the oil-level indication is between the upper limit and lower limit. The oil level should at any time be no lower than the lower-limit on oil dipstick.

Table 2-2 Relations between engine oil brands and suitable lowest temperature

Oil brand	5W/30	10W/30	15W/40	20W/40	30	40
Engine's operating ambient temp. (℃)	-25	-20	-15	-10	5	> 25

For ensuring that the diesel engines properly operate and have a longer service life as well as emission of engines is improved, please use Class CC and CD lube oil, dedicated to Brand Xichai diesel engines. This lube oil meets GB11122-1997 National Standard for Diesel Engine Oil, and its performance conforms to Class CC and CD of American Petroleum Institute (API), and conforms to Viscosity Class SAE30, 40, 15W40 and 20W50 of standard of the Society of Automotive Engineers (SAE), USA.

1. Engine oil quality and class should be selected according to engine model/type and automobile model/type.

2. Viscosity class should be selected according to ambient temperature.

3. Higher class (one class higher than normal required class) oil should be used, when load is heavy or travel distance is long, or where road condition is bad or in dusty regions.

4. Recommended are CD15W40 and CD20W50 engine oil with several viscosities, which not only have low-temperature dynamic viscosity and low-temperature boundary pumping performance, but also have such high-temperature characteristics as high-temperature shear stability, high-temperature viscosity and evaporation loss etc, ensuring engines to be reliable.

Specification & applicable scope of lube oil, dedicated to Brand Xichai diesel engines

Oil spec. / Application scope	CD30	CD40	CD15W20	CD20W50
Service ambient temperature	0℃～30℃	5℃～40℃	-10℃～40℃	0℃～50℃
Suggested oil-change interval	6000～8000 km		10000km	
Suitable engine model / Type of vehicle	Natural aspiration, low supercharging 4DW/ agriculture vehicles, light-weight trucks		Mid supercharging 4DW/ passenger buses, light-weight vehicles	

(3) Cooling water: rainwater, tap water or clean river-water is preferred as the cooling water. However, tap water with well-water as its source, or well-water, which both contain more minerals, should not be used; otherwise, inside the engine cooling system, more water-scale will be produced, thus cooling effectiveness will be affected and engine be troubled. In winter when the temperature is very low, it is possible to add some anti-freeze liquid to prevent freezing. Most commonly used anti-freeze liquid is ethylene glycol (glycol) water solution or alcohol. When

ambient temperature is below 0℃ and the engine has difficulty in starting, cooling water can be heated to higher than 80℃ so that it can be used normally.

Selection of cooling water:

For engines with advanced water-cooling, its cooling system have a very high requirement for cooling medium used. Please use the coolant, dedicated to Brand Xichai diesel engines. This coolant, conforming to National Standard SH0521-92, not only has an anti-freezing capability and has a freezing point of -3.5℃～-4℃, but also has a boiling point as high as 107℃～108℃, effectively preventing the evaporation of water. Also, it can prevent water-scale and prevent the cooling water from forming water-scale and bubbles, by which the cooling effectiveness is improved. In addition it has long-term effective anti-rust and -corrosion characteristics. This coolant is suitable for the cooling systems of all types of diesel engine, and can be used throughout the year, and has a preservation period as long as 1.5～2 years. The coolant dedicated to Brand Xichai diesel engines, which contains water (distilled water or ion water), additives and ethylene glycol, can directly be add into the cooling system.

Its specific parameters and quality indexes as follows:

Item	Coolant Brand	
	-35#	-45#
Color	Blue	
Odor	No peculiar Odor	
Freezing point (℃)	-35	-45
Boiling point (℃)	107	108
Influence on organic coatings	No influence	
PH Value	7.5 ～ 11	
Corrosion test: Varied value on test strip (mg/strip) Copper Brass Steel Cast iron Soldering tin	 ± 10 ± 10 ± 10 ± 10 ± 30	

2. Inspection & preparation before starting the engine

(1) Check each connection on the diesel engine if reliable, and handles (e.g., handle for throttle and stopping etc) if go smoothly and freely.

(2) Turn the crankshaft for several turns, and check all moving parts if move smoothly and freely.

(3) Check the oil level in crankcase sump and fuel-injection pump, if at the scale position specified.

(4) Check the water tank if filled full with the cooling water, and check water-pipe joint(s) if any leaks.

(5) Check the fuel tank if filled full with diesel oil, and check fuel pipelines if fluently and unclogged, and each fuel-pipeline joint if any leaks, and open the valve(s) of fuel tank.

(6) Check the storage battery if full. Check each terminal in electrical system if wired correctly and reliably.

(7) Check each accessory of engine if connected reliably (fuel-injection pump, fuel-transfer pump, diesel oil filter, water pump, fan, charging generator and its support, fan belt, starting motor, engine-oil filter and heat-radiator etc).

3. Starting of engine

(1) Set the speed-governing handle at mid-speed position.

(2) Loosen the air-discharging screw of engine filter, and push the hand-pressured fuel-transfer pump to remove the air in fuel system. In case the engine is new or has not been used for long time, which means substantial amount of air exists in the fuel oil system, loosen the air-discharging screw of fuel-injection pump and continually push the hand-pressured fuel-transfer pump, to remove the air in the system. For engines often being used, this procedure is not necessary.

(3) Turn the ignition switch to start-position, and push the starting pushbutton, to start the engine.

If the engine does not start, release the pushbutton, and re-start it 2～3 minutes later. If such operation bas been performed consecutively for three times and the engine still does not start, then it is necessary to check if any fault, and if so, the engine should not be re-started again until the fault has been eliminated.

(4) After the engine is started, immediately release the pushbutton, and then turn the ignition switch to another position, to switch on the charging circuit of the generator, to make charging. In addition, immediately adjust the throttle and observe tachometer, and make the engine to be idling and check if it is running normally and if any abnormal sound, with special attention being given to whether the engine-oil pressure is normal. Then, pull the speed-governing handle little by little, so that the engine speed reaches 1800～2000 r/min; thus the engine is warmed up with no load.

(5) When the ambient temperature is lower than 0℃ and it is difficult to start the engine, perform air-intake pre-heating for 20s. Once the engine is started successfully, the pre-heating should immediately be stopped.

4. Running of engine

(1) The engine can work with load, only when the temperature of cooling water reaches 50℃, and temperature of engine-oil reaches 40℃. However, when running with the declared power, the water-out temperature should reaches approx. 80℃.

(2) Increase/decrease of loads or speed should be gradual and little by little, and usually, an abrupt increase/decrease of loads or speed is not permitted.

(3) When the engine is running, it is necessary to give attention to whether or not the indications of gauges on gauge-board are normal. Attention should be given to exhaust color and running sound, and stop the engine for inspection, if abnormal conditions are found.

5. Stoppage of engine

(1) Before stoppage, load on the engine should be gradually reduced, and speed should be reduced to approx. 800 r/min so that the engine idles. Only until discharging-water temperature decreases to below 70℃, can the engine be stopped by using the stoppage-handle.

(2) When the ambient temperature is lower than 5℃ in winter, if the water temperature is lower than 60℃ after stoppage, open the water-discharge valves on engine body and heat-radiator to drain away the cooling water and prevent a frost-crack. The discharge of water is unnecessary if anti-freeze has been added into the water.

Chapter III Maintenance

To prolong the service life of the diesel engine, following maintenance procedures should be followed.

I. Daily care

1. Check the engine-oil level in the crankcase sump if it is between the two scale marks and close to the upper scale mark. For an engine that is new or has not been used for long time, after the engine-oil is filled to the upper scale mark, run the engine at a low speed for 5～10 min then stop it, and measure the oil level with the oil dipstick.

2. Check the water amount in the heat-radiator.

3. Check the engine-oil level in the speed regulator of fuel-injection pump, and add oil to specified position if found insufficient.

4. All oil-, water- and gas-leakage in the engine should be eliminated.

5. Check each part/device on the engine for their correctness and firmness.

6. Check if the support connected to engine is secured and other driven equipment if connected properly.

7. Keep the engine clean. Use dry cloth or cloth with dipped gasoline to clean away oil stain and dust, pay special attention to the dry and clean condition of electrical equipment.

8. For a new engine, after running for 50h at light-load, it is necessary to change the engine oil (including the oil in speed regulator of fuel-injection pump) and the element of engine-oil filter, and to clean the crankcase sump and engine-oil filter.

9. Eliminate the faults and abnormal phenomena if found any.

II. Maintenance after running for every 100h

In addition to the instructions in "Daily care", followings should also be performed.

1. Change the engine-oil in the crankcase sump.

2. Clean or replace the element of engine-oil filter.

3. Replace the element of diesel-oil filter (it can also replaced after 200h).

4. Check the bolts on the cylinder cover if secured.

5. Check if valve lash or clearance conform to requirement and adjust it if necessary.

6. Check the tension of fan belt and adjust it if necessary.

7. Inject some lube grease into the parts with a grease cup.

8. Clean away the carbon/soot deposited in air-intake and gas-exhaust pipes and muffler.

9. It is necessary, after running every 200h, to check fuel injector for its pressure and atomization conditions, and clean or adjust it if necessary.

10. Check the battery for its voltage. Specific gravity of electrolyte should be 1.28～1.29 (atmospheric temperature is 15℃), and should normally be no less than 1.27. Additionally, check if the electrolyte level is 10～15mm higher than plate electrode, and if sufficient, distilled water should be supplemented.

11. After running every 200h or according to water muddiness/turbid-ness, change the cooling water. Take out the thermostat, and fit the lid of thermostat (water-out pipe), and start the engine and change ceaselessly the speed so that the cooling water flow fluctuates, flushing the deposit in cooling system. Then, open the water-discharge valves on heat-radiator and engine body, to discharge the water, and stop the engine. Inject continually clean water via radiator inlet, and start the engine and have the engine idle, so that the water flows. Timely inspect the quality of the water discharged through the discharge-valve, and after found clean, close all discharge-valves and stop the engine, and fit back the thermostat.

12. When parts that have been removed for maintenance are fit back, it is necessary to ensure their correct position and reliability.

III. Maintenance after running for every 500h

In addition to the instructions in "Maintenance after running for every 100h", followings should also be performed.

1. Check injection pressure of fuel-injector and observe atomization quality, and if necessary, clean and adjust it.

2. Check fuel-supply advance angle, and if necessary, adjust it.

3. Check gas valve for its tightness, and if found not complying with requirement, grind and correct it.

4. Check the tightening condition for bolts on connecting rod, main bearings and flywheel.

5. Re-tight the bolts on cylinder cover, and adjust the valve clearance or lash as per requirement.

6. Clean or replace the element of air filter. This can, depending on the dusty degree in working environment, be performed as in "Maintenance after running every 100h" or be performed in shorter interval.

7. Change the engine-oil in the speed regulator of fuel-injection pump.

8. Clean the cooling system. Clean liquid is a mixture of NaOH and water (every 150g NaOH is mixed with 1L water). Before the cleaning, drain away all the water in cooling system, and then fill fully clean liquid and remain 8～12h. Then, run the engine, and stop it after water temperature reaches working temperature. Upon stoppage, immediately discharge the clean liquid, to prevent the deposit of water-scale in the liquid. Finally, clean the cooling system with clean-water.

9. Check the working status of thermostat.

10. Check each part of starting electric equipment. Check fasteners if secured, and check wire ends if closely contacted, and it should be replaced if scorch-trace found on it.

11. Check each part of engine, and repair and adjust them if necessary.

In addition to above information on maintenance, users may perform more detailed maintenance depending on actual conditions.

IV. Storage

1. Before out of service for a long time, the engine, after shutdown, should, as in warm state, be drain completely away the engine-oil, cooling water and fuel oil. Crankcase sump and engine-oil filter should be cleaned.

2. Corresponding maintenance should be made.

3. Remove the intake and exhaust pipes. Fill 200g clean and dehydrated engine-oil, via gas-way, into each cylinder (i.e., heat the engine-oil to 110～120℃, until bubbles completely disappear), and turn the crankshaft so that the oil will be uniformly and evenly applied on surfaces of valve, cylinder jacket and piston etc. Fit back the intake and exhaust pipes.

4. Oil stain, water-trace and dust on outer surface of the engine should be wiped and cleaned. Unpainted parts, except for those made from rubber or plastic, should be applied with anti-rust oil.

5. The outlet/inlet of intake and exhaust pipes (muffler) should be blocked with a wooden plug or covered well with plastic cloth, to keep foreign bodies / dust away.

6. The engine should be stored in ventilated, dry and clean places, and in its surrounding areas chemicals are forbidden to be stacked.

The engine can be stored for 3 months if above-mentioned oil-seal procedures are followed. In case this period is exceeded, then oil-seal once more is necessary.

Chapter IV Structure

I. Cylinder head

On the cylinder head, are fitted intake and exhaust valve, valve seat, valve guide (pipe), valve spring, valve rocker and support.

The cylinder head is secured onto the engine body by bolts. When securing the bolts, it is necessary to use a torque wrench, to tighten them one by one, by several times, as per the sequence shown in Fig.2. At first, pre-tighten them; then tighten them as per specified tightening-torque values. In case of assembly/disassembly of the cylinder head, after the engine runs heat at first time, stop and cool the engine, and re-tighten the bolts as per specified tightening-torque values, and re-adjust valve lash or clearance.

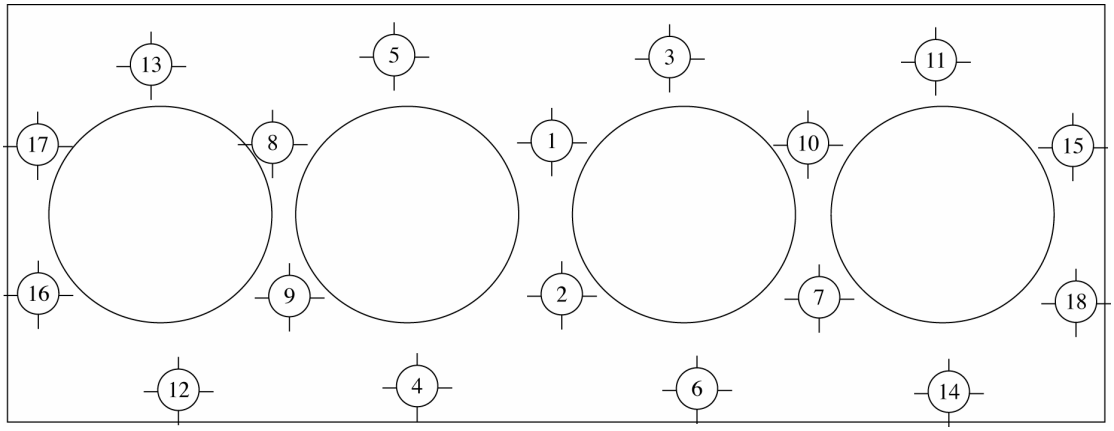


Fig. 2 Tightening sequence of bolts on cylinder head

On the upper part of the cylinder head, is placed the fuel injector, forming an inclination angle with the centerline of the cylinder head. In the mounting hole of the injector, there is a copper shim, used for adjustment of the height from the protruding injector to the base plane of cylinder head, and used for sealing. When installing the fuel injector, please evenly and tightly press the pressboard, without any leakage. It is important that when installing the pressboard, the side with an inclination should face downwards.

1. Intake and exhaust valve, valve seat and valve guide

Both intake and exhaust valve and valve seat should all be paired ground, to avoid leakage.

When on the sealing surface between valve and valve seat, there is burning, pits or wear-off, causing leakage, it is necessary to grind them. Apply some grinding paste (fine valve sand) on the conic sealing surface of valve, then pair-grind the valve and valve seat, until a uniform, continuous and gloss-less sealing surface is obtained. Grinding paste is strictly forbidden to enter the valve guide. After the grinding, valve, valve seat and valve guide should all be carefully cleaned,

because valve guide wear-off can lead to partial grinding of the sealing surface, causing poor sealing. After grinding is done, pour some kerosene or diesel oil into the air-way, to see if the valve leaks and check for its tightness.

Normal width of the sealing surface between valve and valve seat is 1.2～1.7mm. After it has been used for long time and ground for more times, the sealing surface can become wider, causing poor sealing. Therefore it is necessary to use 15° and 75° reamer separately, to scrape and trim it as per the positioning of inner-hole of valve guide, as shown in Fig.3. After the scraping, pair-grinding with valve is again necessary.

The deflected distance between intake/exhaust valve plane and cylinder cover plane is 0.55～0.85mm for a new engine, as shown in Fig.4. After scraping and trimming for several times, the distance will increased and thus will influence the compression ratio. Therefore, the valve seat may necessarily be replaced, if the deflected distance is increased to be 2mm or more.

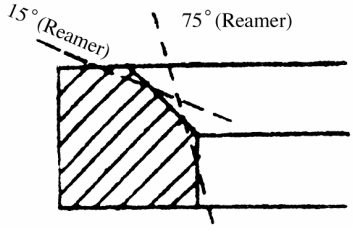


Fig. 3 Trimming of valve seat

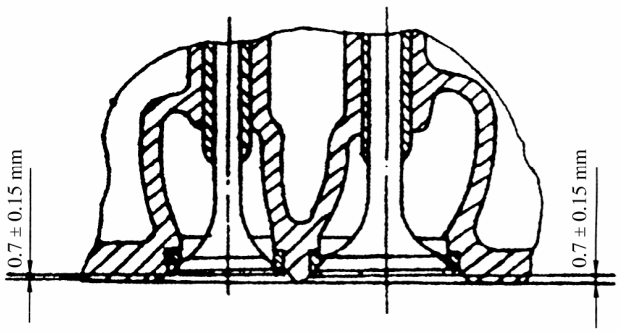


Fig.4 Deflection of valve

The valve guide, when assembled, should be 12.5～13mm higher than the plane of cylinder cover.

It is necessary to often inspect the valve lash or clearance. For its adjusting method please see Section I, Chapter X. Incorrect clearance will influence the accuracy of valve timing and tightness of valve. Additionally, too big clearance will lead to more noise of valve driving device, and too small clearance will lead to an un-tight closing and burn-out of the valve.

2. Cylinder cover gasket

The gasket should be flat and smooth. Gaskets with defects such as warp and burn should be replaced.

When the piston is at top dead center, there should be a clearance between the top of piston and bottom plane of cylinder cover, to prevent the compression ratio from being influenced or the valve from being collided by the top of piston.

II. Engine body

1. Engine body

The engine body is of gantry design.

On the top surface, there are cylinder jacket-opening and bolt holes, and additionally there are water-hole through to cylinder cover. Near the back end, there is lube oil hole, by which the cylinder cover is lubricated.

At the upper part of the front end face of engine body, is cast with the water-in chamber of water pump. Flywheel casing and rear oil-seal cover are fitted at the rear end. On the bottom surface of engine body, there are bolt-holes for bolts of main bearing, lube oil inlet, engine-oil pump opening and bolt-holes on crankcase sump.

On the right side of engine (when viewing from front end), there are engine-oil filter, diesel-oil filter and water-discharge valve.

In the engine body, main oil-passage and branch oil-passages are all horizontal arranged. When disassembling the engine for repair, it is necessary to clean each oil-passage, ensuring cleanness and smoothness. Screw plug for each oil-passage should be tight and reliable, without oil leakage.

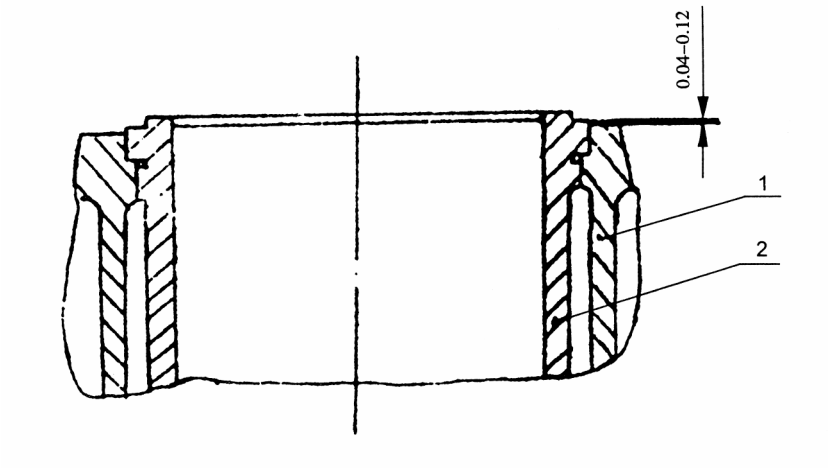
2. Main bearing

The main bearing is of full-support suspension design. Main bearing cap and engine body adopt paired boreholes, with paired marks on the engine body and bearing cap. When assembling/disassembling it, the marks should be followed and incorrect direction is not allowed. When assembling front main bearing cover, it is important that it should be flushed with front end face of engine body, and should not protrude; otherwise the pressing of timing gear chamber will be influenced. When removing the main bearing bushes for cleaning, do not mistake the upper bush and lower bush (bush with oil groove is upper bush). Crankshaft thrust-pieces are installed at the last main bearing, each piece at upper and lower, at front and rear. The thrust-piece is subject to axial thrust force of crankshaft. Its working surface has oil groove on it, and its back side is a plane. When installing it, it is necessary to put the working surface towards the thrust-surface of crank arm, and inverse direction is not allowed. Tighten it and then tap it, ensuring that the upper and lower thrust-pieces are kept on the same plane. Then, tighten them one by one, as per specified tightening-torque. Upon assembling of crankshaft, if turn the crankshaft by hand, at the flywheel end, it should rotate smoothly and freely.

3. Cylinder cover

The cylinder jacket is of wet type. At the lower part of the cylinder jacket, there are two ring-shape grooves, into each of which a rubber water-seal ring is to be fitted.. The water-seal ring should not twist or awry, when fitted into the groove. Then, press the cylinder jacket into the

jacket opening. The flange plane on cylinder jacket should be 0.04～0.12 mm higher than engine body top face, so that the cylinder cover gasket can press closely on it, ensuring the tightness between the cylinder jacket and cylinder cover. See Fig.5.



1-Engine body 2-Cylinder liner

Fig. 5 Distance between cylinder jacket flange plane and engine body top face

The crankcase sump is made from cast aluminum or by drawing from steel plate. When cleaning the inside of crankcase sump, do not leave yarn waste on its wall; otherwise the copper wire gauze of filter and element of lube-oil filter will be clogged.

III. Piston & connecting rod

The assembly of piston and connecting rod consists of piston, piston ring, piston pin, retaining ring, connecting rod, connecting rod bolts, connecting rod bush and connecting rod sleeve etc.

Weight difference between assemblies of piston and connecting rod, for same diesel engine, should be no more than 25g, and weight difference between assemblies of connecting rod should be no more than 15g.

1. Piston

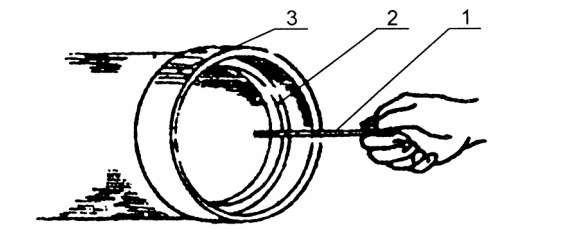
Combustion chamber at the top of piston should be "ω" shape. Skirt section is processed to be drum-shape along height direction, and ellipse-shape along circumference direction. On the piston, there are 2 gas ring grooves and 1 oil ring groove.

2. Piston ring

Ex-circle of first gas ring is plated with porosity chromium, which can help reduce wear-off between cylinder jacket and piston ring. Second gas ring is a conical-face ring. When fitted, its side marked with "Up" should face towards the top face of piston, and do not reverse it.

Oil ring is inside-swell ring. Such ring still can remain certain radial elastic force, when its elasticity is reduced due to wear-off. Therefore the service life of the oil ring can be prolonged.

Inspect the open gap, before the piston ring is fitted. Lie the piston ring flat to the place, which is 15～20mm away from the top face of cylinder; The open gap should, measured with a feeler gage, be 0.25～0.4 mm. See Fig.6. Trimming with a file is possible if the gap is too small, and match it again if the gap is too big. Additionally, it is necessary to use the feeler gage to measure the end-face gap between piston ring and piston ring groove. The end-face gap for first gas ring should be 0.05～0.082 mm; for second gas ring should be 0.03～0.062 mm; and for oil ring should be 0.03～0.062 mm. See Fig.7.



1-Feeler gage 2-Piston ring 3-Cylinder liner

Fig. 6 Measuring the end-face gap of piston ring

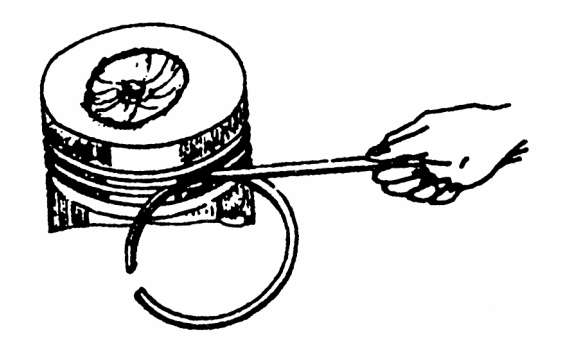


Fig. 7 Measuring the end-face gap of piston ring

The piston rings should be removed and fitted back, by special tools. When fitting the rings, opening of each ring should be staggered each other for 120° , and should not be at the direction of piston pin.

During maintenance/repair, if the piston ring is found seized/dead and cannot move, it is possible to immerse the ring in diesel oil (kerosene or gasoline) for 24h or longer, then tap gently the ring to make it to be loosened. After that the ring should be taken out and then cleaned with diesel oil or carbon tetrachloride.

Check each position of the piston for crack and scar. If defect(s) is found, renew it, and replace the piston ring.

3. Piston pin

Before removing or fitting back the pin, fit a retaining ring at one end (or remove retaining rings at two ends). Place the piston in engine oil (or boiled water), where the piston is heated to

100～120℃. With a appropriate forcer being padded, gently tap the piston pin out or push the pin in. Clean engine oil should be applied into the pinhole and connecting rod sleeve. After the piston pin is fitted, other retaining ring should be fitted.

4. Connecting rod and its bush

The body of connecting rod has a cross-section of "I" shape. The connecting rod and connecting rod cap are pair-bored. Therefore they should be fitted as per pair marks, and do not make mistake.

In the hole of small end of connecting rod, bronze bush is press-fitted. Oil-hole on the bush must be aligned with the oil-hole above the small end, to ensure splash and lubrication onto the piston pin and bush.

When clearance, due to wear-off of the bush, exceeds limit value, or when serious stripping or burning occurs on the surface, replacement with a new pair should be made.

When the engine is overhauled, or when the connecting rod is replaced with a new one, it is necessary to check the parallelism of axes of small end hole to big end hole. The parallelism should be no more than 0.03mm for 100mm at vertical direction, and be no more than 0.06mm for 100mm at horizontal direction. Correct it, if above-mentioned values are exceeded.

Before the assembly of piston and connecting rod is fitted into (or removed from) cylinder jacket, it is necessary to scrape completely the soot and oil dirt at upper part of the jacket. Before it is fitted, it is necessary to apply some clean-use engine-oil, on cylinder-jacket opening, outer surface of the piston and the surfaces of piston ring, rod bush and crankshaft rod journal etc. Then place the guide sleeve onto the cylinder jacket. Turn the crankshaft, and carefully put the assembly of piston and connecting rod into the cylinder jacket. Tighten the bolts on the rod one by one, in several times, as per specified tightening-torque value. After tightening the bolts, the crankshaft should be able to rotate freely and smoothly, if turned by hands.

IV. Crankshaft & flywheel

1. Crankshaft

At the front end of crankshaft, is fitted crankshaft timing gear, engine-oil pump drive gear, crankshaft pulley. At the rear end of crankshaft, is fitted with the bearing and flywheel, positioned by positioning pin(s) and secured by 6 bolts on flywheel tightened as per specified tightening-torque. The bolts on flywheel are prevented from being loosened, by 3 locking pieces. At the center of flange, is fitted a E60203 bearing, for supporting the drive shaft of gearbox. On the crankshaft pulley is marked scale line, used to watch the fuel-supply advance angle. On the cover of timing gear chamber, is fitted an indicator, used to indicate the degree of fuel-supply advance angle.

2. Flywheel

Outer ring nests gear ring. Scale line, used to watch the fuel-supply advance angle, is marked on the flywheel.

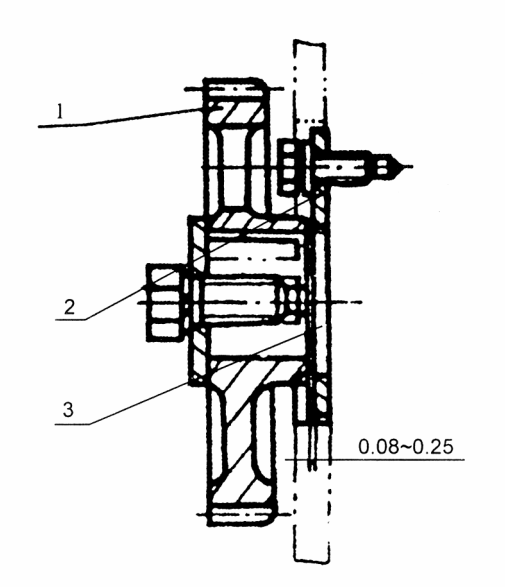
On the flywheel, it is prohibited to directly install a machine which is towed transversely by pulley; otherwise the main bearing can be damaged. Bearing seats should be added and fitted onto the two ends of the pulley, if user needs to use the transversely towed machine.

V. Camshaft

1. Camshaft

The cam profile is symmetrical. Profile of intake cam is different from that of exhaust cam. When the cam rotates, it will push the valve tappet, push-rod, valve rocker and valve, controlling the intake and exhaust respectively. At the front end of cam, there is thrust flange.

At the front end of engine body, is fitted camshaft thrust flange. Length of the thrust flange is 0.08～0.25mm longer than the thrust plate, controlling the axial playing of the shaft. See Fig.8.



1-Timing gear on camshaft 2-Thrust plate 3-Camshaft

Fig. 8 Camshaft timing gear & thrust plate

Each bearing on the camshaft is lubricated by main oil-passage. When fitting the camshaft sleeve, it is necessary to check if the oil-hole on sleeve is connected with the oil-hole on engine body.

2. Valve tappet

The axis of valve tappet is 2mm offset the symmetrical centerline of cam width. While working, the tappet rotates, making the bottom face and cylinder face wear uniformly.

VI. Gear system

1. Timing gear

Gearing system consists of timing gear and timing idle gear on crankshaft, timing gear on camshaft, and timing gear and timing gear seat etc on fuel-injection pump.

Each timing gear is marked with timing-mark. When fitting the gear, marks should correctly be followed where is engaged., so as to ensure correct moving relationship between moving parts. See Fig. 9.

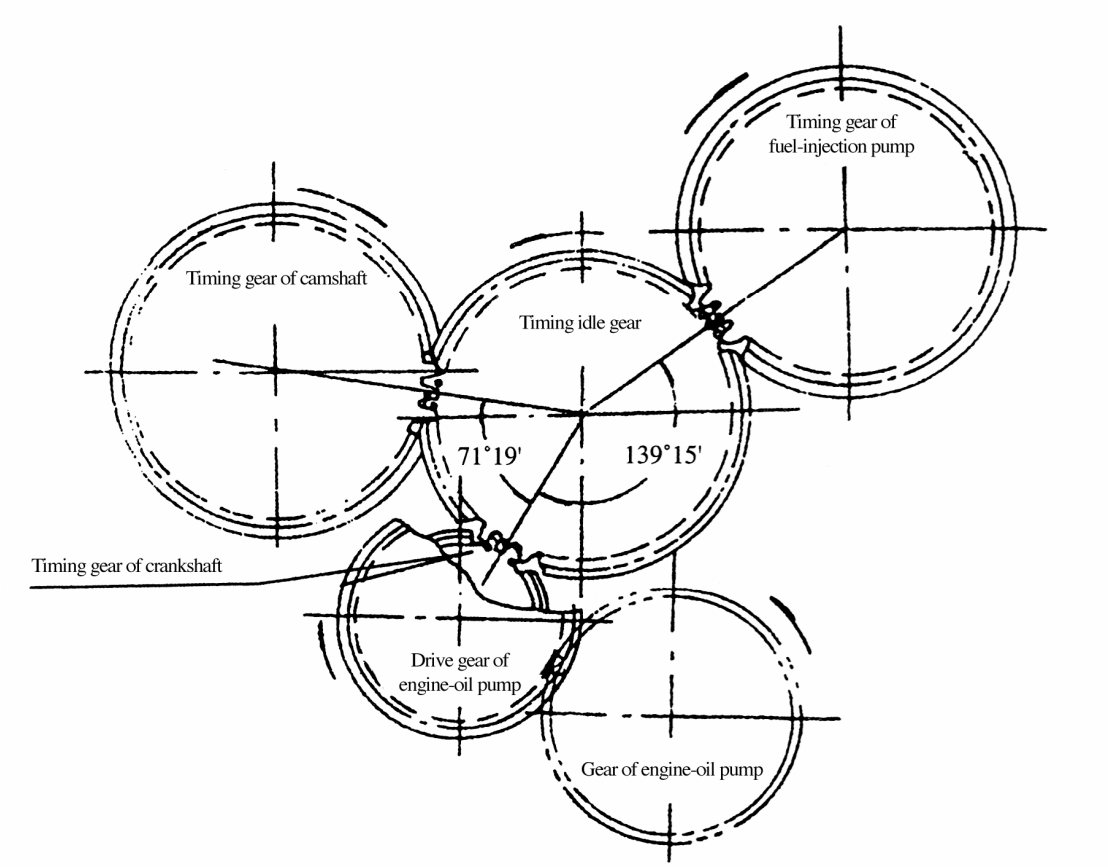


Fig. 9 Timing gear system assembly

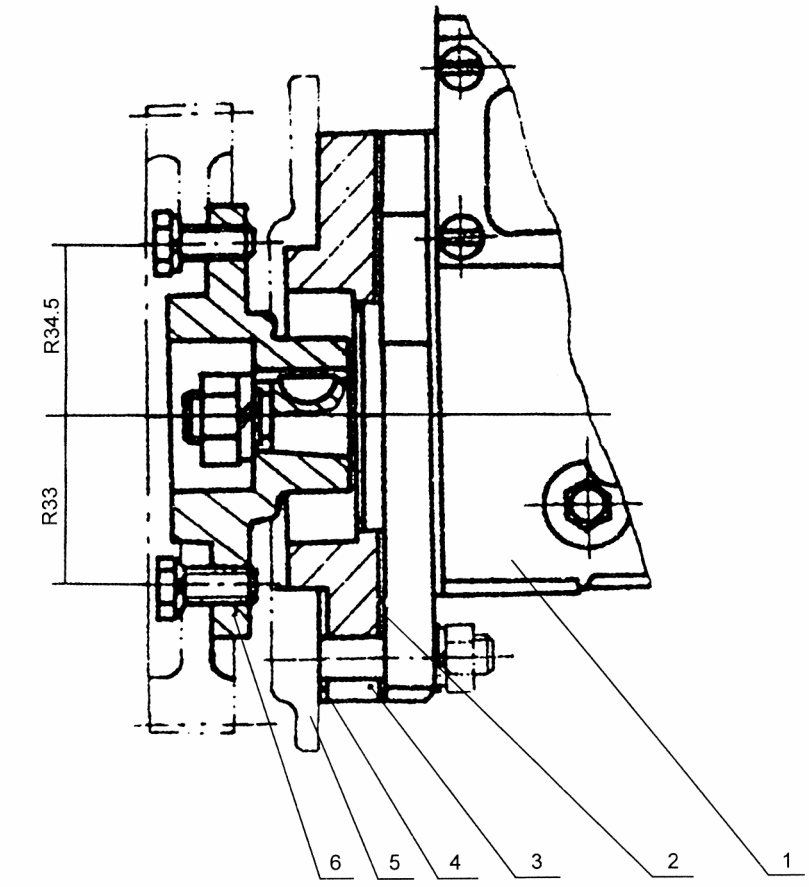
2. Mounting/dismounting of the gears

Mounting/dismounting of the timing gear on crankshaft needs special tools. Timing gear on camshaft can be pulled out by a gearwheel-puller, or be pushed up by a pressing machine. Clearance fit is adopted between the timing idle gear and engine body, be secured with bolts. Mounting of gear of fuel-injection pump: Gear of fuel-injection pump is fitted on the coupling disc of the advancer. Before dismounting the timing gear of fuel-injection pump, the cover of advancer should be removed, then the nut(s) on shaft of fuel-injection pump should be loosened

by a socket wrench. Take out together the timing gear and the advancer, and then take the timing gear from them. See Fig.10. Loosen the three fixing nuts on the pad of fuel-injection pump, then the pump can be pulled out.

When mounting the timing gear of fuel-injection pump, be ensure that the ϕ 7 hole (R34.5) aligns with the M6 hole (R34.5) on the coupling disc of the advancer, and joined by M6 bolt.

The three kidney-shape openings on fuel-injection pump seat are used for adjusting fuel-supply advance angle. When adjusting fuel-supply advance angle, loosen the three nuts for the three openings. Then, if turn the fuel-injection pump towards outside of engine body, the fuel-supply advance angle will decrease; and vice versa.



1-Fuel-injection pump 2-Fuel-injection pump's flanged packing 3-Fuel-injection pump's pad 4-Fuel-injection pump's coupling disc gasket 5-Gear chamber 6-Advancer

Fig. 10 Turning of fuel-injection pump

VII. Fuel & speed-governing system

As the main operating part of the diesel engine, fuel and speed-governing system consists of fuel-transfer pump, diesel oil filter, fuel-injection pump, speed regulator, advancer, H.P. and L.P. oil pipes, and fuel injector etc. See Fig. 11.

The fuel-transfer pump will pump the fuel oil in the fuel tank to the diesel oil filter. After

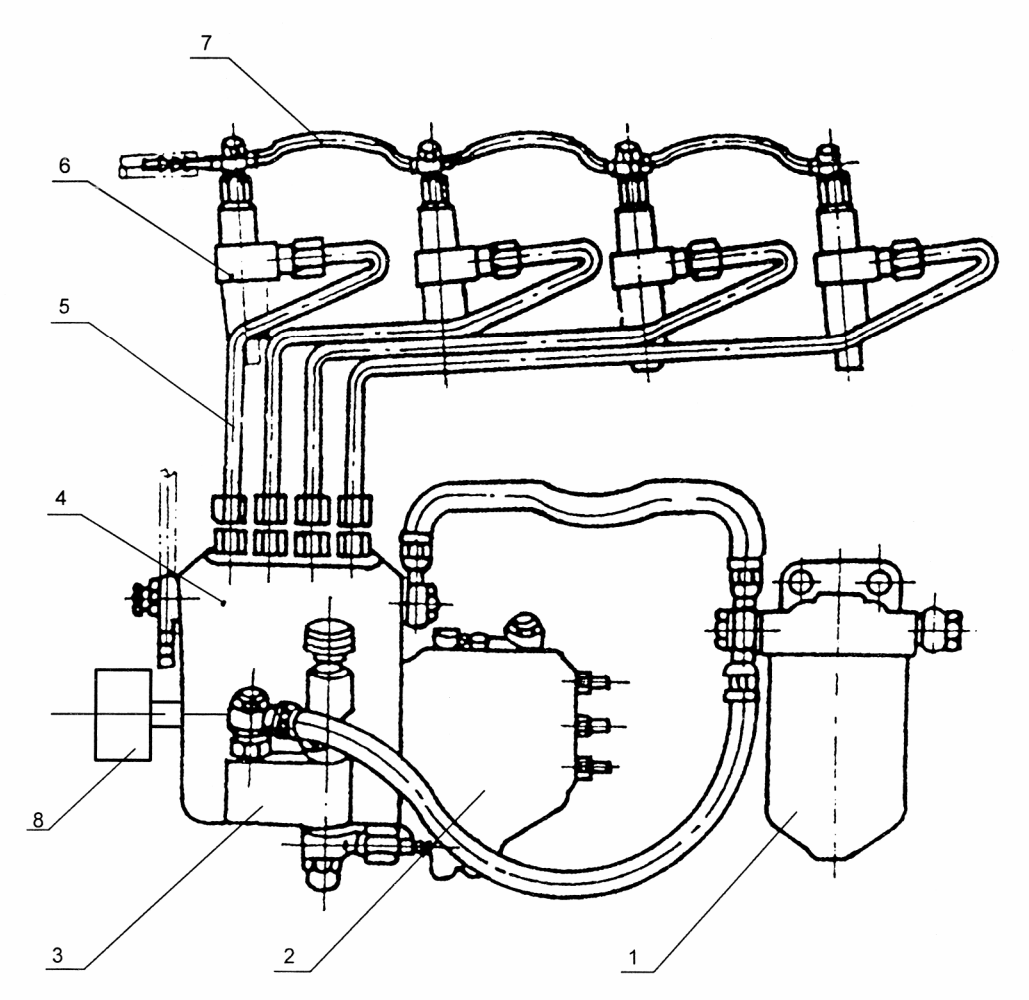
filtered, the fuel oil will enter the fuel-injection pump. Inside the pump, high pressure is produced, by which the fuel will, via high-pressure fuel pipe, be atomized and injected into the combustion chamber, where the fuel is combusted.

1. Fuel-transfer pump

With a single-function roller design, the fuel-transfer pump consists of hand-pressed fuel-transfer pump, roller, piston, piston spring, pump body, fuel-in/-out check valve and fuel-in/-out pipe fittings etc.

The fuel-transfer pump is driven by an eccentric gear on fuel-injection pump camshaft. The eccentric gear pushes the rod, and the rod then pushes the piston, pressing and transferring the fuel into the fuel chamber of fuel-injection pump.

Inside the pipe fitting of fuel-in pipe of fuel-transfer pump, is fitted a filter gauze, used to filter the fuel. During overhaul/maintenance, the filter gauze should be cleaned if found clogged, and should be replaced if found broken or damaged. Otherwise, the friction couple (i.e., friction paired part) of fuel-transfer pump will be severely worn off, and fuel-in/-out check valve will have a poorer sealing, causing insufficient fuel-supply.



1-Diesel oil filter 2-Speed regulator 3-Fuel-transfer pump 4-Fuel-injection pump
5-High-pressure fuel pipe 6-Fuel injector 7-Fuel return pipe 8-Advancer

Fig. 11 Fuel & speed-regulating system

2. Diesel oil filter

Diesel oil filter is used to remove the impurities in diesel oil. It consists of casing, filter seat and filter element etc.

3. Fuel-injection pump

Fuel-injection pump is No.1 series pump or BQ pump type, with right-integration plunger design. This pump consists of pump body, camshaft, plunger couple, oil-out valve couple and control mechanism etc.

The fuel-injection pump is driven by its timing gear. Through transmission effect of fuel-injection pump's camshaft, roller and tappet, the piston of the pump is moved back and forth.

The control mechanism for changing fuel-supply flow-rate consists of speed-governing pull-rod, shifting fork, and adjusting-arm fitted onto plunger of fuel-injection pump. The position of pull-rod is controlled by speed-governor. Moving the pull-rod forward will increase fuel-supply flow-rate, and moving back will decrease it.

Do not arbitrarily disassemble/assemble the fuel-injection pump which has been calibrated by its manufacturer.

When disassembling/assembling, repairing or adjusting is really need, it is necessary to keep clean. Plunger couples and oil-out valve couples etc are not allowed to be interchanged.

4. Speed governor

Speed governor is of whole-course mechanical centrifugal type. It consists of driving parts, sliding disc, sliding bush, speed-governing spring, speed-governing handling shaft etc. See Fig.12. (Speed sensitive element for Model T7B is steel ball, and for Model T110 is fly-ball).

Operating the speed handle can change the speed of the engine. Changing the position of speed-governing handle means changing the acting force of spring, and the balancing position of speed-governing pull-rod will accordingly be changed. When the speed-governing handle is moved towards the direction on which the speed-governing spring is twisted tight, fuel-supply flow-rate will increase and engine speed will increase accordingly . When the handle is moved towards the direction on which the spring is twisted loose, fuel-supply flow-rate will decrease and engine speed will decrease accordingly. Therefore, to restrict maximum idle-speed and minimum steady speed, it is only necessary to restrict the limit positions on the handle, which can be realized by using the two screws on the speed governor. This adjustment work has already been done before delivery, and should not be arbitrarily performed during operation.

On the speed governor is also fitted a maximum fuel flow position-limit screw, which is connected with speed-governing spring thrust-plate. This screw is used to limit maximum fuel-supply flow-rate, and prevent the engine from overloading at each gear of speed. For the maximum fuel flow position-limit screw, the adjustment work has already been done before delivery, and should not be performed during operation.

On the casing of speed governor, a stoppage handle is fitted. When the engine needs to be stopped, move this handle, then the engine will be stopped.

Above the cover of speed governor, is fitted a respirator part, below which there is a oil-drain screw plug. As the speed governor seat is connected with oil pump body, when oil level appears in oil indication window of fuel-injection pump, oil level in the speed governor can also meet requirement for lubrication.

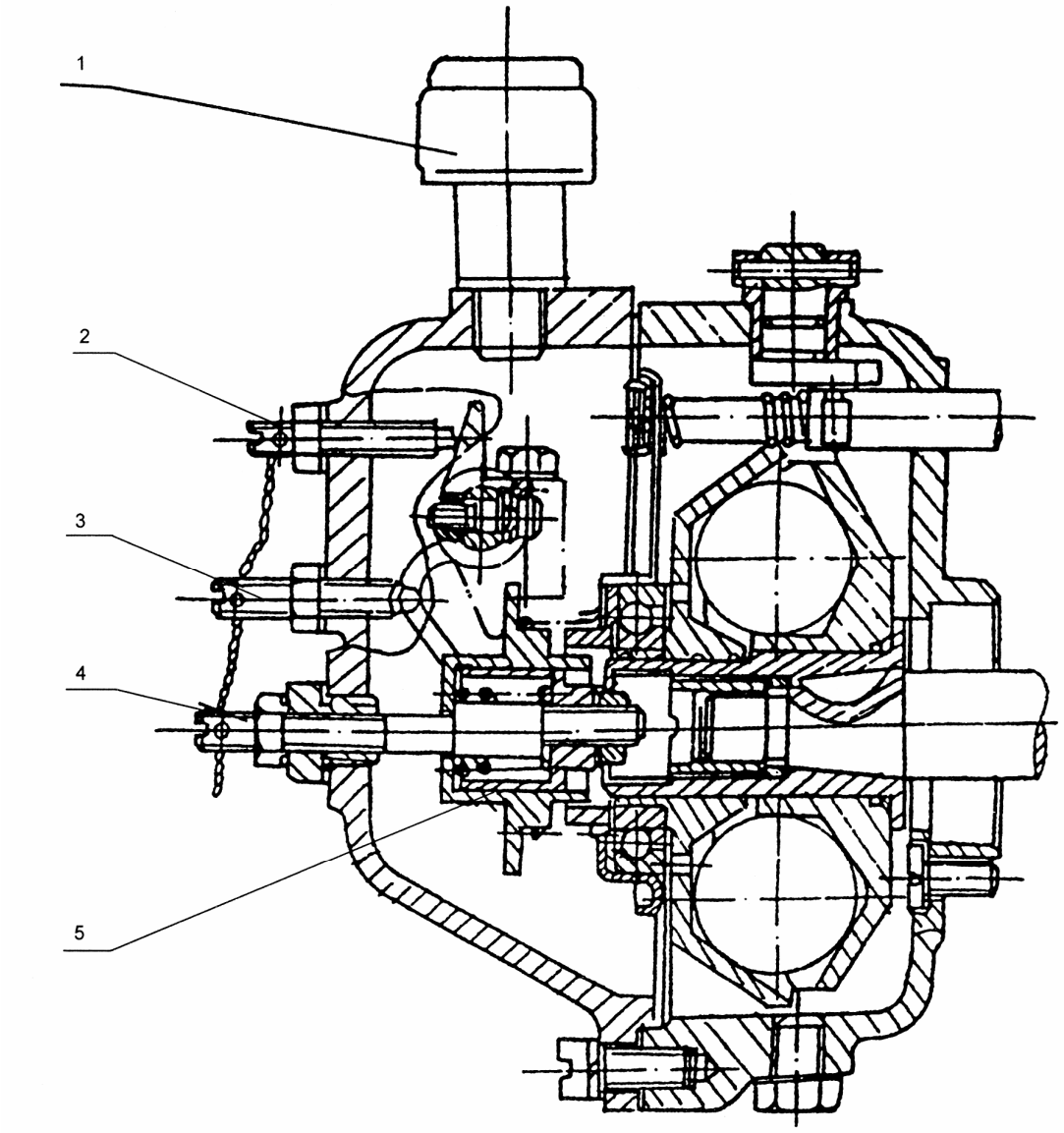
5. Fuel injector

Fuel injector is S series.

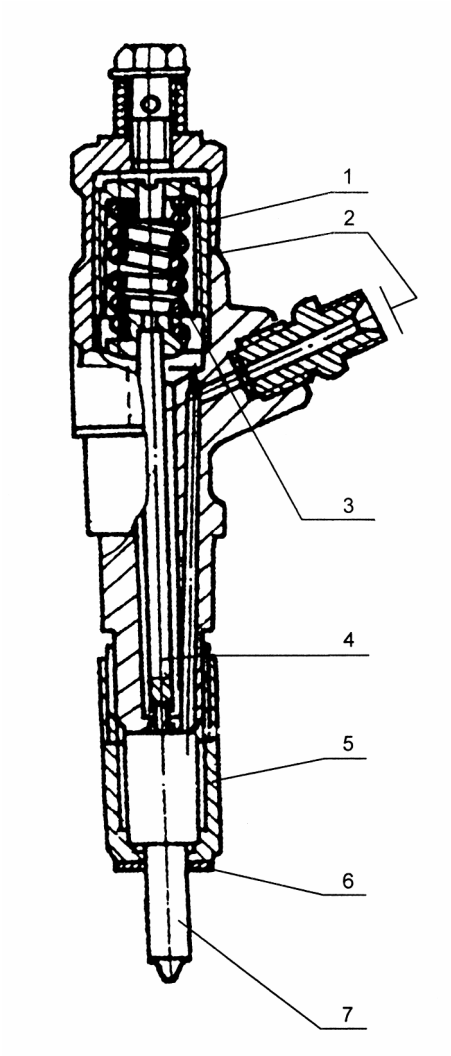
Fuel injector consists of injector body, nozzle cap, needle valve couple, push rod, pressure-adjusting spring and pressure-adjusting screw etc. See Fig. 13.

The high-pressure fuel oil, pumped by fuel-injection pump, enters the chamber of fuel injector needle valve couples, via high-pressure fuel pipe. Oil pressure acts on the conic surface of needle valve. When fuel pressure overcomes the resistance of pressure-adjust spring, the needle valve is raised, and fuel oil is injected via fuel-injecting hole into the combustion chamber.

Fuel injection nozzle's needle valve and needle valve body are couples, having been pair-ground. During disassembling/assembling process, do not interchange them, and keep them clean.



1-Respirator and fuel filling port 2-High-speed limiting screw
3-Idle-speed limiting screw 4-Max. fuel flow-rate limiting screw 5-Sliding sleeve
Fig. 12 T7B Speed governor



1-Screw cap 2-Washer 3-Pressure-adjusting spring 4-Push rod
5-Injection nozzle cap 6-Washer 7-Needle valve couple
Fig. 13 Fuel injector

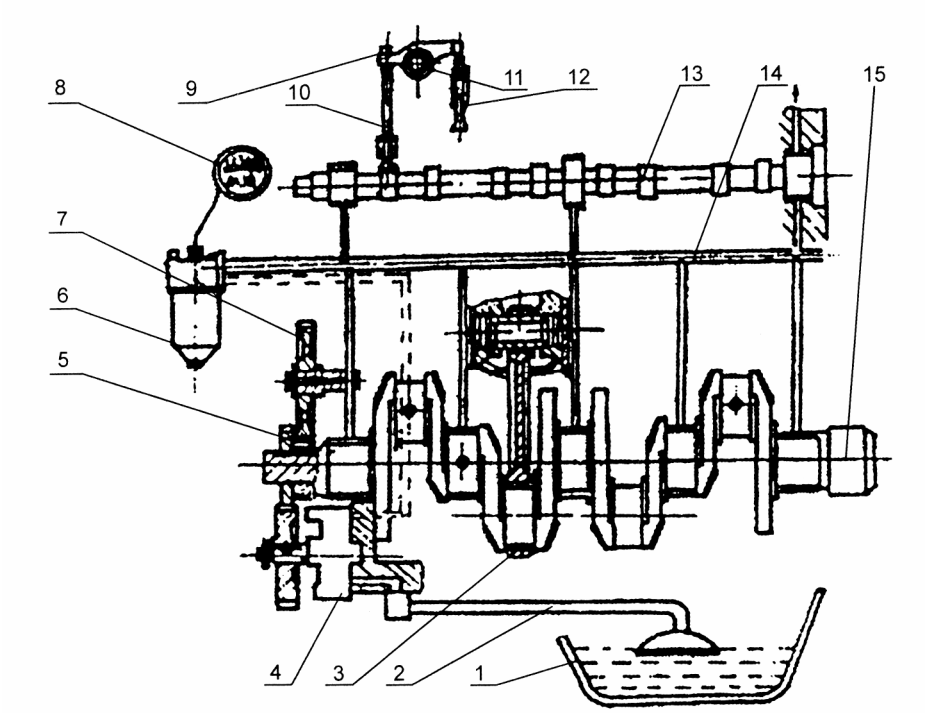
VIII. Lubricating system

Lubricating system consists of engine-oil collector, engine-oil pump, engine-oil filter and pipes, as shown in Fig.14.

The diesel engine adopts pressure lubrication and splash lubrication. Pressure lubrication is used for crankshaft main bearing, connecting rod bearing, camshaft bush, fuel-injection pump seat bearing and rocker shaft bush etc, while splash lubrication is used for cylinder jacket, piston pin, connecting rod bush, cam and tappet, and valve and valve guide etc. Additionally, rolling bearings used for water pump and generator etc will periodically be added grease for lubrication.

Oil stored in the crankcase sump will, via engine-oil collector, pass through oil-in pipe, and then sucked into engine-oil pump, where the oil is pressurized and sent to engine-oil filter. Filtered oil enters the main oil-passage of engine, and then divided into three branches. One branch leads to main bearing, passes crankshaft oil-hole and reach connecting rod bearing; one

branch leads to camshaft bearing, and then to cylinder cover, to lubricate rocker arm bearing; other branch leads to idle-gear bearing, passes to timing gear chamber branch oil-passage, and then to the timing gear seat bearing of fuel-injection pump.



1-Crankcase sump 2-Engine-oil collector 3-Assembly of piston and connecting rod and cylinder jacket
4-Engine-oil pump 5-Driving gear of engine-oil pump 6-Engine-oil filter
7-Gearing system 8-Engine-oil pressure gauge 9-Valve rocker arm
10-Valve push-rod, valve tappet and valve tappet hole of engine body
11-Valve rocker shaft 12-Valve and valve guide 13-Camshaft and bush
14-Oil-passages in engine body 15-Crankshaft and bearing
Fig. 14 Lubricating system schematic diagram

1. Engine-oil pump

The engine-oil pump is of rotor type. The rotor inside the pump is fixed on shaft with pin(s). The gear of the engine-oil pump is driven by the driving gear of engine-oil pump on the crankshaft. On the engine-oil pump body, is fitted pressure-limiting valve, which can regulate the flow-rate and oil-pressure. On the cover of engine-oil pump is cast oil-in/-out hole, which connects to cylinder body. The pump body and cover are fixed by bolts to the cylinder body. During operation, when engine-oil temperature is 80℃, engine-oil pressure is 200～400 kPa (2～4 kgf/cm2). Lowest pressure at idle should be no lower than 98 kPa (1 kgf/cm2).

2. Engine-oil filter

The filter can periodically be replaced. The filter is equipped with safety valve. In case of clogging, open the safety valve to let oil enter into main oil-passage, but this will make it lose filtering effect. Therefore, it is necessary to periodically clean and replace the filter element, as per requirement in "Maintenance".

3. Oil-drain screw plug

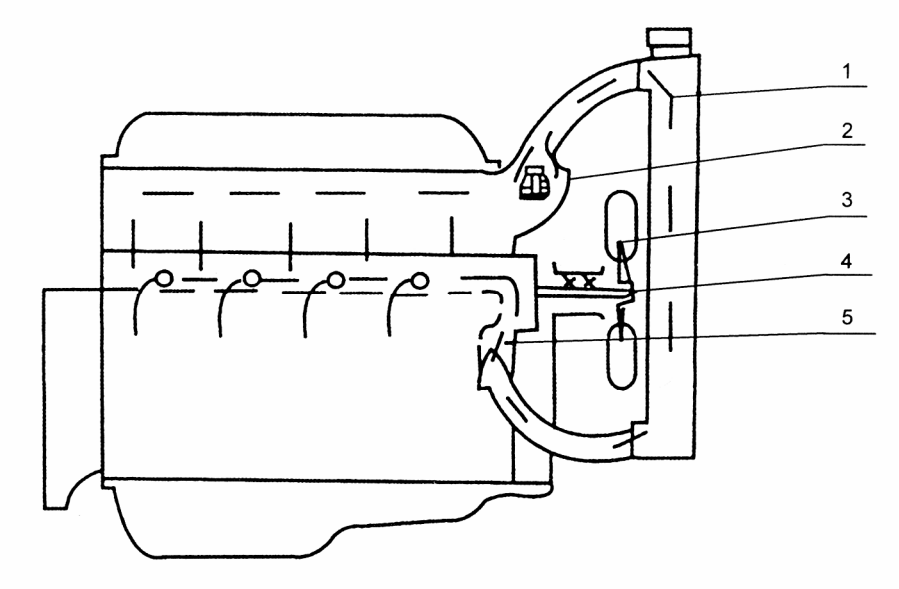
This screw plug is located at lower right bottom in crankcase sump. Each time engine-oil is changed, remove the screw plug and drain completely the oil, then clear up the iron filings and impurities. Before adding engine-oil, it is necessary to check the oil-drain screw plug if any oil leakage.

IX. Cooling system

Cooling system is of forced-circulation loop water-cooling type.

Cooling system includes heat-radiator, water pump, air fan, thermostat and wind-guide hood etc.

1. Cooling water passage (See Fig.15)



1-Heat-radiator 2-Thermostat 3-Air fan 4-Water pump 5-Water-in pipe

Fig. 15 Cooling system

Cooling water in heat-radiator is pumped by the water pump, into main water-passage, and directly enter into the cylinder cover. Then, via water-in guide, one branch of it firstly cools the triangular area of valve and combustion chamber, while the other branch enters tangentially the outer area of cylinder jacket, and then enters around cylinder jacket to the cylinder cover. Worked cooling-water all flows from the front end of cylinder cover, via thermostat and water-out pipe, then back to heat-radiator. When water-out temperature is lower than 70℃, the thermostat will

be off, and the cooling water flows through small-circulation pipe, without through heat-radiator, and directly enters into water pump. Thus the small circulation in body is realized. When water-out temperature is higher than 70～80℃, thermostat will be full on, and at this moment cooling water flows via the thermostat to the upper water chamber of heat-radiator, and flows along flat copper pipe, to the lower water chamber of heat-radiator. During this course, cooling water is cooled by the fan. Thus the big circulation is realized. Heat-radiator is preferred to be Model BJ130, with a heat-dissipation area of 10.62 m2.

Depending on use, the air fan can be of air-suction or exhaust type. Distance between end face of fan and heat-radiator is preferred to be 45mm.

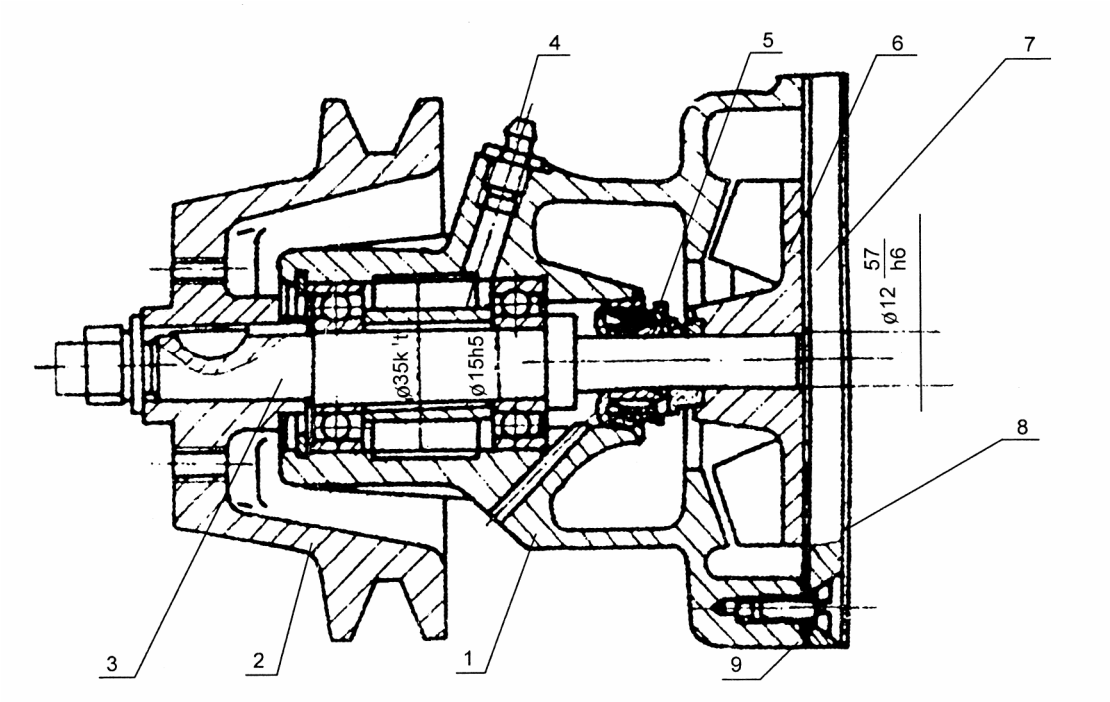
When water temperature is too low in winter, it is possible to be able to invert the arrangement of blades, converting air-suction to exhaust type, facilitate heat-preservation for engine.

Where it is very hot or when water temperature is too high in summer, the thermostat can be removed, to increase the flow-rate of cooling water and raise heat-dissipation efficiency.

2. Water pump

The water pump is of centrifugal type. Its water-in chamber is at front end face of engine body. The water pump is supported by two E60202 bearings. Water-seal is of ceramics graphite design. Driven by crankshaft pulley fan belt, the water pump consists of pump body, impeller, shaft, bearing and water-seal etc. See Fig.16. During its use, in case the water-seal is damaged and the drain-hole below pump body has serious dripping, the water-seal should be replaced, and it is not permitted that the leakage drain-hole is clogged; otherwise water will enter the bearing, causing it soon to be worn off. The bearing, if giving abnormal noise while running, should be preferred to be replaced.

The grease cup of water pump should periodically be added 4# calcium-based lube-grease, according to requirement in "Maintenance". The lube-grease should not be too much; otherwise overheating on bearing can be caused. It is suggested that the amount of lube-grease be approx. 1/2～1/3 of cavity of bearing.



1-Water pump housing 2-Pump belt pulley 3-Pump shaft
4-Grease cup, M8 × 1 5-Water seal II F-12 6-Pump impeller
7-Connecting plate 8-Connecting plate gasket 9-Pump gasket

Fig. 16 Water pump

3. Thermostat

The thermostat is tubular and wax type, is fitted in a casing at water-out, at the front end of cylinder cover. It automatically controls the on/off of valve.

It both indicates a fault at thermostat that, after engine is cold-started and before water temperature reaches 70℃, there is water flowing out of water-out pipe, or when the water temperature is 70℃ or higher, there is no water flowing out of water-out pipe. The faulted thermostat should be removed for inspection. Heat the thermostat slowly in the water. When water temperature reaches 70℃, valve on thermostat should open, and when water temperature reaches 85℃, the valve should fully open. If this requirement cannot be met, then the thermostat should be replaced.

The thermostat should preferably not be removed. Cooling water with a over-low temperature has a negative effect on normal operation of the engine.

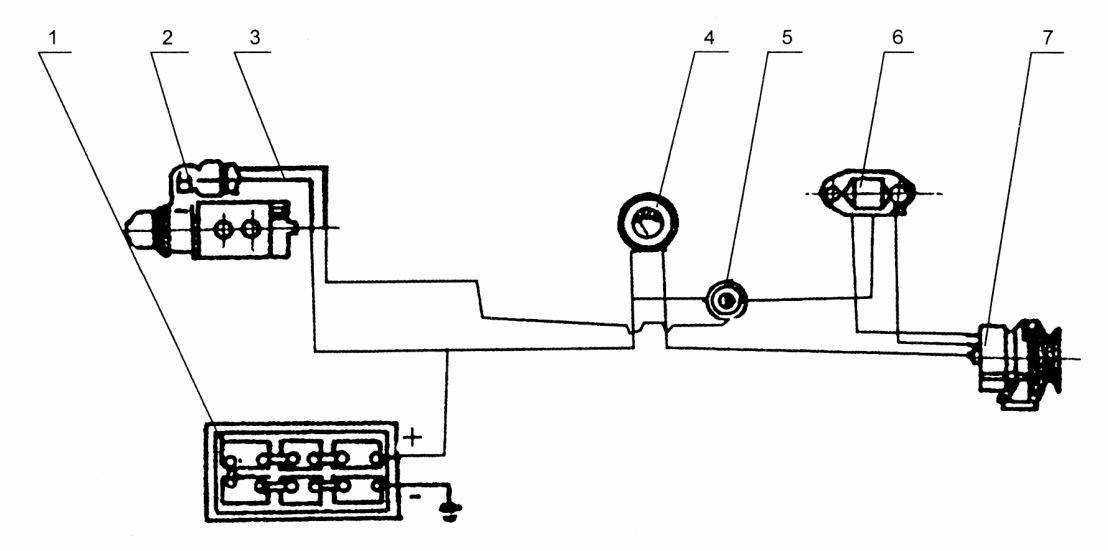
4. Air fan

It is required to inspect periodically the belt of fan, as per "Maintenance", for its tightness or tension, and adjust it if necessary.

Tightness of the belt can be judged appropriate, if the belt between fan and generator pulley is pressed down by hand a distance of 10～20 mm. It is possible to make adjustment, after loosening the bolts on generator bracket and support.

X. Electrical system

Electrical system consists of starting motor, charging generator, starting pushbutton and meters etc. Wiring of electrical system is shown as Fig.17.



1-Storage battery 2-Starting motor 3-Electric wire part
4-Ammeter 5-Ignition switch 6-Regulator 7-Charging generator
Fig. 17 Electrical system schematic diagram

1. Storage battery

Model 6-Q-150 battery can be used. A new battery, without being re-charged, needs to be charged. (This diesel engine, when delivered, does not have a storage battery in it).

When the engine is running, it is necessary to give attention to the value of charging current. If it is near "0", it indicates that the battery has fully been charged, and the charging circuit can be turned off.

When measuring the electrolyte of battery, metal rod is prohibited to be used, to prevent it from reacting chemically with the electrolyte. Only when distilled water is not available, can the boiled water, rainwater and snow-water after precipitated to remove impurities be added. Use of well water and river water is strictly prohibited. In winter, it is necessary to add water when the engine is running and the battery is being charged, to avoid freezing caused by uneven and un-uniform mixture of water and electrolyte.

When in daily use, the plug-cover of battery should be screwed and tightened, venting hole

on the cover should be kept un-clogged, and battery outer surface should be kept clean and dry.

After discharging, the battery must be re-charged within 24h, to avoid sulfuration on plate electrode, and long time delay is prohibited. If the battery needs be stored for long time, then it should firstly be fully charged (i.e., Battery should be so charged that inside it air-bubbles occur). Later, the battery should be re-charged once a month. When the battery is being stored, never pour out the electrolyte.

2. Charging generator

It is a silicon rectified shunt-excitation generator. It consists of 3-phase a.c. generator and silicon diode rectifier. Negative pole is grounded (i.e., connected to iron). Do not mistake the polarity, or the generator will be damaged.

For use and maintenance of the generator, refer to《Operation and Service Manual for JF Series Silicon Rectified Excited Generator》

3. Regulator

JF11A generator is matched with FT111 voltage regulator. When the speed of generator changes, a regulator can automatically stabilize the output voltage of generator within specified range, automatically limit load current, and automatically switch on/off the electric circuit of battery and generator.

When installing the regulator, it should be vertically placed, with its two terminal posts downward, and with its wiring being correct and reliable. As regulator is a precise device, its working clearance should not be arbitrarily adjusted. For its inspection and adjustment, it is possible to refer to《Operation Manual for FT111 Regulator》

4. Starting motor

It is series-excited d.c. motor.

The engagement between the starting motor and engine flywheel gear-ring is controlled electro-magnetically. When the starting switch is turned on, electromagnetic switch makes gearwheel to be engaged with gear ring, and at the same time the circuit of starting motor is switched on, thus driving the flywheel.

After the engine is started, immediately turn off the starting switch. The iron core, under the action of spring, will drive the gear to go back to original place. Each continuous duration period for the use of starting motor must not exceed 5s. Interval between every two starts should be more than 2 min. If three successive starts all fail, then it is necessary to inspect and eliminate faults.

5. Ignition switch

Ignition switch has 3 positions. Middle position means the circuit(s) is completed cut off. When turn the key clockwise, turn on the starting switch and regulator, now the engine can be started. After the engine is started, turn the key anticlockwise to the end. At this moment, only

regulator is on, and the generator can charge the battery, but the starting motor cannot start, to avoid accidents.

XI. Oil-pressure sensor & water-temperature sensitive plug

With double metal-piece design internally, the oil-pressure sensor and water-temperature sensitive plug are matched for electro-thermal type meters. Inside, there is silver contact for conduction. Gently installing the sensor is necessary, because accidental vibration can cause the contact relocate resulting in failure. It is preferable that the resistance be measured when installing the sensor. Resistance is 8-11Ω for Model 303 oil-pressure sensor, and 8Ωfor Model 306 water-temperature sensitive plug. If the resistance value is measured to be "0", it means that the sensor is directly connected, and indicating needle of oil-pressure gauge will go to the end, and the gauge can possibly be damaged. If the resistance is measured to be " ∞ " or " infinity ", it means that the sensor is disconnected, and indicating needle of oil-pressure gauge (water temperature gauge) will not move.

Chapter V　Adjustment

I.　Adjustment of valve lash

When the engine is overhauled or maintained, it is necessary to check and adjust valve lash or clearance.

Adjusting procedure of valve lash and valve timing mechanism is as follows:

1. Dismantle the hood of cylinder cover, and check and tighten/press the nuts on valve rocker arm seat.

2. Turn the crankshaft to the position of top dead center, at first cylinder piston, between the end of compression stroke and beginning of expansion stroke. Now the mark at sight window on flywheel is just aligned with the "0" scale line on flywheel, or the "0" scale line on crankshaft pulley is just aligned with the indicator on the cover of timing gear chamber.

3. Insert feeler gage into intake valve and exhaust valve of first cylinder, into intake valve of second cylinder, and into exhaust valve of third cylinder and rocker arm, respectively, and inspect and adjust intake valve lash and exhaust valve lash. Cold-state clearance should be kept as 0.28～0.33 mm. Turn the crankshaft by 360°, and adjust the valve clearance of the rest cylinders as per foregoing procedure.

II.　Adjustment of fuel-supply advance angle

To ensure that the engine has most economical fuel consumption rate and good running performance, fuel-supply advance angle must be adjusted appropriately. Correct fuel-supply advance angle should be 16°±1° before top dead center.

Adjusting procedure of fuel-supply advance angle is as follows:

1. Remove the air in fuel oil system. Turn the crankshaft repeatedly to make fuel-injection pump to be filled fully with fuel oil. Remove high-pressure oil pipe in first cylinder, and blow off the leftover fuel oil inside the joint hole on fuel-discharge valve seat. Turn the crankshaft slowly on positive direction, paying attention to the fuel level inside joint hole. As soon as the fuel level begins fluctuating, immediately stop turning the crankshaft.

2. Check if the top dead center mark on sight window of flywheel casing　is aligned with the scale on flywheel (or the scale on crankshaft pulley), and if conforms to best angle degree specified above.

3. If the advance angle is too small, loosen the nuts on the three kidney-shape openings in fuel-injection pump seat, and turn the fuel-injection pump inwards the engine body. Contrarily, if the advance angle is too big, it can be turned outwards.

III. Adjustment of fuel injector

Testing and adjustment for fuel injector should be performed on a tester. The purpose is to adjust the fuel-injecting pressure and eliminate faults.

If fuel-injecting pressure inside the oil injector is too high or too low, fuel-injection is abnormal, and part(s) is damaged, when the engine runs, faults will occur, such as the occurrence of black smoke, decrease of power and speed, increase of exhaust temperature or knock of cylinder etc. For fuel injector judged to be faulted, in-turn cylinder-stoppage method can be used. That is, loosen the oil injector and high-pressure oil pipe one by one, and stop injecting oil. At the same time, watch the color of exhaust gas. If faulted injector stops injecting oil, exhaust gas will stop producing black smoke. Now, speed of engine has little or no change. It is also possible to turn the flywheel (by hands) to listen to fuel-injection sound of each cylinder. If the sound is not clear and melodious, the oil injector is this cylinder may have a fault.

1. Adjusting procedure

(1) Use hand-pump, to pump to a gauge pressure of 12.7MPa. Continue to slowly press the hand-pump, to raise the gauge pressure to 13.7MPa, at which the fuel is injected. Watch if fuel-dripping or leakage, at fuel-injection hole at fuel nozzle. If fuel dripping is found in tests by several times, it is necessary to remove the fuel nozzle couple, for a cleaning. After inspection or grind, perform test again.

(2) Adjust the pressure of fuel injection. Remove the pressure-adjusting screw cap(s) on the fuel injector, and loosen or tighten the pressure-adjusting screw(s), make the pressure of fuel injection to be 13.7MPa. Then, tighten the pressure-adjusting screw cap(s), and perform re-test.

(3) Watch the quality of atomization. Perform atomization test, with a fuel-injecting rate of 1 time/sec. Atomized fuel should be thin, uniform and mist-like, without abnormal phenomena such as visible splashed tiny foam, local un-uniform density and one-side fuel injection. When the fuel oil is cut off, an obvious and clear sound should be heard. Abnormal fuel injection is usually caused by free-less and smooth-less nozzle needle-valve motion. Fuel dripping at fuel-injecting hole is caused by a damaged sealing surface. Branched fuel beam is caused by a head which is accumulated with soot or deformed due to heat.

2. Dismantle and repair of fuel injector

(1) When dismantle the oil injector, at first, clean the outer part. With the nozzle facing upwards, clamp tightly the injector onto a bench clamp padded with copper. Unscrew the screw cap and take out the needle-valve couple, and pull out the needle-valve and immerse it in clean kerosene. Turn the fuel injector by 180° and then clamp tightly it. Unscrew the pressure-adjusting screw cap and pressure-adjusting screw, then the pressure-adjusting spring and push-rod can be taken out.

(2) When the needle-valve couple is jammed or atomization is poor, it is necessary to clean it. The jammed needle-valve couple should at first be immersed in kerosene for some time, then the needle-valve should be clamped by a pair of wire pliers lined with cloth, and turned gently and pulled out. Care should be given to prevent it from being napped. Wooden pieces with gasoline or kerosene can be used to scrub the needle-valve couple, and metal pieces are prohibited for this purpose. If the needle-valve and valve body are not smooth or active enough, it is possible to adjust it by grinding it with clean kerosene. When pair-grinding them, the needle-valve should not collide with the valve body seat surface. After the grinding, carefully clean them, with no dirt leftover.

3. Protruding distance

The distance between injector head end and the bottom plane of cylinder cover should be 3 ± 0.25 mm. Adjustment, if necessary, can be made with 0.2 mm copper shim.

IV. Fuel injection pump

The fuel injection pump has been adjusted and inspected before delivery. Re-adjustment, if necessary, should be made on a test stand specially for fuel injection pump, with standard fuel injector and standard-length high-pressure fuel pipes on it. For specific parameters for adjustment, please refer to relevant instructions for fuel injection pump.

Chapter VI Troubles & Troubleshooting

Trouble causes	Remedial methods
I. Engine does not start	
1. Low starting speed	
(1) Battery runs low, or connecting terminals are loosened.	(1) Recharge it: tighten the terminals; repair wire-post if necessary.
(2) Starting motor's carbon brush contacts poorly with commutator.	(2) Repair or replace the carbon brush.
(3) Starting motor's gearwheel cannot nest the gear ring of flywheel.	(3) Turn the flywheel to another position. If necessary, inspect the installation of starting motor, and eliminate the non-parallelism between the axes of starting motor and gear ring.
2. Abnormal fuel system	
(1) No fuel oil in the fuel tank, or valve of the tank not open.	(1) Fill it; or open the valve.
(2) Air in fuel system; water in diesel oil; oil leaks at joints.	(2) Remove the air; change the oil; tighten the joints.
(3) Fuel passage clogged.	(3) Clean the passage, replace element of diesel oil filter, and clean fuel-in pipe of fuel-transfer pump.
(4) Fuel-transfer pump does not supply fuel.	(4) Inspect if any air leakage on fuel-in pipe. Inspect and repair fuel-transfer pump.
(5) Fuel injector injects no or little fuel; too-low pressure and poor atomization; fuel injector pressure-adjusting spring is broken; injection-hole is clogged.	(5) Dismantle the fuel injector and adjust it on its tester, and inspect if fuel-injection pump starting has more concentricity.
(6) Fuel-injection pump fuel-discharge valve leaks fuel; spring is broken; plunger couple is worn off.	(6) Grinding it: repair or replace parts.
3. Insufficient compression pressure	
(1) Valve clearance too big	(1) Adjust it as per requirement
(2) Valve leaks	(2) Grind the valve
(3) Cylinder cover gasket leaks	(3) Replace the cylinder cover gasket, and tighten the bolts on cylinder cover.
(4) Piston ring worn off, stuck; opening overlapped	(4) Replace it, clean it, adjust it
4. Other causes	
(1) Air temperature too low; oil viscosity too big	(1) Put some water into the cooling system. Start after pre-heating. Use engine-oil with brand specified.
(2) Water in combustion chamber or cylinder	(2) Inspect, repair or replace it

Trouble causes	Remedial methods
II. Abnormal engine-oil pressure	
1. No or little pressure for engine-oil	
(1) Engine-oil level too low; oil deteriorates or is thinned.	(1) Add the oil; change the oil.
(2) Oil pipe is broken; pipe joint not tight enough causing oil leakage; engine-oil pressure gauge is damaged.	(2) Weld, tighten or replace it.
(3) Engine-oil pump pressure-adjusting spring is deformed or broken.	(3) Replace it.
(4) Engine-oil pump has too much clearance.	(4) Return it to factory for repair; replace it.
(5) Engine-oil pump gasket is broken.	(5) Replace it.
(6) fit clearance between bearings is too much.	(6) Inspect, adjust or replace it.
(7) Oil-passage screw-plug is loosened and leaks.	(7) Inspect it; block it.
2. Engine-oil pressure too high	
(1) Engine-oil pump's pressure-limiting valve does work abnormally, oil-returning does not go smoothly.	(1) Inspect and adjust it.
(2) Air temperature too low, engine-oil viscosity too higher.	(2) Use engine-oil with brand specified; decrease is possible after the engine is warmed up.
3. Rocker arm cannot be added engine-oil.	
(1) Upper cylinder-head oil-passage and oil-hole at support bottom of rocker arm shaft are clogged.	(1) Clean and make it unclogged.
III. Smoke emitted in exhaust gas	
1. Black smoke emitted in exhaust gas	
(1) Oil injector is clogged with accumulated soot, and needle valve is clogged.	(1) Inspect, repair or replace it.
(2) Load is too much.	(2) Adjust the load to the range specified.
(3) Fuel injecting is too late, and partial fuel is burned during the course of exhaustion.	(3) Adjust the fuel-supply advance angle of fuel-injection pump.
(4) Incorrect valve clearance; valve sealed poorly.	(4) Inspect the valve clearance and sealing surface and spring force etc, and eliminate the problems.
(5) For each cylinder, fuel supply by fuel-injection pump is not uniform and even.	(5) Adjust fuel supply amount for each cylinder.
(6) Intake pipe, air filter clogged, and air-intake is not smooth.	(6) Dismantle and clean the filter.
2. White smoke emitted in exhaust gas	
(1) Fuel-injecting pressure is too low; atomization is poor; fuel dripping.	(1) Inspect, adjust, repair or replace the fuel nozzle couple.

Trouble causes	Remedial methods
(2) Cooling water temperature is too low.	(2) Increase the temperature of cooling water.
(3) Moisture enters cylinder	(3) Inspect the gasket of cylinder cover.
3. Blue smoke emitted in exhaust gas	
(1) Piston ring severely worn off, or elasticity not enough due to accumulation of soot, causing engine-oil enter the combustion chamber of the cylinder.	(1) Clean or replace the piston ring.
(2) Engine-oil level too high	(2) Discharge excessive oil.
(3) Conic surface gas ring is mistaken for its upper and lower direction	(3) The side marked with a "Up" should face up.
IV. Insufficient power	
1. Filter gauze in oil-in pipe joint of diesel oil filter or oil-transfer pump is clogged.	1. Clean or replace it.
2. Oil injector has an incorrect pressure or poor atomization.	2. Inspect, repair the injector, or replace the oil nozzle couple.
3. Precise pair part of fuel-injection pump is severely worn off.	3. Adjust oil-supply work-detection plunger couple and oil-delivery valve couple.
4. Speed governor spring is deformed and loosened, thus rated speed cannot be reached.	4. Adjust high-speed limiting screw, and replace speed-governing spring.
5. Air enters into fuel system.	5. Remove the air in fuel oil system.
6. Fuel-supply advance angle is not correct.	6. Adjust it as per requirement.
7. Oil-supply rate for each cylinder is not uniform or even.	7. Adjust the oil-supply rate for each cylinder.
8. Air filter not fluent or be clogged.	8. Clean or replace filter element.
9. Valve leaks gas.	9. Inspect valve clearance, spring force, and inspect valve guide for wear-off conditions, and inspect valve if stuck, and inspect valve sealing surface. If necessary, replace part(s) and grind the valve.
10. Compression pressure is not enough.	10. See III of this chapter
11. Valve timing is not correct.	11. Camshaft is severely worn,. The camshaft can possibly be replaced.
12. Hole in oil injector leaks.	12. Replace the copper washer, and clean seat hole surface, and tighten uniformly the nuts on pressure plate of oil injector.
13. Bolts on cylinder cover loosened	13. Tighten them as per specified tightening-torque.

Trouble causes	Remedial methods
V. Abnormal sound	
1. Fuel-supply advance angle is too big, and metal-knock rhythmic sound can be heard from inside of cylinder.	1. Adjust the advance angle.
2. Oil nozzle drips oil, and needle valve is jammed, causing the sound like "ta, ta, ta".	2. Clean, repair or replace the needle valve couple.
3. Valve clearance too big, and clear and rhythmic knocking-sound	3. Adjust valve clearance.
4. Piston collides with valve, causing heavy and rhythmic knocking-sound (if put a hand at nut on cylinder cover, vibration can be felt).	4. Increase the valve clearance a little bigger, correct the gap of connecting rod's bearing, or replace the rod's bush.
5. Piston collides with the bottom of cylinder cover, causing heavy and strong knocking-sound.	5. Replace cylinder cover gasket.
6. Valve spring is broken, valve push-rod is bent, valve tappet is worn off, causing valve mechanism to produce slight knocking-sound.	6. Replace the spring, push-rod or tappet etc, and adjust valve clearance.
7. Sound due to too much gap between piston and cylinder jacket. This sort of sound will be reduced, with the engine being warmed up.	7. Depending wearing conditions, determine if cylinder jacket and piston are to be replaced.
8. If connecting rod bearing gap is too big, when speed is abruptly reduced, heavy and strong knocking-sound can be heard.	8. Replace connecting rod's bush.
9. Gap between connecting rod bush and piston pin is too big. This sound is low but sharp, and	9. Replace connecting rod's bush
10. If crankshaft thrust-piece is worn off, gap is too big, the collision sound of crankshaft playing back and forth can be heard.	10. Replace the thrust-piece of crankshaft.
VI. Severe vibration	
1. Oil-supply for each cylinder is not uniform; oil nozzle of one or two cylinders has poor atomization; one or two cylinders severely leak; compression ratio difference is big, etc.	1. Inspect and adjust oil-supply rate of fuel-injection pump; repair the oil nozzle; eliminate the leakage problem; inspect and adjust compression pressure of each cylinder.
2. Water or air enters into diesel oil.	2. discharge the air; make the diesel oil to be deposited.
3. Poor alignment when the engine is installed; support's bolts are loosened.	3. Correct the alignment; tighten them.
4. Cylinder(s) is heavily knocked. Engine works roughly.	4. Inspect the fuel-supply advance angle; apply load after engine is warmed up.

Trouble causes	Remedial methods
VII. Engine overheat	
1. Fuel enters into crankcase; or engine-oil is mixed by water, it becomes thinner; too much or less engine-oil; low flow-rate and pressure of engine-oil; fit clearance of bearing is too small. 2. Water pump impeller is damaged and broken, and fan belt slips; positions of heat radiator and fan are improper; thermostat is failure; cooling system piping is clogged; too thick water-scale in water jacket; water pump displacement is not enough; cylinder cover gasket is broken and fuel gas enters water-passage.	1. Inspect and replace piston ring; change engine-oil; inspect oil level; inspect wearing conditions of inner/outer rotor; inspect and adjust the fit clearance of each bearing. 2. Inspect and replace the impeller; inspect the belt's tightness or replace the belt; inspect the position of heat radiator; inspect the working condition of thermostat; clean the cooling system and water jacket; inspect the clearance of impeller; fill fully water; replace the cylinder cover gasket.
VIII. Too much engine-oil consumption	
1. The viscosity of the oil used is too low, or the brand is not correct. 2. Piston and cylinder jacket is severely worn; oil-return hole on piston ring groove is clogged. 3. Piston ring is stuck by glue; gas ring if fitted with upper and lower faces being reversed; too much wearing 4. Oil leaks on crankshaft front/rear oil-seal, crankcase sump joint plane and side cover etc. 5. Engine-oil temperature or pressure is too high, or evaporated and splashed.	1. The oil, the brand of which is specified (in this Manual), should be used. 2. Replace; clean the oil-return hole. 3. Clean or replace it. 4. Inspect or replace them, if necessary. 5. Reduce the temperature (see previous section); inspect and adjust the pressure-limit valve of engine-oil pump.
IX. Speed increased greatly	
1. Speed governor is failure, and pull-rod is jammed at "large oil flow-rate" position. 2. Speed governor's sliding disc shaft sleeve is jammed. 3. Adjust-arm is released from shifting fork.	1. Inspect and repair the speed governor and its pull-rod. 2. Inspect and repair it. 3. Inspect and repair it.
X. Engine stops by itself	
1. Air in oil-passage; oil-transfer pump does not supply oil; diesel oil filter is clogged. 2. Piston is jammed in cylinder; journal is jammed by bush. 3. Fuel-injection oil-delivery valve is jammed; plunger spring is broken; speed governor sliding disc sleeve is jammed.	1. Discharge the air; inspect and repair oil-transfer pump; clean diesel oil filter. 2. Fit clearance is not correct; repair and replace it. 3. Inspect, repair or replace it.

Trouble causes	Remedial methods
XI. Rough idle	
1. Un-uniform oil flow-rate in each cylinder; oil injector drips oil; pull-rods shifting-fork screw is loosened.	1. Make the flow-rate uniform; repair or replace oil nozzle needle-valve couple, secure shifting-fork screw
2. Gap between shifting-fork and adjusting-arm is too big; steel ball and sliding disc is worn and dent(s) occurs.	2. Replace them.
3. Too much axial moving clearance of fuel-injection pump camshaft.	3. Adjust it with copper shim.
4. Sleeve of sliding disc is jammed.	4. Clean, repair or replace it.
XII. Engine-oil raised high	
1. Cylinder jacket water-seal ring is damaged.	1. Replace the ring.
2. Cylinder jacket gasket leaks water.	2. Replace the gasket.
3. Cylinder cover or engine body leaks water.	3. Inspect and replace it.

Annex Fit Clearance Table

No.	Names	Standard size	Fit category	Fit clearance for assembly of new engine	Allowable clearance limit
1	Conn. Rod bush / Conn. Rod small-end hole	Shaft Φ 32 $^{+0.090}_{+0.050}$ / Hole Φ 32 $^{+0.025}_{0}$	Interference	0.025～0.090	
2	Piston pin / Conn. Rod bush	Shaft Φ 28 $^{0}_{-0.009}$ / Hole Φ 28 $^{+0.033}_{+0.020}$	Clearance	0.020～0.042	0.10
3	Piston pin / Piston pin's hole	Shaft Φ 28 $^{0}_{-0.009}$ / Hole Φ 28 $^{+0.009}_{0}$	Clearance	0～0.018	
4	1st piston ring / Piston ring groove	2.5 $^{0}_{-0.012}$ / 2.5 $^{+0.070}_{+0.050}$	End-face clearance	0.05～0.082	0.21
5	2nd piston ring / Piston ring groove	2.5 $^{0}_{-0.012}$ / 2.5 $^{+0.050}_{+0.030}$	End-face clearance	0.03～0.062	0.18
6	Oil ring / Piston ring groove	5 $^{0}_{-0.012}$ / 5 $^{+0.050}_{+0.030}$	End-face clearance	0.03～0.062	
7	1st piston ring		Open clearance	0.25～0.40	1.6
8	2nd piston ring		Open clearance	0.25～0.40	2.2
9	Crankshaft thrust-face width / Crankshaft thrust journal distance	Φ 31 $^{-0.185}_{-0.325}$ / Φ 31 $^{+0.050}_{0}$	Axial clearance	0.185～0.335	0.50
10	Camshaft bush (front, rear) / Hole on engine body	Shaft Φ 50 $^{0}_{+0.070}$ / Hole Φ 32 $^{+0.025}_{0}$	Interference fit	0.045～0.086	
11	Camshaft journal / Camshaft bush (front, rear)	Shaft Φ 46 $^{-0.050}_{-0.075}$ / Hole Φ 46 $^{+0.025}_{0}$	Clearance	0.050～0.100	0.18
12	Valve tappet / Tappet hole	Shaft Φ 14 $^{-0.016}_{-0.034}$ / Hole Φ 14 $^{+0.018}_{0}$	Clearance	0.016～0.052	0.25

No.	Names	Standard size	Fit category	Fit clearance for assembly of new engine	Allowable clearance limit
13	Camshaft pressure plate / Camshaft thrust journal distance	4 $^{-0.08}_{-0.15}$ / 4 $^{+0.10}_{0}$	Axial clearance	0.13～0.30	0.60
14	Valve guide pipe / Cylinder cover	Shaft Φ 13 $^{+0.046}_{+0.028}$ / Hole Φ 13 $^{+0.018}_{0}$	Interference fit	0.010～0.046	
15	Timing idle gear shaft / Bush	Shaft Φ 45 $^{-0.025}_{-0.050}$ / Hole Φ 45 $^{+0.025}_{0}$	Clearance	0.025～0.075	0.20
16	Idle gear shaft / Idle gear shaft hole on engine body	Shaft Φ 14 $^{0}_{-0.011}$ / Hole Φ 14 $^{+0.018}_{0}$	Clearance	0～0.029	
17	Meshing side-clearance of each timing gear		Clearance	0.13～0.17	0.30
18	Intake valve seat / Cylinder cover	Shaft Φ 41 $^{+0.090}_{+0.066}$ / Hole Φ 41 $^{+0.025}_{0}$	Interference fit	0.041～0.090	
19	Exhaust valve seat / Cylinder cover	Shaft Φ 33 $^{+0.090}_{+0.065}$ / Hole Φ 33 $^{+0.025}_{0}$	Interference fit	0.040～0.090	
20	Intake valve / Valve guide	Shaft Φ 8 $^{-0.025}_{-0.040}$ / Hole Φ 8 $^{+0.022}_{0}$	Clearance	0.025～0.062	0.15
21	Exhaust valve / Valve guide	Shaft Φ 8 $^{-0.040}_{-0.055}$ / Hole Φ 8 $^{+0.022}_{0}$	Clearance	0.04～0.077	0.15
22	Rocker arm shaft / Valve rocker arm bush	Shaft Φ 18 $^{0}_{-0.018}$ / Hole Φ 18 $^{+0.034}_{+0.016}$	Clearance	0.016～0.052	0.20
23	External rotor of engine-oil pump / Engine-oil pump body	Shaft Φ 50 $^{-0.080}_{-0.119}$ / Hole Φ 50 $^{+0.025}_{0}$	Clearance	0.080～0.144	0.30
24	Rocker arm bush / Valve rocker arm	Shaft Φ 21 $^{+0.056}_{+0.035}$ / Hole Φ 21 $^{+0.021}_{0}$	Interference fit	0.014～0.056	

No.	Names	Standard size	Fit category	Fit clearance for assembly of new engine	Allowable clearance limit
25	Engine-oil pump shaft / Engine-oil pump body	Shaft Φ 14 $^{0}_{-0.018}$ / Hole Φ 14 $^{+0.043}_{+0.016}$	Clearance	0.016～0.061	0.15
26	Injection pump pad / Timing gear chamber	Shaft Φ 68 $^{+0.025}_{0}$ / Hole Φ 68 $^{+0.030}_{0}$	Transition	-0.025～0.030	
27	Conn. Rod journal / Conn. Rod bush	Shaft Φ 54 $^{0}_{-0.019}$ / Hole Φ 54 $^{+0.089}_{+0.050}$	Clearance	0.050～0.108	0.25
28	Crankshaft main journal / Main bearing bush	Shaft Φ 65 $^{0}_{-0.019}$ / Hole Φ 65 $^{+0.089}_{+0.060}$	Clearance	0.060～0.108	0.25
29	Piston skirt section / Cylinder jacket	Shaft Φ 85 $^{-0.100}_{-0.120}$ / Hole Φ 85 $^{+0.035}_{0}$	Clearance	Divided into 2 groups: 0.11～0.145	
30	Valve concaving into cylinder cover / Bottom plane depth			0.7 ± 0.15	
31	Extruded part of nozzle above cylinder cover / Bottom plane height			3 ± 0.25	
32	Fuel-supply advance angle			16° ± 1°	
33	Intake valve clearance / (At cold state)		Clearance	0.28～0.33	
34	Exhaust valve clearance / (At cold state)		Clearance	0.28～0.33	