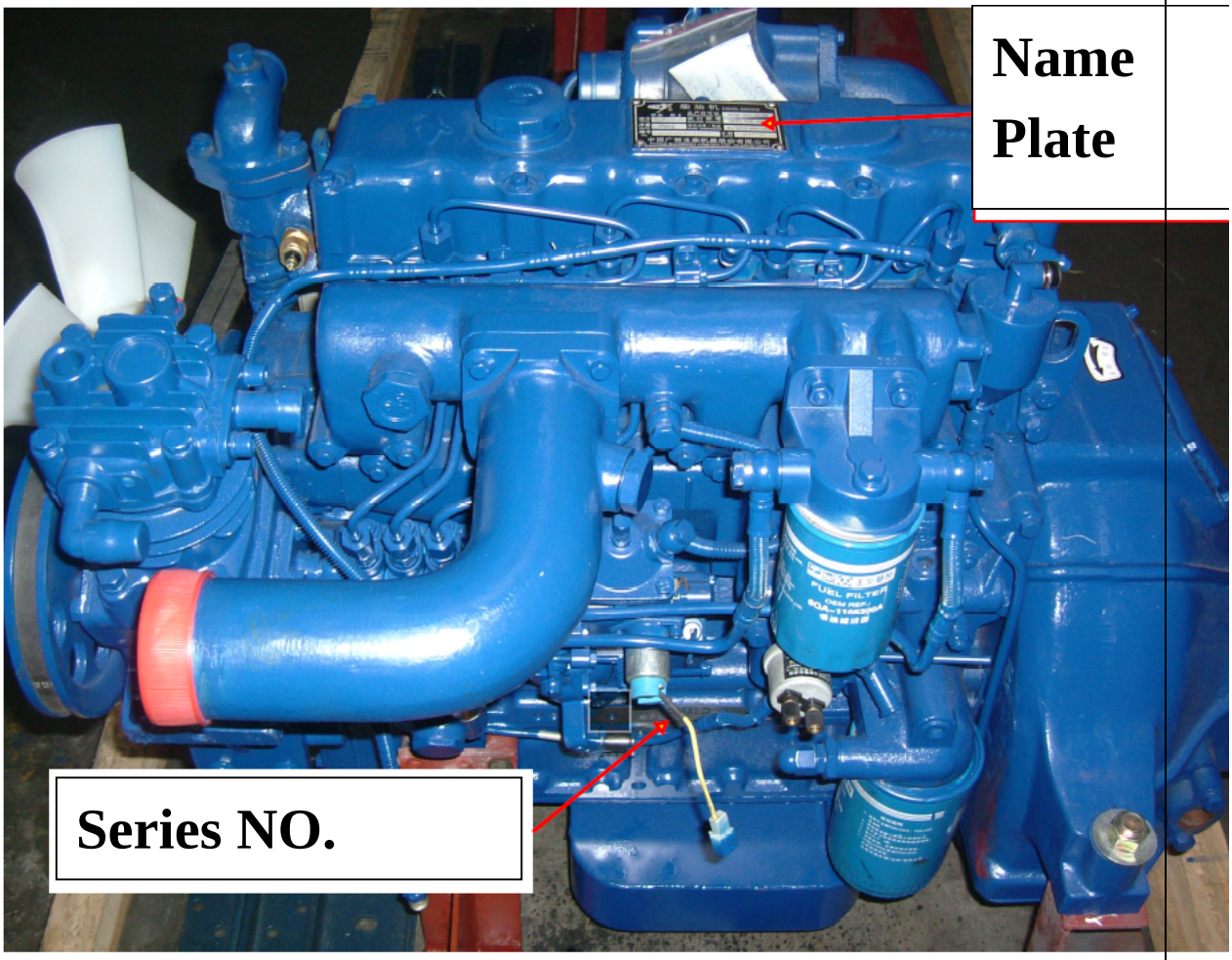
Operation and Maintenance Manual for Diesel Engine

YC 4F Series

Guangxi Yuchai Machinery Co., Ltd.

June, 2006



YC4F Series Diesel Engine Production License Number

Corporation Name	Specification	License #	Expiration Date	Granted Date	Detail	Censorship	File #	Province
Yuchai Machinery Co. Ltd.	Multi-cylinder diesel engine ≤58.00kW Engineering Machinery	XK06-205-00187	July. 1, 2008	July. 2, 2003	License granted	Department of Machinery Product Censorship	903	GuangXi
Yuchai Machinery Co. Ltd.	Multi-cylinder diesel engine ≤132.00kW, >58.82kW, Vehicle	XK06-205-00188	July. 1, 2008	July. 2, 2003	License granted	Department of Machinery Product Censorship	903	GuangXi

Content

Features of YC4F series diesel engine

- **The YC4F Series engine is a wholly new model which designed with the world developed designing conception and means, and combine with Yuchai's experienced technologies in the turbocharger and depth mechanical development. Its overall design is carried out by a team of worldwide-known automobile experts from Germany at the request of Yuchai, and it has been tested and improved with the cooperation by YUCHAI and the YAMAHA MARINE COMPANY in the performances of marine-used engine and its reliability-improvement.**
- **Wide output power coverage: powering from 40kW（55Ps）～90kW（122Ps）.**
- **Excellent maneuverability: good in climbing and accelerating.**
- **Effective economy: high fuel/lube-effectiveness.**
- **Exceptional comfort: lower vibration and noise.**
- **Completely meeting and even surpassing Euro-II exhaust emission standards.**
- **Extensive application range: YC4F is simultaneously put into service for vehicle, boat and construction machinery. It was delicately built for the clients' comforts, better-than-expected, no matter for traffic between city and countryside, farming-purpose transport, or medium/top-grade light trucks/buses, passenger vehicles, boat and ship, and others.**
- **High reliability: The reliability is co-developed in step respectively by Yuchai Technical Center, the state-level center, and the YAMAHA MARINE COMPANY(Japan), through 3-round improvements(with 20 units of samples per round) to ensure the safety and reliability of the engines.**
- **Compact construction and Small specific weight: the power and the torque per litre of YC4F series engine hold the top position in China in comparison with the other engines of the same displacement.**

To Customers

In order to ensure the engine's normal capability and safety, and also for your great benefits, please pay your attention to the following statements and take them in your heart before you start the engine:

1. Considering the essential importance of the oil-pressure transmitter, the water-temperature sensor and, especially, the oil-pressure (over-low) alarm, do replacement if any wrong happens so to assure the normal operation of the other parts. Abnormal work of any of them should cause the crankshaft burning-out or the cylinder head cracking due to oil or water lack.

2、Do remember to restart the engine and keep it running to normal state after cleaning or replacing the oil filter element during maintenance. Then checks and make sure there is no any leakage in the filter. Leakage should be eliminated promptly to prevent the crankshaft from burning-out due to the oil lack.

3、Be sure to start the engine and keep it running in idle speed for 10 minutes before getting to work, especially for those turbocharged engines or those having been kept in store for a long time. Don't try to get the engine to work in a rush time without warming-up, which would damage the engine's instruments and key parts and as a result to shorter the engine's lifespan.

4、Abruptly stop the turbocharged engine should be avoided as far as possible while the engine is running in a high-speed and heavy load, otherwise we should drop the engine and lower its load gradually and keep it running in idle speed for 5～10 minutes before stop.

5、Adjust the fuel supply advance angle strictly in the ways stated in the manual. Check the intake system for the leakage before adjustments and maintenance when the engine power drops down.

6、Stop the engine promptly whenever any signs of abnormal happen to the engine or the vehicle. Never run the engine in its malfunctioning state.

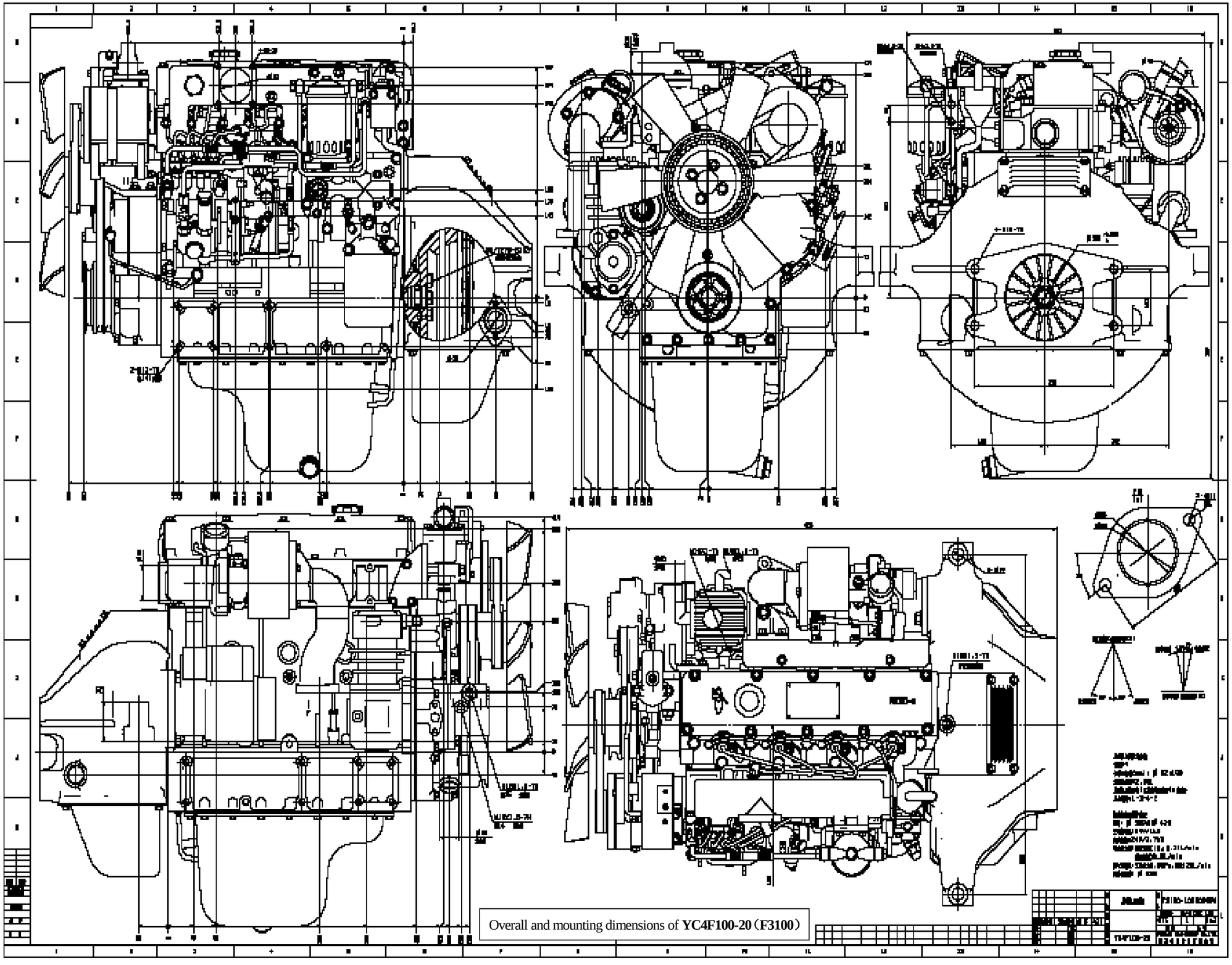
7、Getting the new engine to the authorized YUCHAI service-shop for the break-in maintenance after running for 1500~2500km, otherwise the warranty maintenance would not be guaranteed.

8、Use a Class CF or higher grade lubricant for the engine depending on the ambient temperature to ensure the engine's capability, reliability and durability. Yuchai recommends the CF 15W40 lubricant for the summer time while the CF 10W30 lubricant for the winter time.

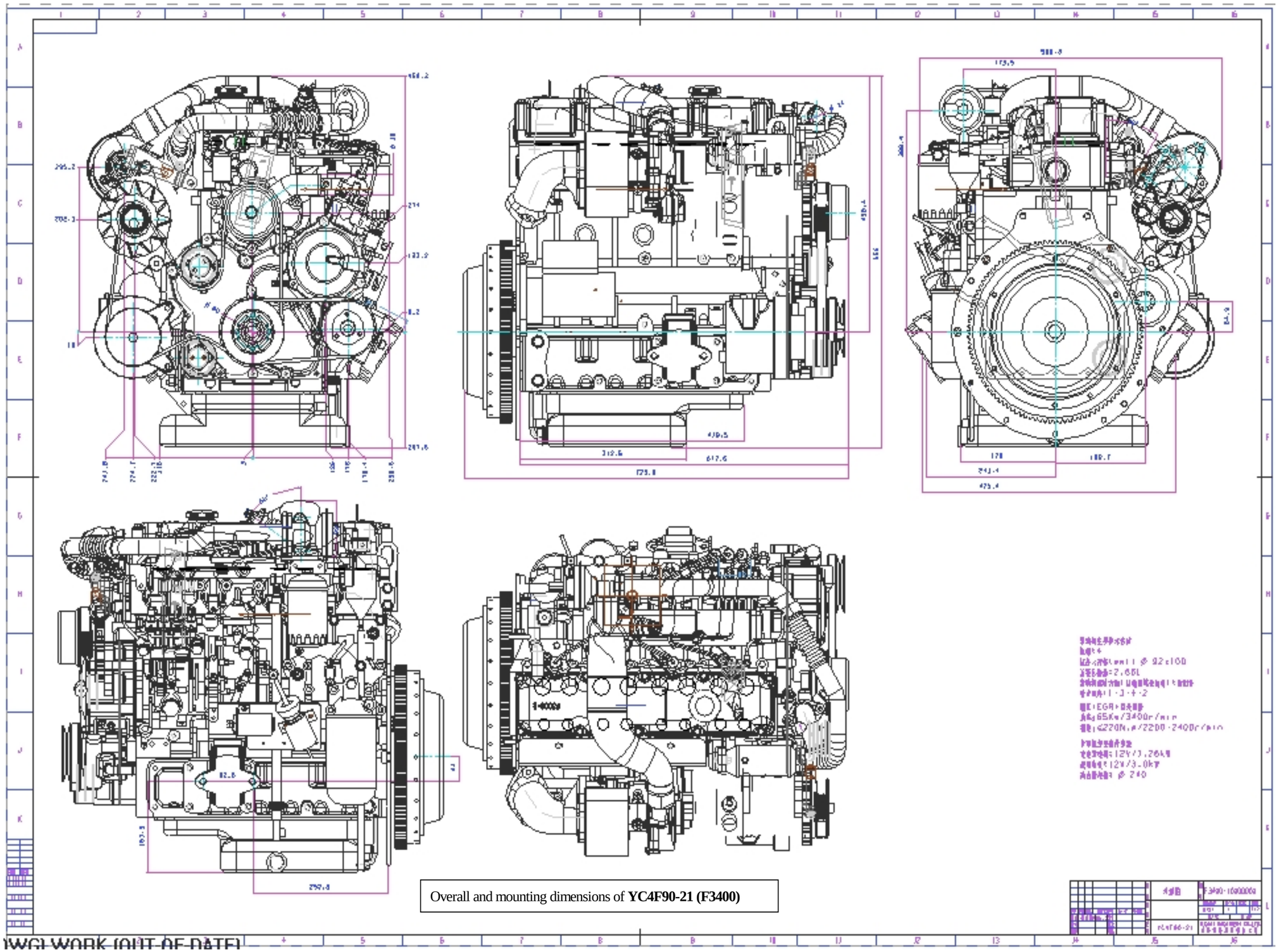
9、Use the fuel as per statements specified in the GB252-87<light diesel> and change the fuel vary from the ambient temperature. Generally use No. O# for the summer time and No. –O# for the winter time, but use the No.-20# when the ambient temperature drops to -20℃ and No.-35# when the ambient temperature drops to -30℃.

10、Use the coolant as stated in the manual's attachment so as to improve the engine's anti-freeze and anti-rust functions, and to prevent the engine from fatal troubles as cylinder scoring, engine boiling and the cavitation of the cylinder liner. Therefore to prolong the engine's working life.

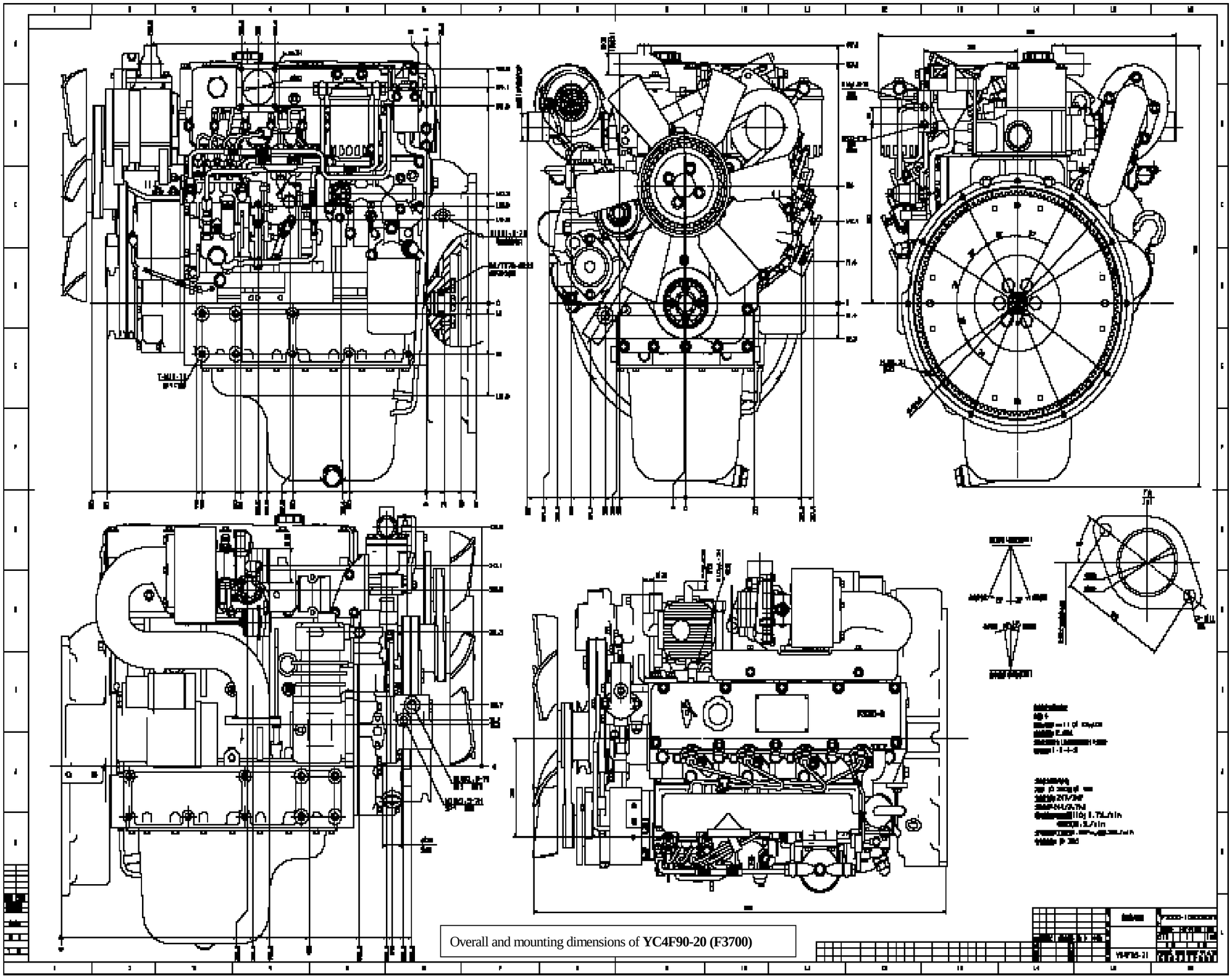
Guangxi Yuchai Machinery Company Limited



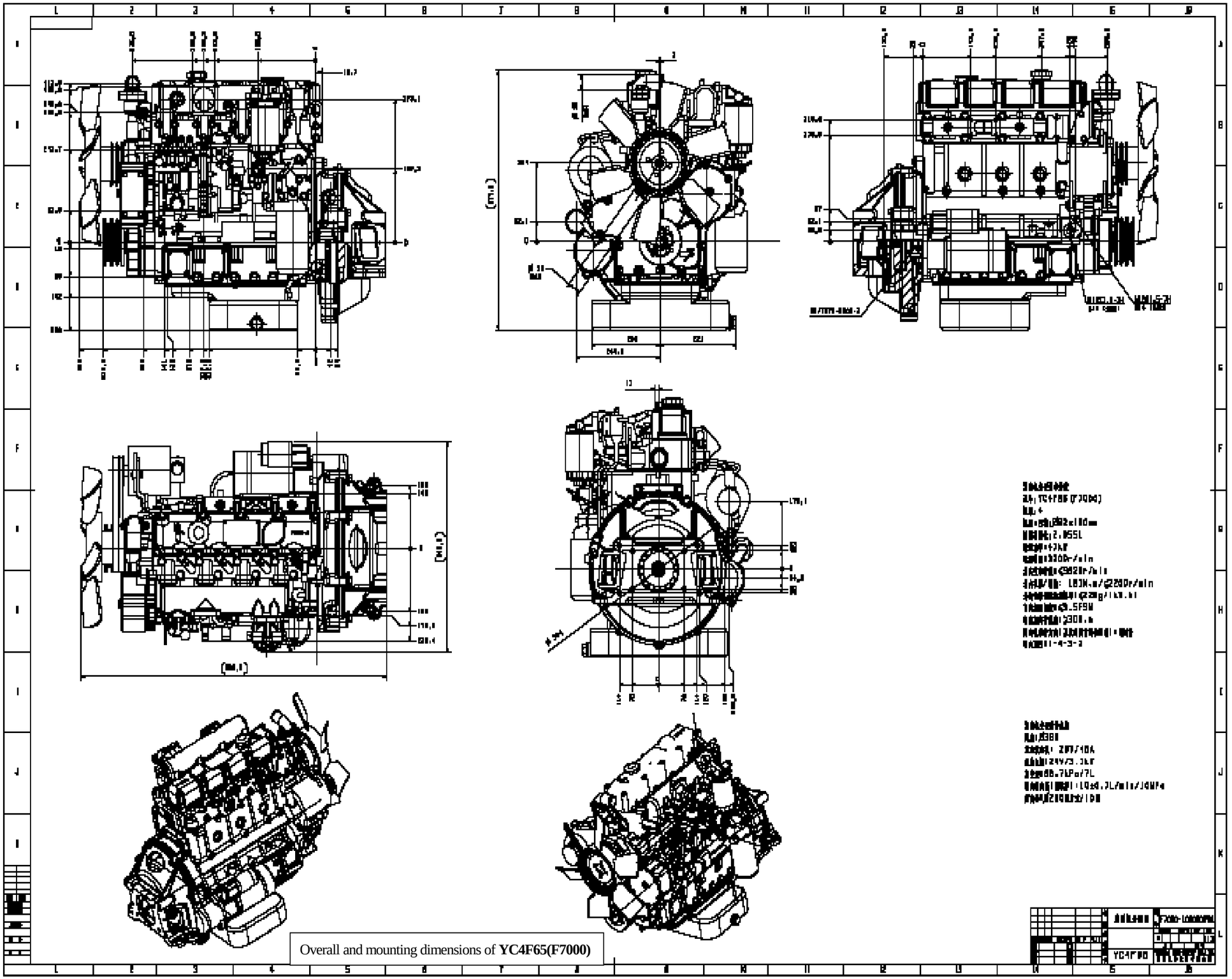
Overall and mounting dimensions of **YC4F100-20（F3100）**



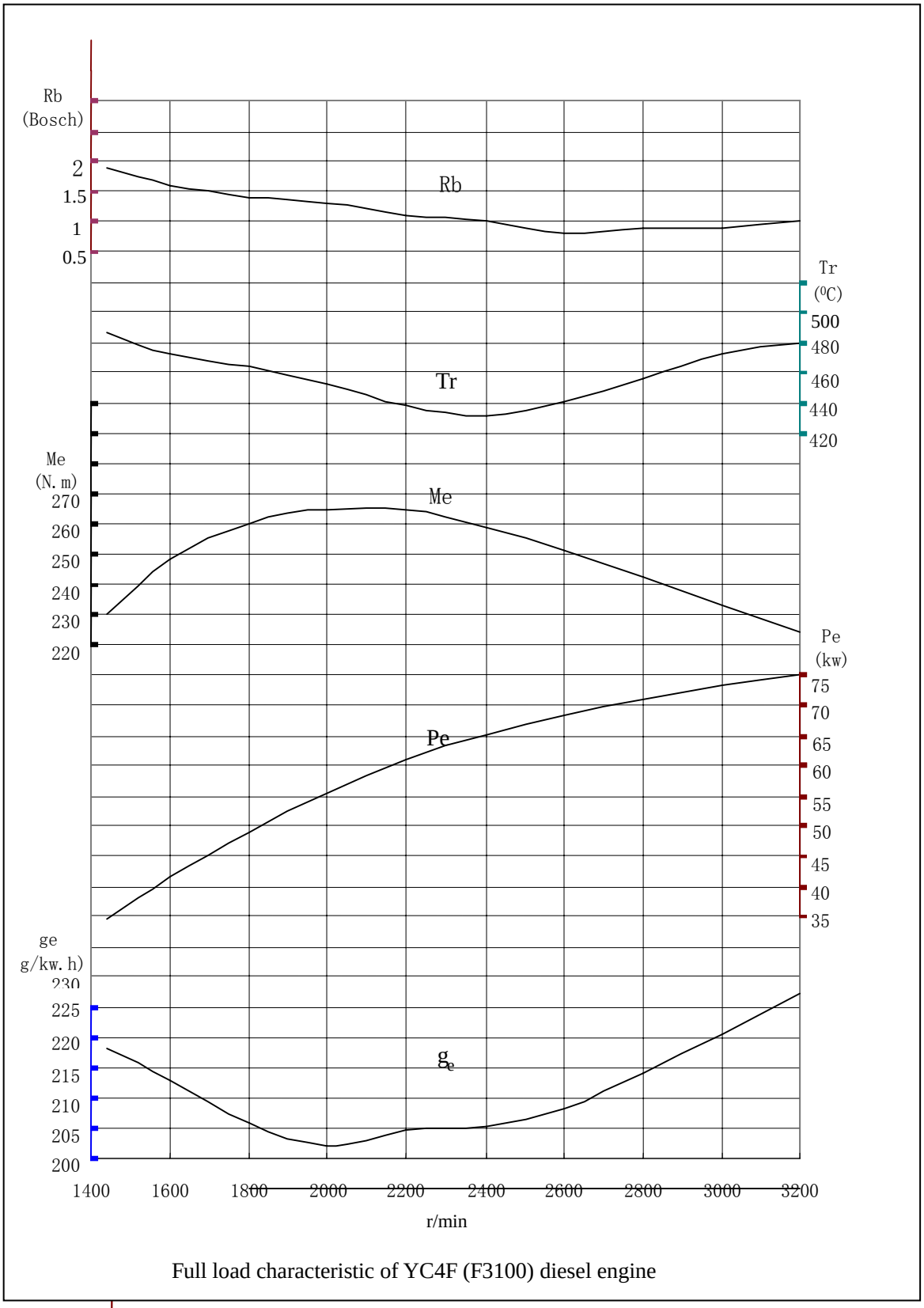
Overall and mounting dimensions of **YC4F90-21 (F3400)**



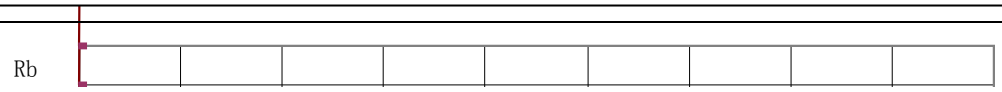
Overall and mounting dimensions of **YC4F90-20 (F3700)**

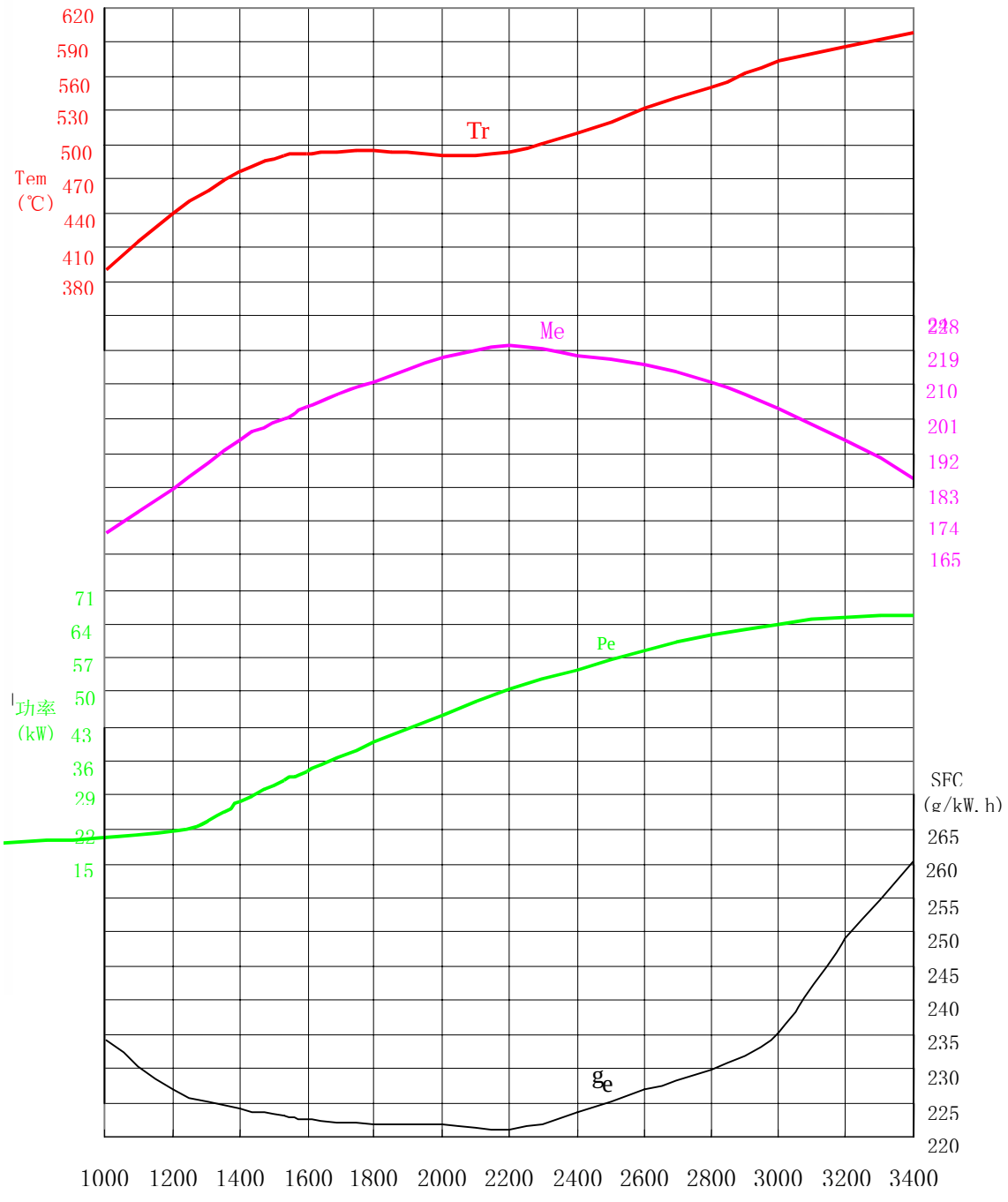


Overall and mounting dimensions of **YC4F65(F7000)**



Full load characteristic of YC4F (F3100) diesel engine





Full load characteristic of YC4F (F3400) diesel engine

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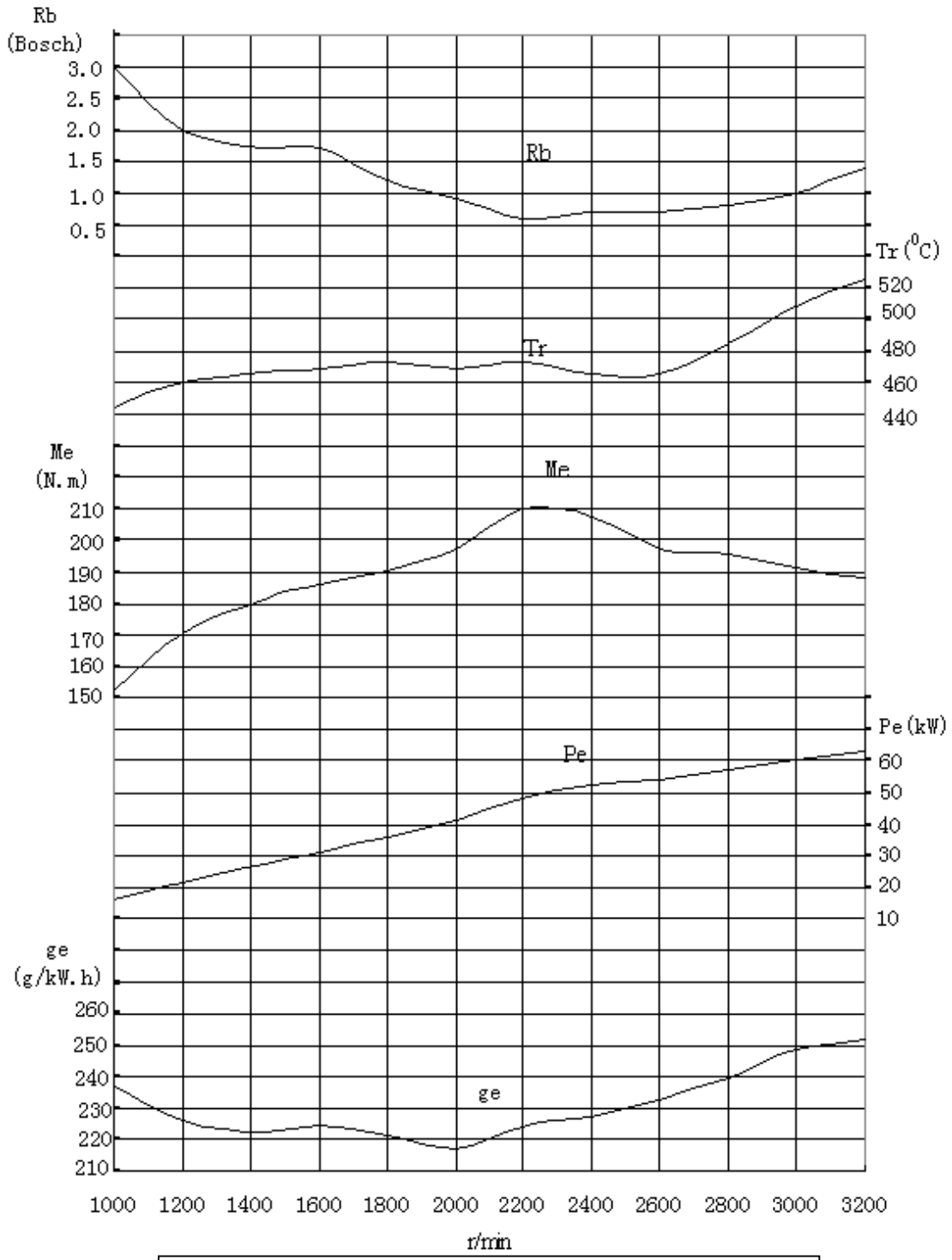
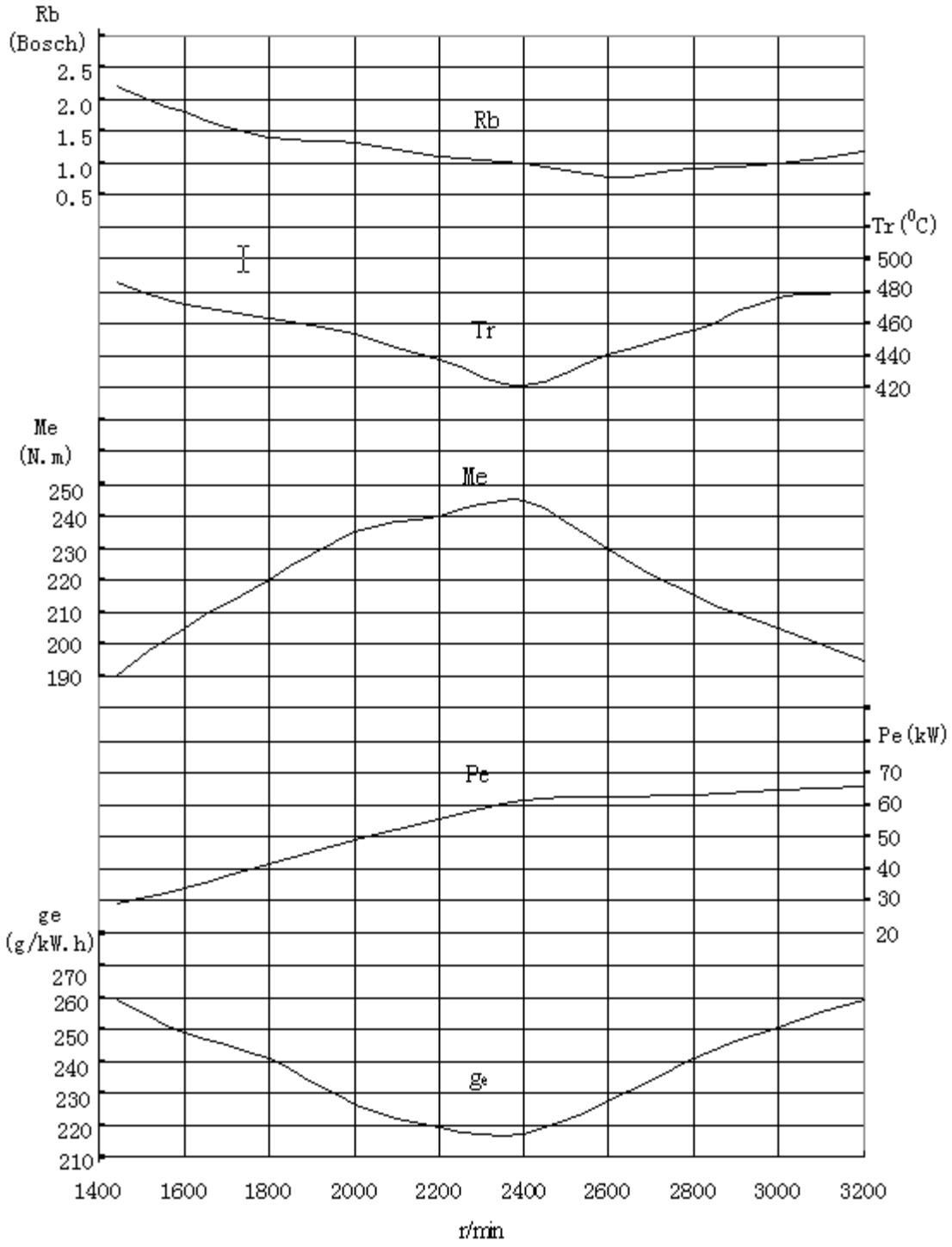
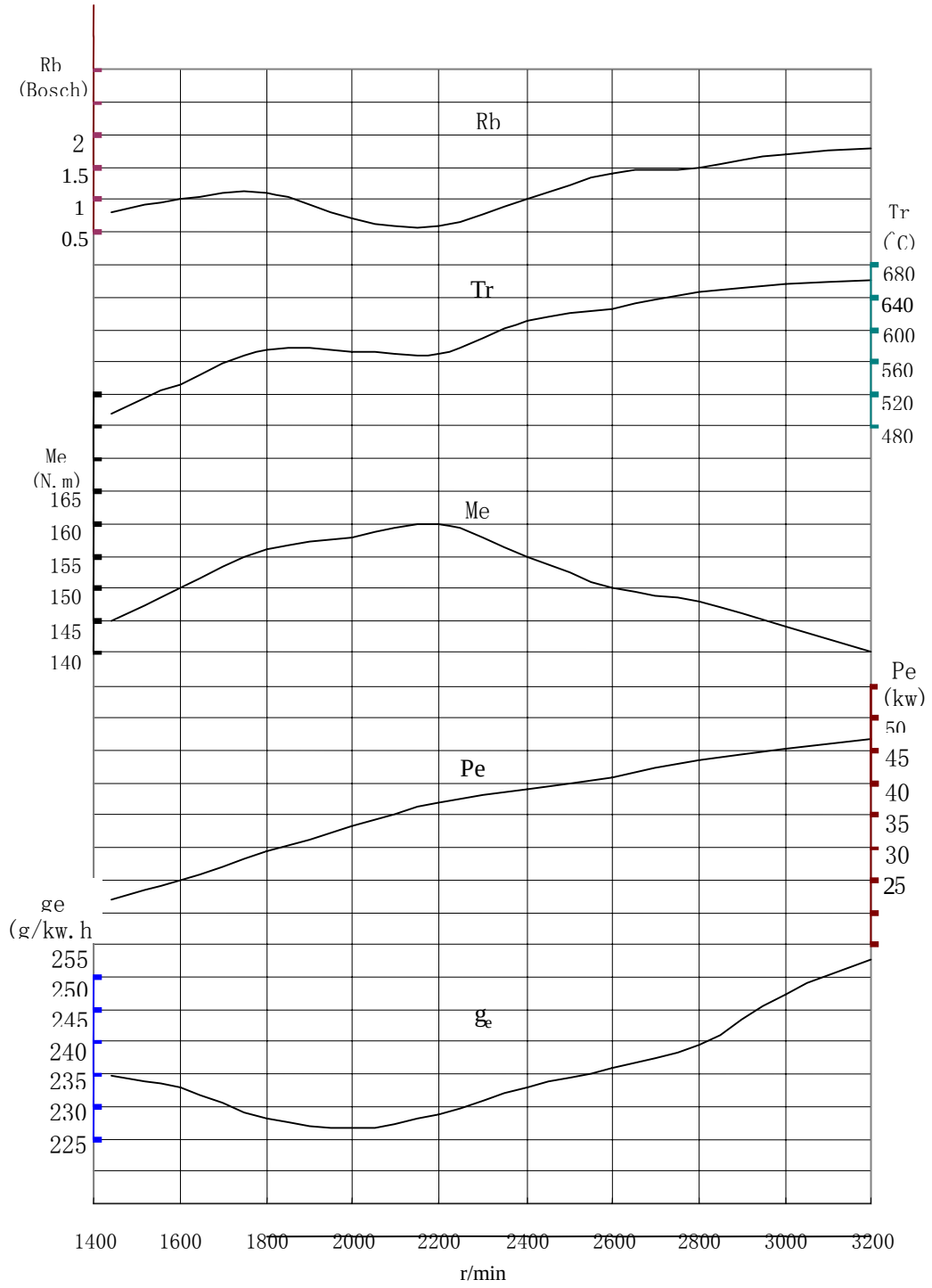


Full load characteristic of YC4F (F3500) diesel engine

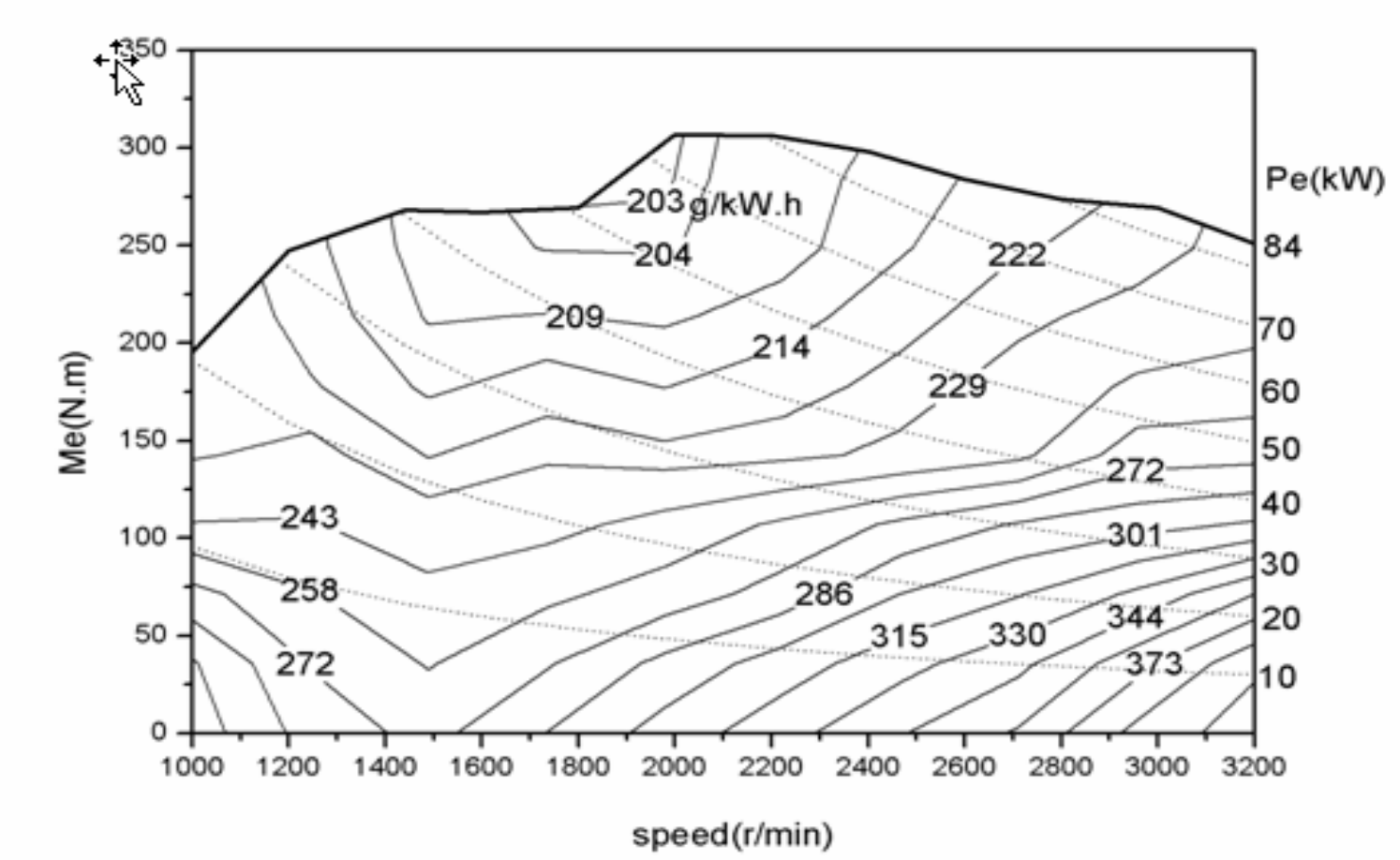


Full load characteristic of YC4F (F3700) diesel engine

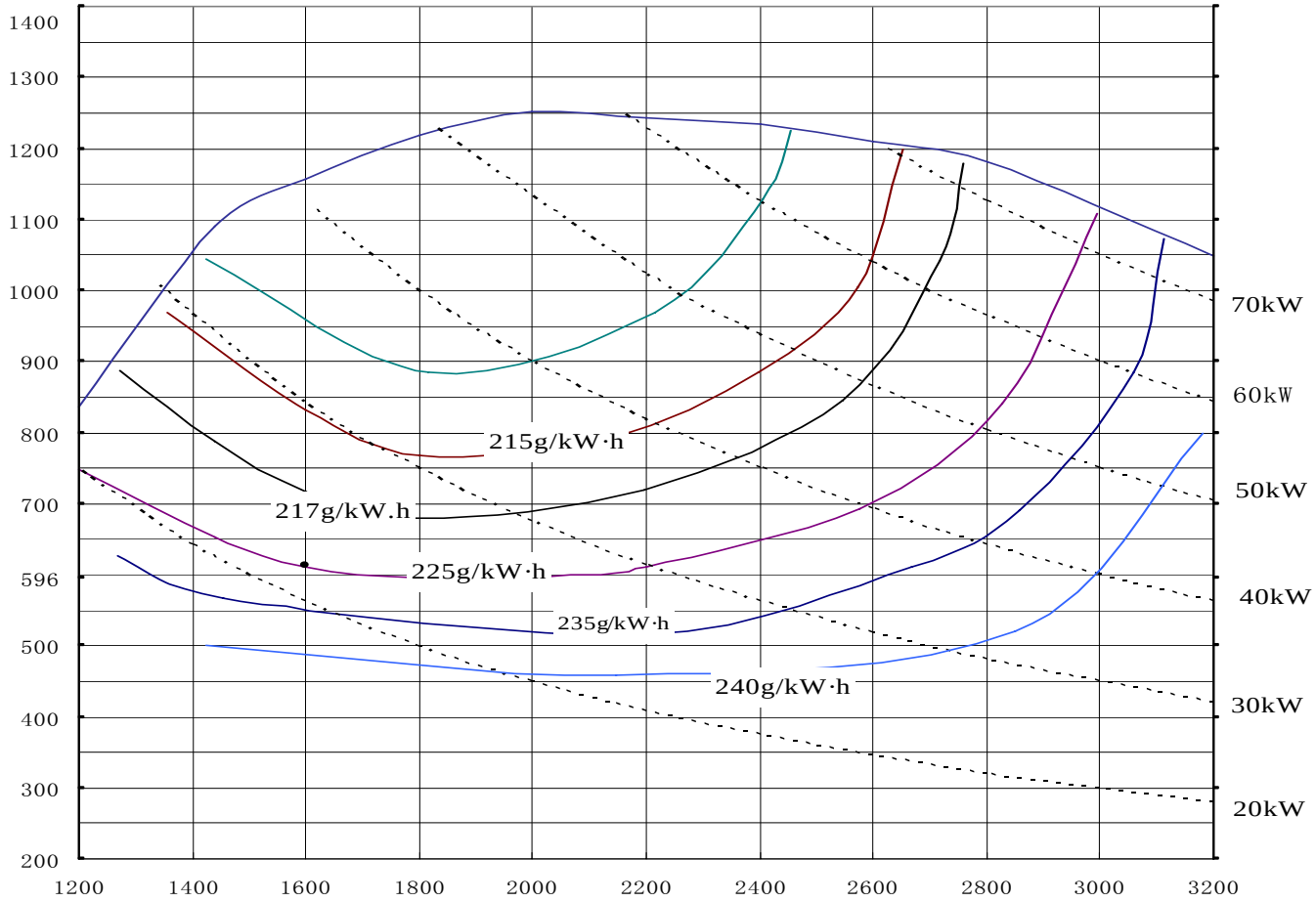


Full load characteristic of YC4F (F7000) diesel engine

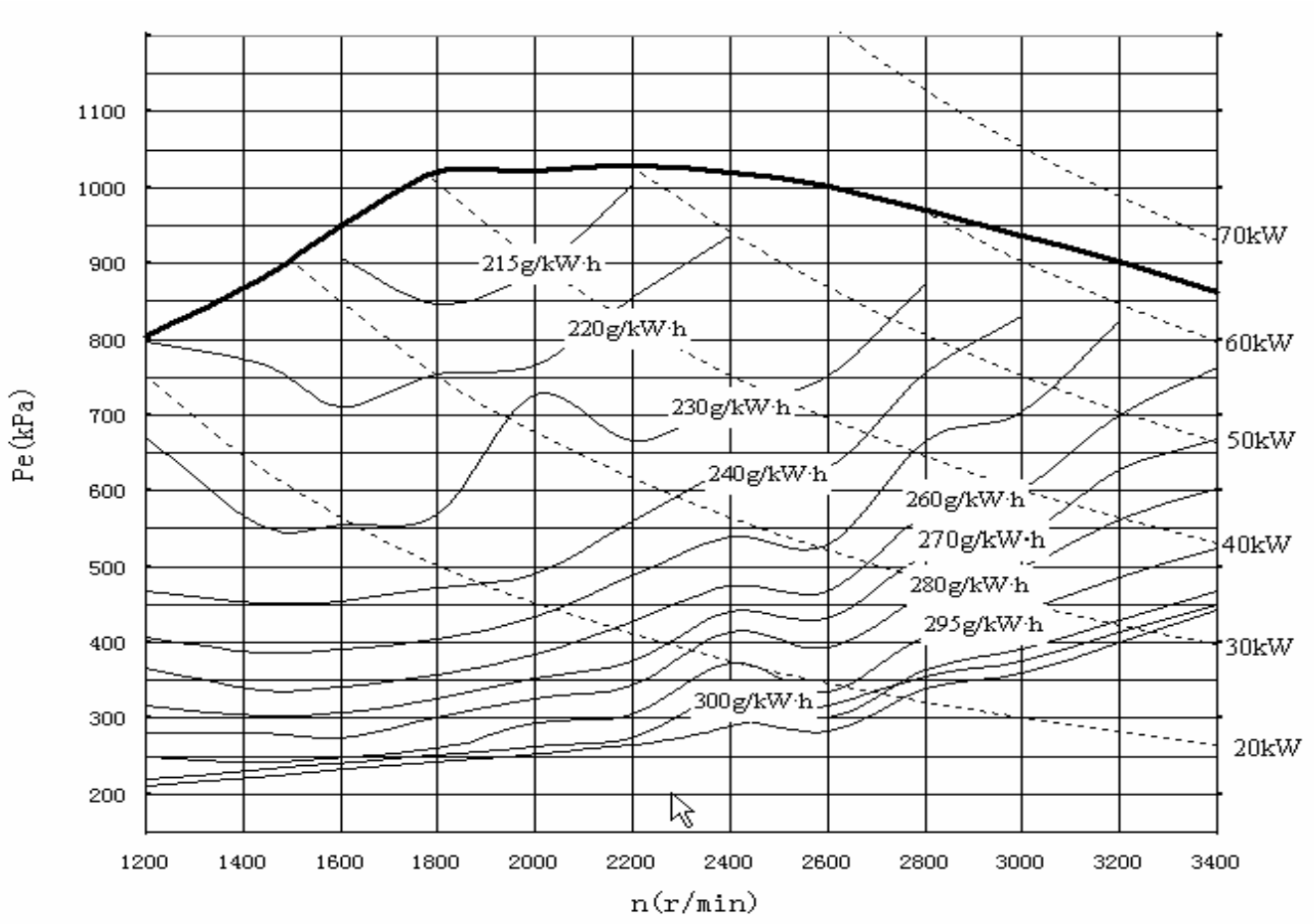
Performance map of YC4F（F3000）



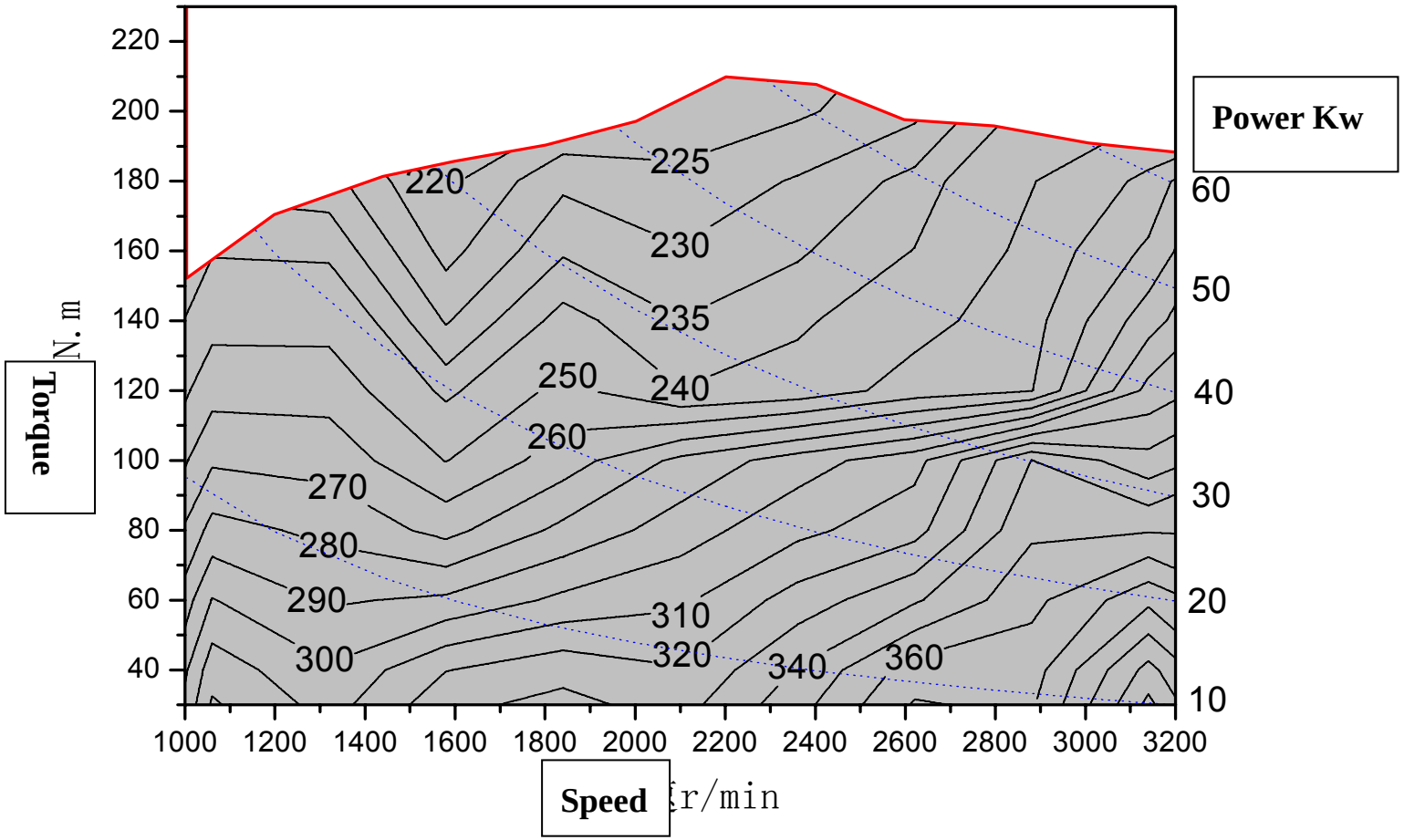
Performance map of YC4F（F3100）



Performance map of YC4F (F3400)



Performance map of YC4F (F3500)



1. Engine and accessories specifications

1.1 Engine specifications (Table 1)

Type code / Parameter	YC4F55G (F7200)	YC4F85-21 (F3500)	YC4F115-20 (F3000)	YC4F100-20 (F3100)	YC4F90-21 (F3700)	YC4F115-21 (F3600)	YC4F90-21 （F3400）
Type	Vertical, in-line, six-cylinder, liquid cooled, and four stroke						
Intake type	Naturally aspirated	Turbocharged+DOC	Turbocharged & inter-cooled				Turbocharged +EGR
Combustion chamber	Direct injection						
Cylinder number	4						
Cylinder bore（mm）	92						
Cylinder stroke（mm）	100						
Displacement（L）	2．66						
Compression ratio	17.5∶1						
Ignition order	1—3—4—2						
Rotation direction	Counter-clockwise（crankshaft, power output end）						
Rated power（kW）	40	62.5	85	75	66	85	65
Rated speed（r/min）	2650	3200	3200	3200	3200	3600	3400
Max. torque（N・m）	165	245	300	245	245	300	220

Speed at Max.torque（r/min）	≤2000	≤2200	≤2200	≤2200	≤2200	≤2400	≤2200
Min. SFC at full load (g/kW • h)	225	215	215	≤215	≤215	≤215	215
Max. Speed without load（r/min）	≤3050	≤3650	≤3650	≤3650	≤3650	≤4100	≤3900
Idle speed（r/min）	700～750						
Oil to fuel consumption ratio	≤0.2（%）						
Oil type	15W40 CF or 5W30CF						
Oil capatity（L）	10						7.5
Exhaust temperature (after turbo)	≤580						
Exhaust smoke(FSN)	≤3.5	≤2.0					
Emission		EURO Ⅱ					
Cooling	Closed forcing water cooling system						
Lubricating	Pressure and splash						
Starting	Electrical						
Gross weight（kg）	260						

1.2 Main accessories specifications (Table 2)

Table 2

No.	Name			F7200	F3000	F3500	F3100	F3700	F3400	F3600
1	Fuel injection pump assmbly	Model	Wuxi	IW/ BQ	4PM	4PL				VE
			Kangda	BQ2000	BH4QK	BH4QK				
		Type		Inline barrel and plunger with single slot						Distribute
		Plunger diameter (mm)	Wuxi	ϕ8.5	ϕ8.5	ϕ8.5				\
			Kangda	ϕ8.0	ϕ9.5					
		Plunger stroke (mm)	Wuxi	9	9	9	9			\
			Kangda	9.5	11	9.5	11			
		Governor type	Wuxi	BHF4PL090	BHF4PL090					\
			Kangda	TQFG	TQZ1					
2	Fuel injector assembly	Type		P						
		Model code		5× ϕ0.23	5× ϕ0.25					
3	Fuel filter assembly	Type		Paper element and rotation						
		Yuchai model code		D30-1105010						
4	Oil filter	Type		Paper element and rotation						

No.	Name		F7200	F3000	F3500	F3100	F3700	F3400	F3600
		Yuchai model code	186-1012000						
5	Thermostat	Type	Wax-element						
		Opening temperature（℃）	68±2					75±2	68±2
		Full opening temperature（℃）	80±2					85±2	80±2
6	Oil pump	Type	Inner and outer rotor type						
		Flow rate	≥55L/min						
7	Water pump	Type	Centrifugal type						
		Rated speed（r/min）	3600						
		Flow rate（L/min）	≥180						
		Lift（m）	10						
8	Fan	Type	Axial suction						Axial suction
		Model code	φ360 或φ380						φ360 φ380
9	Starter motor	Type	D.C.						
		Voltage（V）	12	24				12	24

No.	Name		F7200	F3000	F3500	F3100	F3700	F3400	F3600
9	Starter motor	Power（kW）	3	3.7				2.8	3.7
10	Air compress -or	Type		air-cooled single cylinder with piston					air-cooled single cylinder with piston
		Working pressure		0.8MPa					
		Rated displacement		≥125L/2100r/min					
11	Chargeable generator	Voltage（V）	14	28				14	28
		Power（kW）	1	1				1.26	1
12	Generator belt	Type and model code	SPA890	SPA650				SPK1375	SPA650
13	Turbo-charger	Type		SJ50FY/ JP50A					
		Max. turbocharged pressure (kPa)		135(kPa)					
14	Steering pump	Type		Vane pump				\	Vane pump
		Max. working pressure		10MPa				\	10MPa
		Controllable flow rate (L/min)		10±0.7				\	10±0.7

1.3 Main technical parameters

1. Valve timing (in crankshaft angle)

(valve clearance at cold state: intake valve 0.35mm, exhaust valve 0.40mm)

intake advance angle:	14° CA
intake lag angle:	46° CA
exhaust advance angle:	46° CA
exhaust lag angle:	14° CA

2. Static fuel supply advance angle: 8° ~10° CA

3. Fuel injector opening pressure (MPa): 24～25

4. Compression clearance (mm): 0.9～1.1

5. Idle speed (rpm): 700～750

6. Oil pressure

At high speed (MPa):	≤0.6
At idle speed (MPa):	≥0.15

7. Normal operation temperature range

Exhaust temperature after turbine (℃):	≤580
Oil temperature in oil pan (℃):	≤120
Water outlet temperature (℃):	≤95

1.4 Main component parts tolerance clearance (Table 3)

Table 3 (unit: mm)

No.	Description	Prescribed dimensions (mm)	Type of fit	Assembly tolerance
1	Exhaust valve seat hole / exhaust valve seat	$\Phi37^{+0.025}_{0}$ / $\Phi37^{+0.11}_{+0.094}$	interference	0.069～0.110
2	Intake valve seat hole / intake valve seat	$\Phi42^{+0.025}_{0}$ / $\Phi42^{+0.130}_{+0.114}$	interference	0.089~0.130
3	Cylinder head valve guide hole / valve guide	$\Phi13^{+0.018}_{0}$ / $\Phi13^{+0.046}_{+0.028}$	interference	0.018~0.046
4	Valve guide hole / exhaust valve	$\Phi8^{+0.015}_{0}$ / $\Phi8^{-0.025}_{-0.040}$	radial clearance	0.025~0.055
5	Valve guide hole / intake valve	$\Phi8^{+0.015}_{0}$ / $\Phi8^{-0.025}_{-0.040}$	radial clearance	0.025~0.055
6	Valve recession height			0.9~1.2
7	Rocker arm hole / rocker arm busing	$\Phi24^{+0.021}_{0}$ / $\Phi24^{+0.054}_{+0.041}$	interference	0.020~0.054
8	Rocker shaft busing/rocker shaft	$\Phi20^{+0.021}_{0}$ / $\Phi20^{0}_{-0.021}$	radial clearance	0.020~0.074
9	Liner / lower part of the piston skirt	$\Phi92^{+0.022}_{0}$ / $\Phi91.88 \pm 0.1$	radial clearance	0.110~0.152
10	Valve lifter hole / valve lifter	$\Phi20^{+0.033}_{0}$ / $\Phi20^{-0.02}_{-0.041}$	radial clearance	0.020~0.074
11	Camshaft bearing bore / camshaft bearing bush	$\Phi53^{+0.03}_{0}$ / $\Phi53^{+0.06}_{+0.041}$	interference	0.011~0.060
12	Camshaft bearing bush hole / camshaft journal	$\Phi48^{+0.025}_{0}$ / $\Phi48^{-0.025}_{-0.041}$	radial clearance	0.025~0.074
13	Timing idle gear bush hole / idle gear shaft	$\Phi48^{+0.039}_{0}$ / $\Phi48^{-0.050}_{-0.075}$	radial clearance	0.050~0.114
14	Timing idle gear shaft length / timing idle gear shaft width	$\Phi18^{+0.12}_{0.06}$ / $\Phi18^{0}_{-0.08}$	interference	0.06~0.20
15	First ring groove height / first gas ring height		axial clearance	0.050~0.082
16	Second ring groove height / second gas ring height		axial clearance	0.040~0.072
17	Oil ring groove height /oil ring height		axial clearance	0.035~0.062

18	End gap when ring inserted in gauge with a Φ92 inner diameter		top gas ring: second gas ring: oil ring:	0.25~0.40 0.25~0.40 0.25~0.40
20	Connecting rod bush hole / piston pin	$\Phi 34^{+0.02}_{0.01} / \Phi 34^{0}_{-0.006}$	radial clearance	0.010~0.026
21	Piston pin boss / piston pin	$\Phi 34^{+0.01}_{0.01} / \Phi 34^{0}_{-0.006}$	radial clearance	0~0.016
22	Connecting rod big end hole with bush / crankshaft journal	$\Phi 56^{+0.059}_{0.020} / \Phi 56^{0}_{-0.019}$	radial clearance	0.020~0.068
23	Main bearing hole (with shell)/ main journal	$\Phi 70^{+0.066}_{0.031} / \Phi 70^{0}_{-0.019}$	radial interference	0.031~0.085
24	Crankshaft thrust face / thrust shell / thrust collar	$32^{+0.05}_{0} / 3^{0}_{-0.004} / 26^{-0.12}_{-0.20}$	axial clearance	0.02~0.33
25	Camshaft thrust protrude width / camshaft thrust plate width	$4^{+0.118}_{+0.070} / 4^{0}_{-0.03}$	axial clearance	0.070~0.148
26	Mesh backlash of gear		gear backlash	0.07~0.25
27	Clearance between intake valve and rocker arm at cold state		clearance	0.35~0.40
28	Clearance between exhaust valve and rocker arm at cold state		clearance	0.40~0.45
29	Oil pump driving gear hole/ small end crankshaft journal	$\Phi 40^{+0.050}_{0.025} / \Phi 40^{0.059}_{+0.048}$	transition	Max. clearance: 0.034 Max interface: 0.002
30	Camshaft gear hole/ small end camshaft journal	$\Phi 35^{+0.025}_{0} / \Phi 35^{0.076}_{+0.060}$	interference	0.035~0.076
31	Liner recess depth / liner flange height	$8^{+0.04} / 8^{+0.082}_{+0.060}$	protrude	0.020~0.082

1.5 Tightening torques of main bolts, studs and nuts in diesel engines (Table 4)

Tightening torque of other plugs and bolts are in Table 5 and Table 6.

Table 4 Tightening torques of main bolts, studs and nuts in YC4F series diesel engines

No.	Description	Thread standard	Tightening torque (N.m)
1	Crankshaft pulley bolt	M16	140~160
2	Flywheel bolt	M12	120~140
3	Camshaft thrust plate bolt	M8 (10.9 Grade)	25~35
4	Oil pan bolt	M8	20~30
5	Gear housing front plate bolt	M8	20~30
6	Gear housing cover bolt	M8	20~30
7	Flywheel cover bolt	M12	100~120 140~160
8	Rocker arm shaft seat tightening bolt	M8 (10.9 Grade)	20~30
9	Water pump bolt	M8 (10.9 Grade)	20~30
10	Starter bolt	M12 (10.9 Grade)	100~120
11	Injector pressing plate nut	M10 (10.9 Grade)	28~40
12	High-pressure connection pipe turnbuckle	M22	35~45
13	Fuel return pipe screw	M8 (10.9 Grade)	7~9
14	Fuel return passing seat bolt	M10	28~40
15	Generator adjustment supporting bracket bolt	M10	35~55
16	Generator adjustment plate fastening bolt	M8	20~30
17	Generator fixed supporting bracket bolt	M10	28~45
18	Exhaust pipe bolt	M10(10.9 Grade)	35~55
19	Intake pipe bolt	M8	18~24
20	Hanger tightening bolt	M8 M10	18~24 35~55
21	Turbocharger oil return pipe bolt	M8	20~30
22	Fuel injector gear cover bolt	M8	20~30
23	Fuel injector flange fastening nut	M8	20~30
24	Fuel injection timing device nut		90~110
25	Air compressor oil return pipe screw	M8	18~30
26	Air compressor gear nut	M20	230~300
27	Oil cooler fastening bolt	M8	20~30
28	Oil pump fixed bolt	M8 (10.9 Grade)	35~55
29	Turbocharger flange nut	M8 (heat-resistant steel)	25~35

Table 5 General guide for other bolt tightening

Screw thread	Tightening torque (N•m)
M6	10～20
M8	20～30
M10	30～40
M12	60～70
M14	80～100

NOTE: Screw plugs installed on water passages and oil galleries should be spread with sealant glue and their tightening torques are show in Table 6.

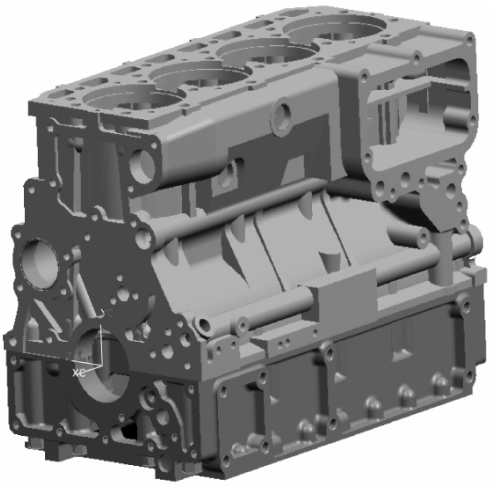
Table 6 General guide for screw plug tightening

Screw thread	**NPT 1/8**	**NPT 1/4**	**NPT 3/8**	**NPT 1/2**	**NPT 3/4**	**NPT 1**
Tightening torque (N•m)	8～14	24～34	47～68	68～95	88～102	

2 Fundamental structure and maintenance

2.1 Cylinder block

The cylinder block structure is of the case type. The upper part is cylinder block and the lower part is crankcase. The crankshaft journal holes at crankcase and cylinder block are precisely machined together and are assembled in pairs.



The cylinder liner is of wet type in order to have easy maintenance.

The cylinder block cast in HT250 is the basic skeleton of the engine. There are 18 threaded holes in the top end of the cylinder block used to fasten the cylinder head by cylinder head bolts. The threaded holes in the bottom end of the cylinder block are used for mounting the crankcase through main bearing cover bolts. Engine mounting cushion are installed at the front end of the crankcase.

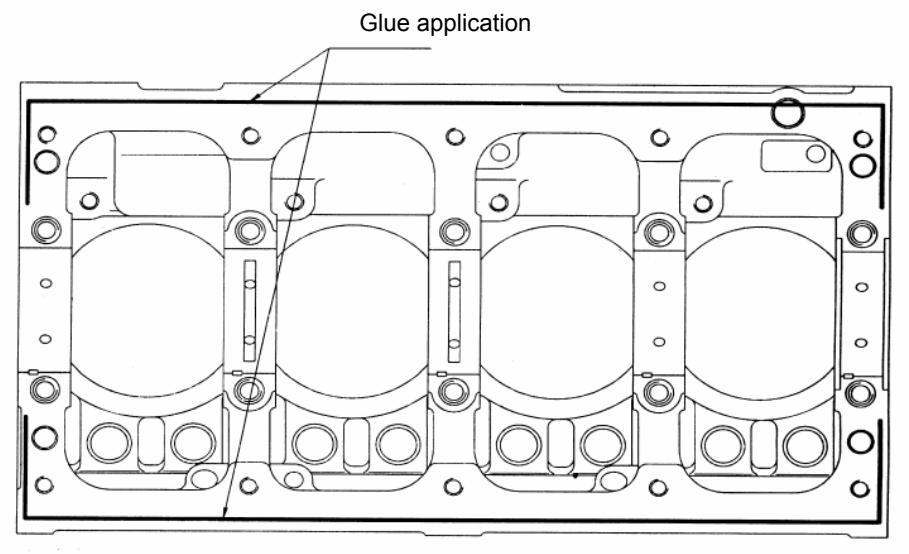
Viewing from the front of the cylinder block, the intake manifold, generator, fuel filter, fuel injection pump, oil cooler and oil filter are mounted on the right of the cylinder block, and the generator, steering pump, exhaust manifold, turbocharger, and starter are mounted on the left on the cylinder block.

At the front of the cylinder block is the timing gear housing containing the timing gear, oil pump driving gear, fuel injection pump advancer gear etc. The pointer on the timing gear cover directs to the angle marks on the damper in order to check fuel supply timing and valve timing.

Flywheel housing and clutch assemble are mounted at the rear of the cylinder block.

The oil pan to store lubricating oil is mounted at the bottom of the cylinder block.

The crankcase should not be installed with opposite direction. Please spread sealing glue on the sealing surface of the block. Glue application is shown in the figure below:



Then, install the crankcase without any touching of the hole-wall of the crankcase by the bolts, and fasten the bolts manually. The tightening torque for main bearing bolts should be applied as specified as follow, and don’t fasten the bolts in one time:

Fasten the 10 M12 inner bolts (6 bolts for main bearing cover and 4 long bolts for cylinder head) which used to fix the crankshaft along two banks first, and start the tighten work evenly and crossly from the middle two bolts to the two ends in turn within 3 steps:

First, tighten to 30～50N.m;

Then, tighten to 80～100N.m;

Third, tighten to 120～140N.m.

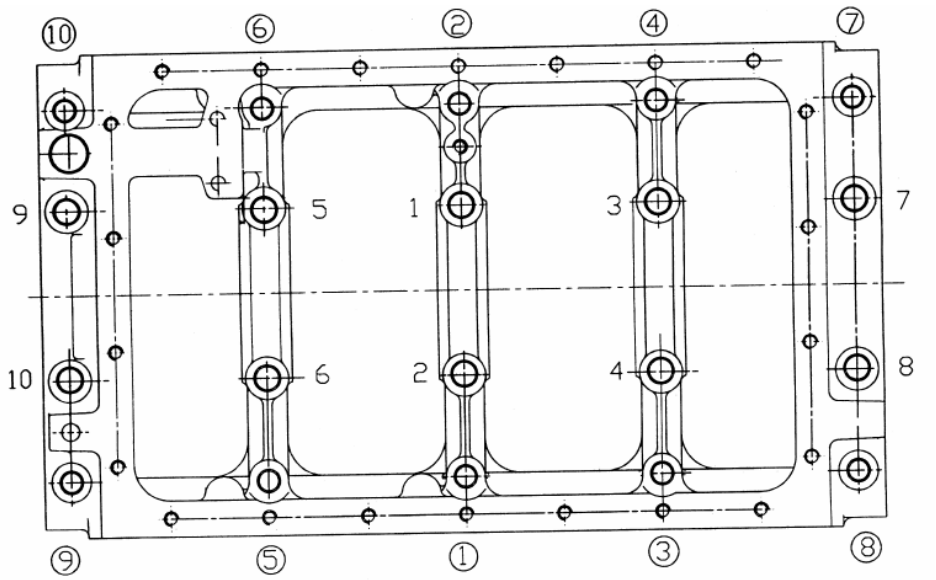
Rotate the crankshaft after every tightening to check the mobility.

Finally, 10 M10 outer bolts along the two banks should be tightened (6 short secondary bolts for main bearing cover, 4 long secondary bolts for main bearing cover), then they will still be tightened evenly and crossly from the center to the two ends in turn within 2 steps:

First, tighten to 30～40N.m;

Then, tighten to 70～80N.m;

When use Atlas wrench for overall tightening, please follow the procedures. The order of bolt tightening is shown in the figure below:



2.2 Cylinder head and cylinder head gasket

2.2.1 Cylinder head

The cylinder head has 2 valves for one cylinder. It is of an integral structure cast in alloy-iron. It has good rigidity and strength. The intake port has excellent gas exchange performance that gets high power and low emission.

The bottom surface of the cylinder head is one of the most important sealing surfaces in diesel engine. Pay attention not to damage the surface when installing or dismantling.

The cylinder head bolts bear large preload. To ensure the cylinder head distort less and has good sealability, cylinder head bolts should be tightened to a specified torque in a prescribed order. The tightening order is shown in the figure below in 3 steps.

For naturally aspirated engine equipped with graphite cylinder head gasket, tightening torques is as follows:

Firstly, tighten bolts to 40～50N.m

Secondly, tighten bolts to 80～90N.m

Thirdly, tighten bolts to 120～140N.m

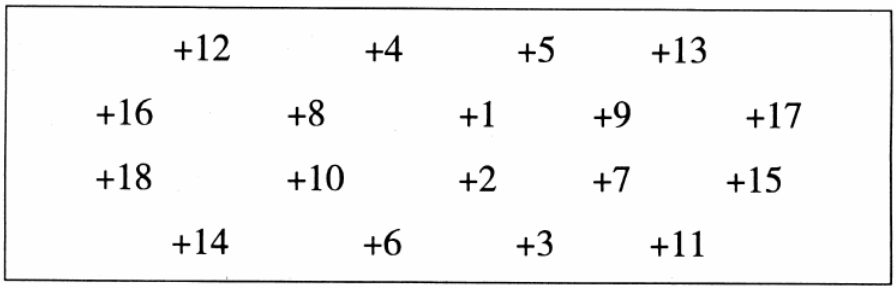
Last, make sure the tightening torque of each bolt conform to the specified value.

For turbocharged and inter-cooled engine equipped with metal cylinder head gasket, tightening torques are as follows:

Firstly, tighten bolts to 40～50N.m

Secondly, tighten bolts to 100～110N.m
Thirdly, tighten bolts to 140～160N.m
Last, make sure the tightening torque of each bolt conform to the specified value.

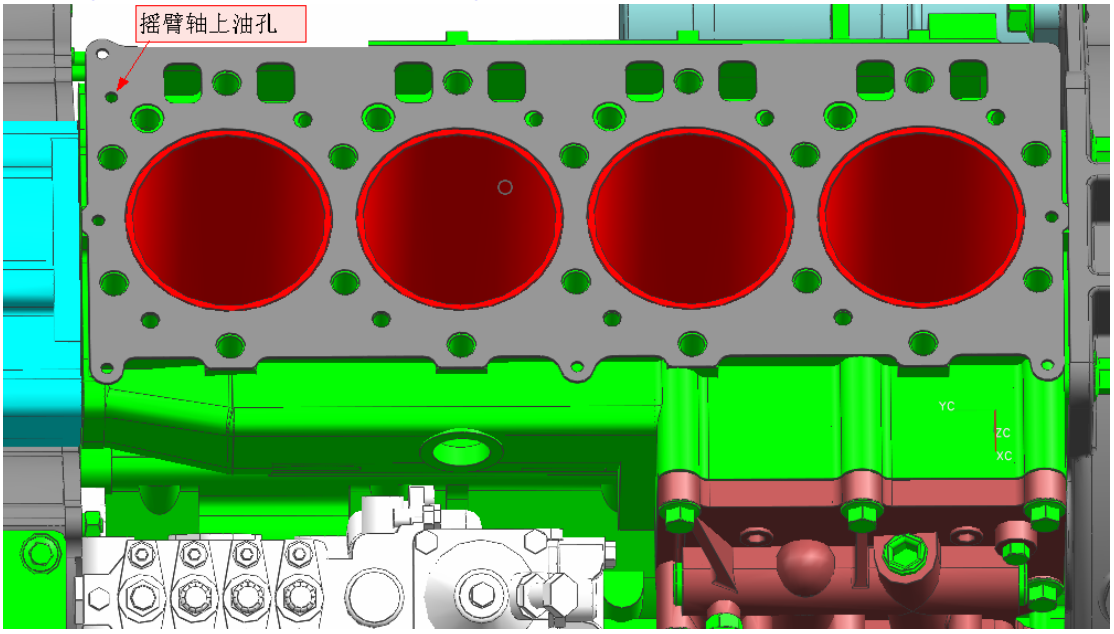
The order of bolt tightening is shown in the figure below:



2.2.2 Cylinder head gasket

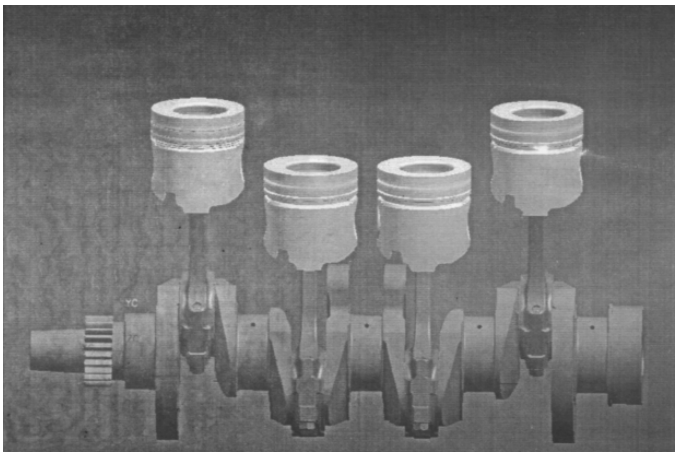
After break-in period for the new engine, the cylinder head bolt should be fastened again with prescribed torque to prevent water leakage, oil leakage and gasket damage.

Notes: When repair work is being done to re-installed cylinder head gasket, the side marked with sigh “top” should be installed upwardly, and assure water holes on the gasket are in the right position with those on the cylinder block (three water holes per cylinder), oil adding holes of rocker arm axle of the exhaust pipe on the front end surface are in the right position of those holes on the cylinder block. Otherwise, inappropriate installment of cylinder head gasket shall defect overhaul performance of the engine, as following drawing shows: The oil adding hole on the rocker arm axle



2.3 Crankshaft-connecting rod mechanism

The piston and piston pin are of clearance fit and need not to be assembled at hot state. The horizontally split connecting-rod assembly is positioned by the stem of the connecting-rod bolt. The connecting rod and cap should be assembled in pairs according to mark. When the piston-connecting rod assembly is installed into the cylinder liner, the offset orientation of the combustion chamber on the piston top should be accordance with the side of the fuel injection pump.



Scheme of piston-crankshaft-connecting rod assembly

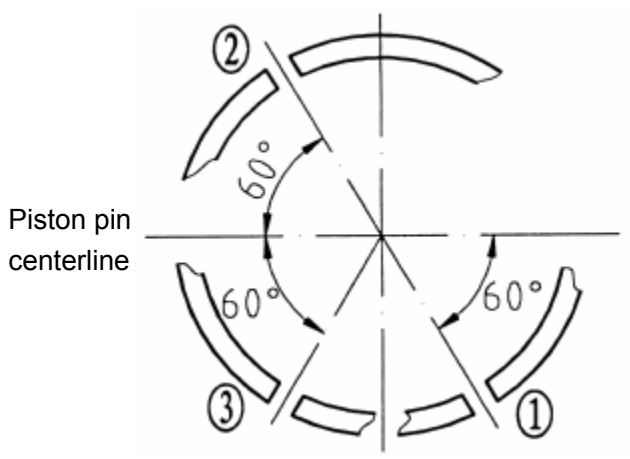
Before install connecting-rod bolt, spread some clean oil on the thread, the bolt stem and the bolt supporting surface. Screw connecting-rod bolt to its end manually and then fasten it with wrench to the specified tightening torque, this procedure is done in 3 steps as follows::

Firstly, tighten bolts to 20～30N.m

Secondly, tighten bolts to 50～60N.m

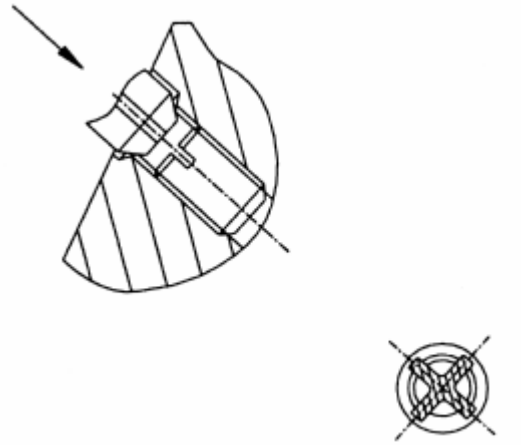
Thirdly, tighten bolts to 70～80N.m

There are two compression rings and an oil ring on per piston shown in Figure 3. The top ring is a single-face keystone ring and of good anti-sticking and snap ring functions. During installation, the “Top” marked surface should be upward. The second ring is a rectangle ring with good sealing in oil and gas. But the second ring is not easy to be installed correctly，it should be installed with the mark “TOP” upwards. The third ring is a coil spring expanded oil scraper ring. During the piston-connecting rod assembly installation, the orientation of the piston ring gap must be accordance with the prescript to make sure the sealing reliability.

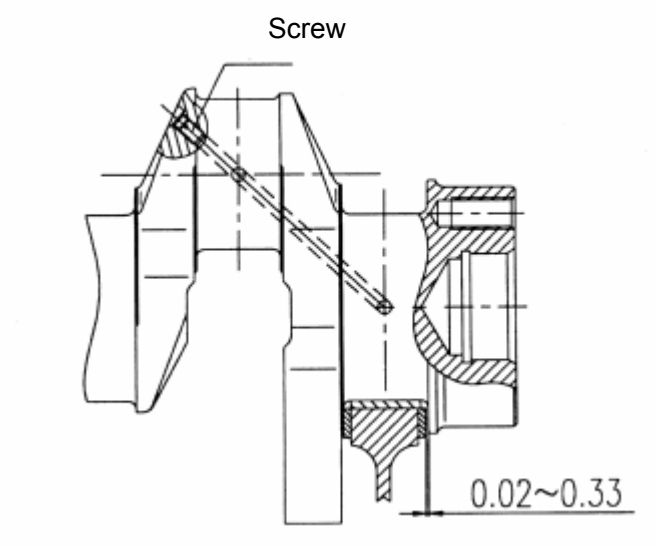


The upper and lower thrust plates are at the end of the main bear of crankshaft. The crank pin has an oil passage to make sure lubrication of connecting rod shell.

The tilted oil passage opening has a hole with M8 thread and is plugged. If the crankshaft needs to be replaced during engine overhaul, the oil passage of crankshaft should be cleaned first and then tighten the screw to the countersunk state. In the end, damage the thread upside the screw head with tool to make sure the screw cannot move out.

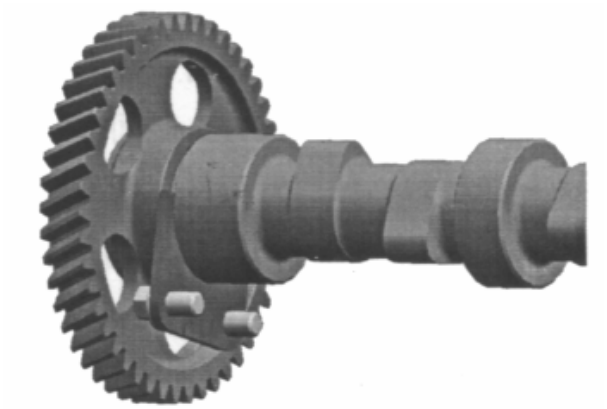


After crankshaft is installed into the cylinder block, tighten every bolt of the main bearing with specified tightening torque. Then, the crankshaft should rotate freely. The axial displacement of the crankshaft should be in the range of 0.02~0.33mm.

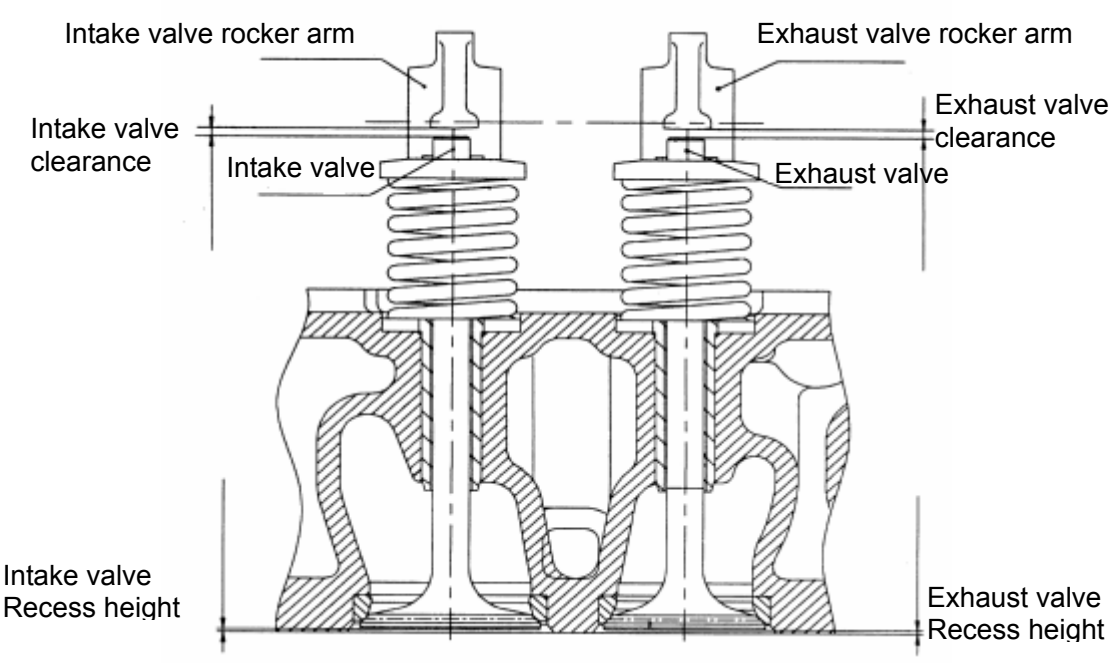


2.4 The valve train and intake and exhaust system

The fit between camshaft and camshaft gear is of interference type. The camshaft gear is positioned by the camshaft bolts and the thrust washer with the tightening torque of 80~100N.m. The camshaft axial clearance is controlled by a haft-moon type thrust washer within the range of 0.06~0.20mm. The thrust is fixed on the block by two bolts at the flange end.



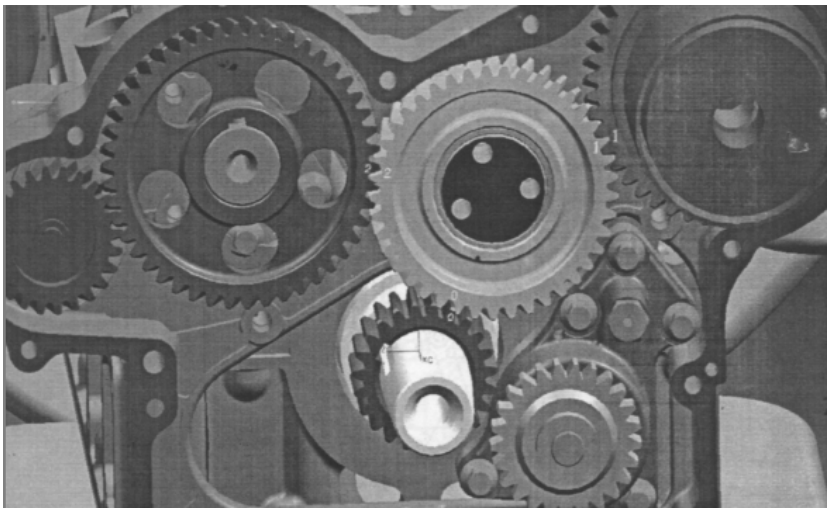
The taper face angle is 89° for the valve and its seat. The valve recess height is 0.9 ~ 1.2mm before shipping out of factory. The intake valve clearance is 0.35~0.40mm, and the exhaust valve clearance is 0.40~0.50mm in engine cold state. The engine will have its best power and economy performance with the valve clearance range mentioned above. As too big or too small valve clearance will damage engine performance, customers should check the clearance periodically. The check should be performed carefully with special feeler gauge and cannot be relied on experiences.



The method of adjusting valve clearances is as follows (Note: the engine should be adjusted under fully cooled state):

1. Dismantle the cylinder head cover.
2. Rotate the crankshaft (clockwise seen from the belt pulley to the flywheel) to the position that the No.1 piston is on the compression TDC.
3. Use wrench and screwdriver to loose the fastening nuts and adjustment bolts of intake and exhaust valves of the No.1 cylinder, intake valve of the No.2 cylinder and exhaust valve the No.3 cylinder. (Note: No.1 cylinder is the nearest to the front of the engine)
4. Then check the clearance between rocker arm and the end of valve stem with a feeler gauge.
5. Tighten the adjusting screw with screwdriver so that rocker arm and the end of valve stem touch the feeler gauge moderately.
6. Tighten the fastening nut and take out the feeler gauge.
7. Check the clearance again.
8. Rotate the crankshaft for one revolution in its described direction. Adjust and check the clearances for the other four valves (exhaust valve of No.2 cylinder, intake valve of No. 3 cylinder, intake and exhaust valves of No. 4 cylinder).
9. Re-install the cylinder head cover.

There are timing marks on the crankshaft timing gear, the timing idle gear, injection pump gear and the camshaft timing gear. Make sure their relative positions are correct (for example the tooth marked with 1, 2, 3, respectively must accord with that on the pulley). The backlash should be between 0.07mm~0.25mm.



The clearance of driving gear of oil pump and the small end of crankshaft is of interface fit. After installing those gears, spread some oil to the hole of the driving gear of oil pump and push it to the operation position with special tools.

2.5 Fuel system

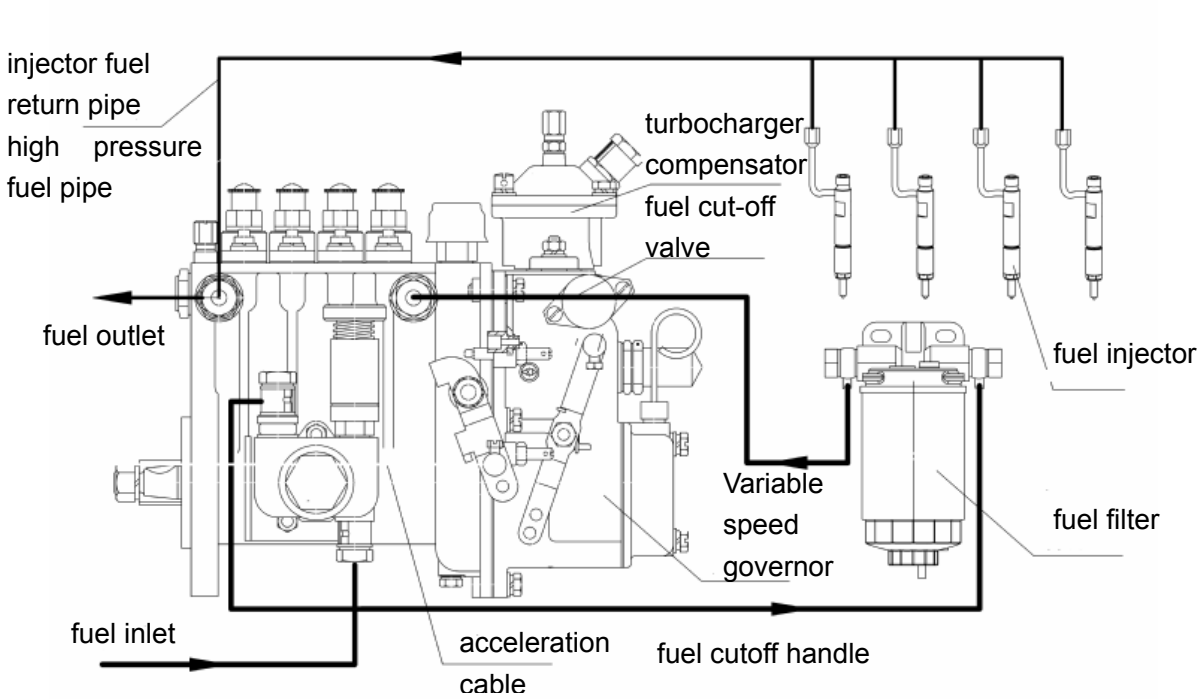
The fuel system in the YC6L series diesel engine consists of a fuel tank (chassis component), a fuel supply pump, a fuel filter, a fuel injection pump, a governor, a fuel injection timing device, a soot limiter, a fuel cut-off solenoid valve, high/low pressure fuel pipes and so on.

The working process of the fuel system is as follows:

The fuel is drawn from the tank, delivered to the fuel supply pump outside the injection pump, and then enters the fuel passage of the injection pump through the fuel filter with high efficient water/fuel separator under pressure created by the fuel supply pump. The highly pressurized fuel from the injection pump is delivered to each injector through a high-pressure fuel line. Then the right amount of clean fuel must be injected into each combustion chamber at the correct time with a controlled rate and pressure, adequately atomizing the fuel and rapidly mixing with the air in the cylinder for good combustion. The remaining fuel from the fuel injector and overflow valve of the fuel injection pump will return to the fuel tank through the returning fuel line.

To make sure the driving safety, all fuel delivery pipes in the fuel system must be reliably sealed. Check the sealing every day before starting engine. If there is leakage in the fuel system, replace the fuel pipe and union bolt. Do not weld or repair the pipe with leakage!

The working process of the fuel system is as follows:



2.5.1 Injection pump assembly

The adjustment for the fuel injection pump needs special technology. When a problem occurs, please do not adjust the pumps randomly. They should be sent to the maintenance center authorized by YUCHAI for repairs.

The mechanical governor of 4F series diesel engine is the variable-speed type. The governor can control not only the idle and maximum speed but also intervening speeds independent of the engine load through changing the supplied fuel amount automatically. The fuel injection per stroke at every engine load is controlled by the different location where the rocker contacts the full load stop. When a problem occurs to the governor, please do not dismantle and repair it by yourself. They should be sent to the maintenance center authorized by YUCHAI or for repairs.

Turbocharger compensator is equipped with the injection pump in turbocharged engine. The turbocharger compensator (in other name ‘soot limiter’) limits the fuel injection amount per stroke when the engine runs at low speed and, therefore, the turbocharged air pressure is low. This optimizes the matching between the fuel and air amount in the combustion chamber to keep the soot level below the maximum limit and make the engine have large enough power output. The turbocharger compensator is connected to intake manifold through a soft tube. Leakage or loosening problems are not permitted in all engine operations, otherwise, the output power of engine will definitely decrease.

2.5.2 Governor

The mechanical governor of 4F series diesel engine is the variable-speed type. It is simple

reliable.

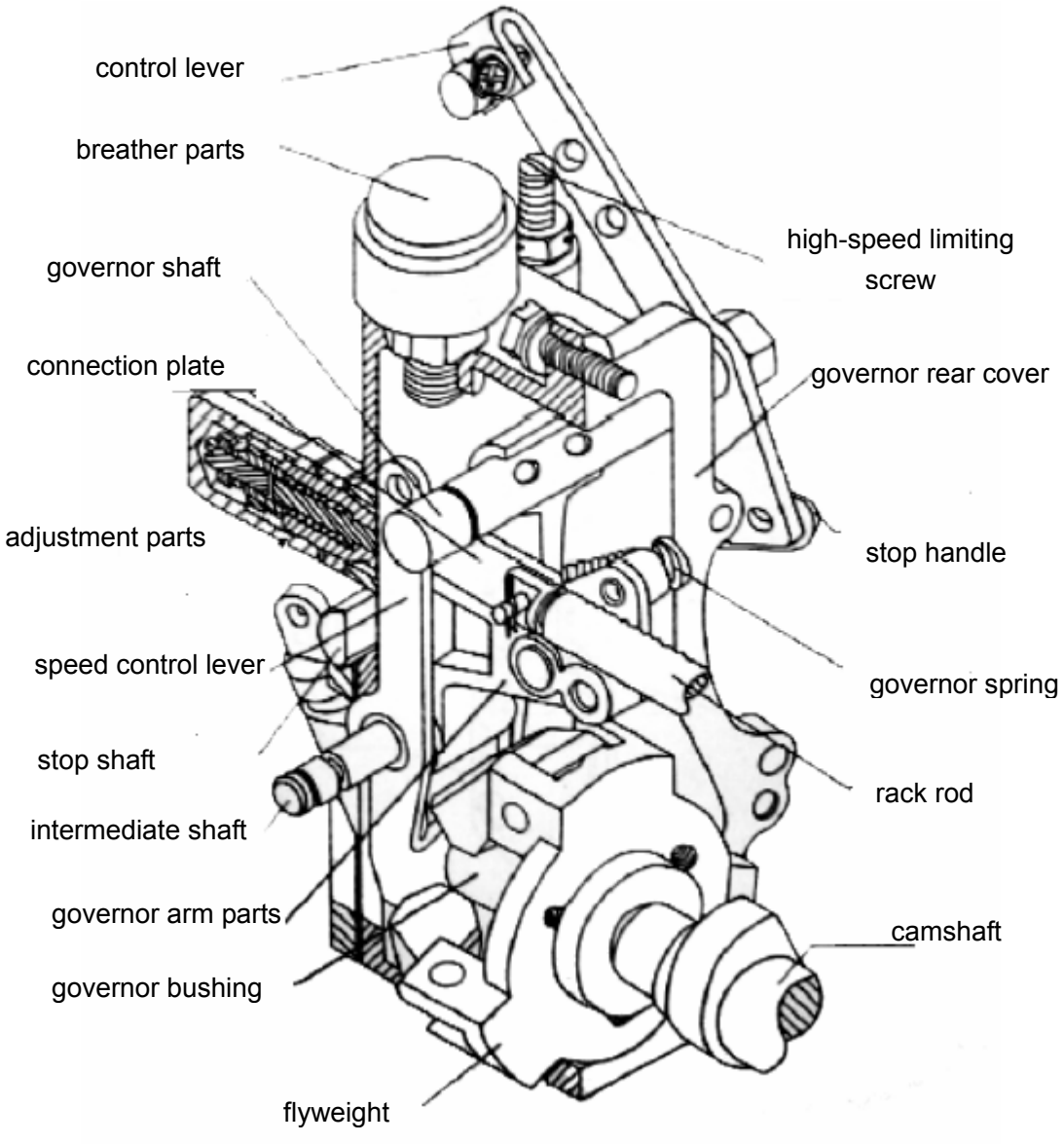
The construction of the governor is shown in the figure below.

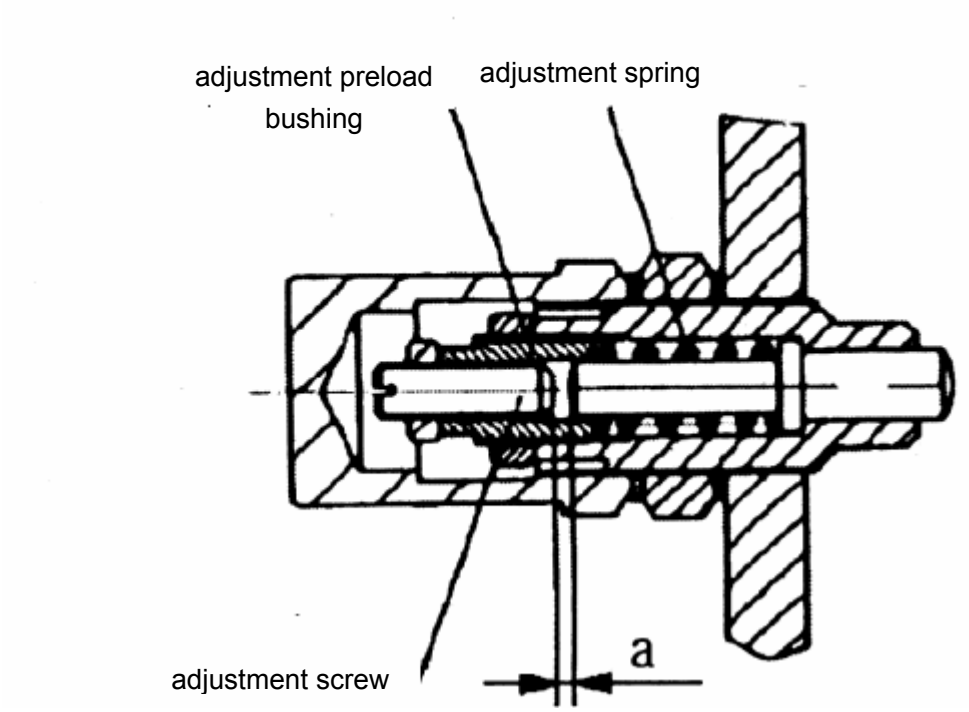
The operation fundamentals are:

When the camshaft rotates, the centrifugal force of the flyweight is converted into axial force through governor bushing. The force is exerted on the governor spring through speed control lever, start spring and governor arm assembly. When the axial force of the flyweight is balanced to the governor spring force, the governor will stabilize.

If the speed rises up, the centrifugal force of the flyweight and then the axial force will also increase, the balance between the axial force and the spring force is damaged, therefore the governor spring pushes the speed control lever forward under the increased axial force through the lever system and the control rack moves towards the fuel-delivery-decreasing direction. On the contrary, when the speed decreases, the delivered fuel amount will be increased by the rack's fuel-delivery-increasing movement. Through this method, the engine speed is controlled in all range. Special note: Lubrication oil is stored in governor case for 4F series diesel engine. When adding oil from the hole on the injection pump for the dipstick, check oil level to see whether the level is in the range marked on oil dipstick. If the level is below the minimum limit, please add some oil.

The schematic of adjustment part is shown in the figure below. Screw in the adjustment screw, the fuel supply will be decreased. Otherwise it will be increased. Screw in the adjustment preload bushing, the adjustment spring preload increases and the engine speed will decrease. On the contrary, it will increase.


control lever
breather parts
governor shaft
connection plate
adjustment parts
speed control lever
stop shaft
intermediate shaft
governor arm parts
governor bushing
flyweight
high-speed limiting screw
governor rear cover
stop handle
governor spring
rack rod
camshaft



Notes: Since 4PL injection pump of non-forced lubrication is applied to part of 4F series engines, lube oil should be added with regularity, which is of the same type with those used for engines. There is oil gauge on governor of the injection pump (shown in the following drawing). Regular examination should be done to check if the oil level in the fuel injection pump is within the scale range of the oil gauge. If the oil level is below the bottom line the oil gauge, lube oil should be added then.

2.5.2 Fuel injector

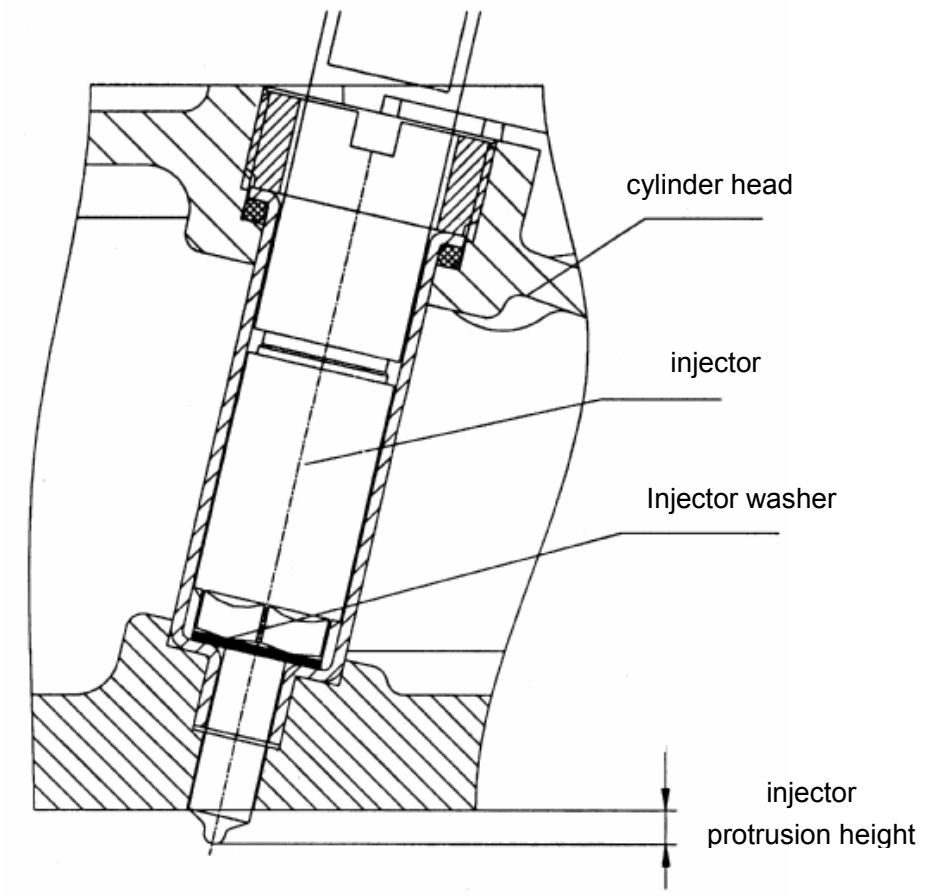
The fuel injector is of P type. P525 type is used on turbocharged engine, and P523 type injector used on naturally aspirated engine. The fuel injector opening pressure of both P525 type and P523 type are 24~25MPa.

The fuel injector consists of the injector body, the nozzle couple and the pressure adjusting spring and so on. The opening pressure of the injector is determined by the preload of the pressure adjusting spring. The preload can be adjusted by changing the pressure spring shim thickness on the spring seat.

The injector protrusion height is a very important factor for engine performance. The fuel injector and its washer (copper washer's thickness has been adjusted before shipping out of factory) must be installed to its original corresponding cylinder during repair. The replaced washer should have the same thickness; otherwise it will change the injector protrusion height, and then affect the diesel performance. The injector protrusion height of 4F series diesel engines is: 1.8±0.1mm for P525 injector in turbocharged engine; 2.0±0.1mm for P523 injector in naturally aspirated engine.

In order to ensure normal operation of engine, diesel fuel must be filtered properly and can

only be used after 48-hour sediment. Diesel filter has to be replaced and fuel tank should be cleaned periodically as specified so that the injector hole will not be blocked and fuel will atomize properly.



2.5.3 De-aeration of the fuel supply system

During engine running, there should not be any air in the fuel line; otherwise, the engine will be hard to start. De-aeration should be completed before cranking (especially for a new machine or after long period of disuse). The method is as follows: unscrew the fuel outlet bolt of the fuel filter in turn; pump the hand priming pump continuously until no air bubbles come out; and fasten the bolt. Unscrew the fuel overflow bolt of the fuel injection pump; pump the hand priming pump continuously until no air bubbles come out; and fasten the bolt. Attention: after de-aeration, the hand priming pump should be set to its original position (fastening).

2.5.4 Adjustment of static fuel supply advance angle

The static fuel supply advance angle has already been adjusted before shipping out of factory. If customers have to adjust it during engine maintenance and repair, unscrew the three fastening nuts on the flange of injection pump, rotate the pump a certain angle if necessary. After adjustment, fasten the three nuts mentioned above. Unscrew the nut which connects the high pressure fuel line for the No.1 cylinder and fuel injection pump,

crank the crankshaft slowly until the fuel level in the delivery valve holder begins to fluctuate. At this time, the timing value indicated by the pointer and the dial on the belt pulley damper is the fuel supply advance angle. If it is not within requirement, unscrew the three M8 nuts on the flange of the injection pump, rotate the pump to a proper angle. Fasten the nuts and check the angle again.

2.5.5 Diesel fuel filter

The fuel filter is of paper element rotation type. The whole filter element should be replaced every 20000km (or accumulated 400 hours) in order to avoid the insufficient fuel supply with too large resistance through the element. During the installation of the fuel filter, fill with the filter with clean fuel to prevent the air from entering the fuel supply system, thus making the engine start difficultly and run unstably. Then lubricate the seal ring with little clean oil and install the filter.

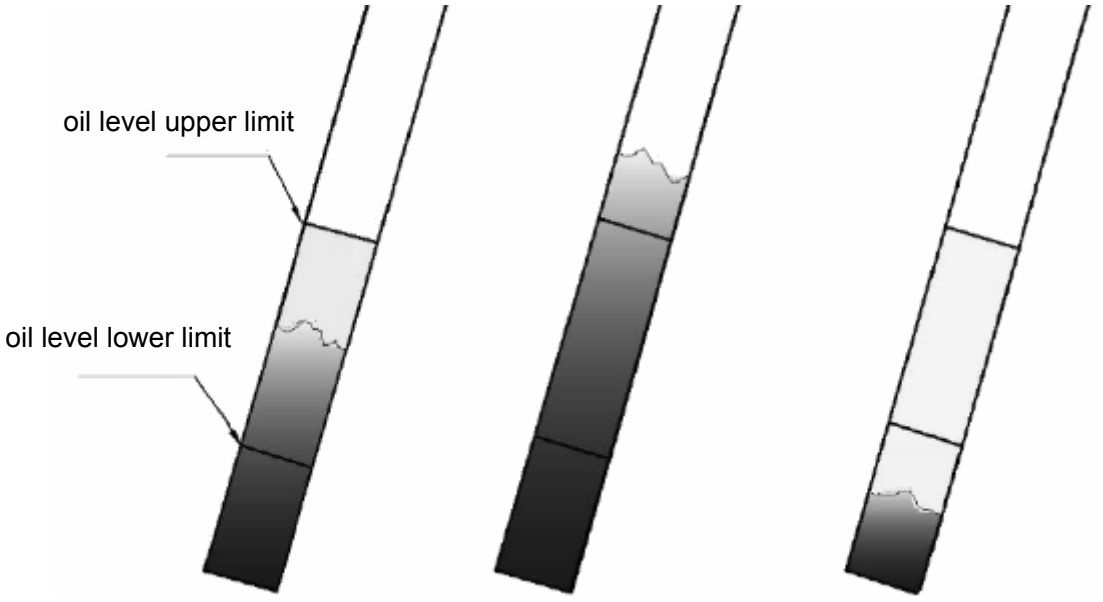
2.6 Lubrication system

The task of the lubrication system is to deliver clean oil with suitable pressure and temperature to the friction surfaces, which can make every component work well. The oil used in diesel is referred to this manual of “To Customers”.

Lubrication system of YC4F series diesel engine is shown in the figure below.

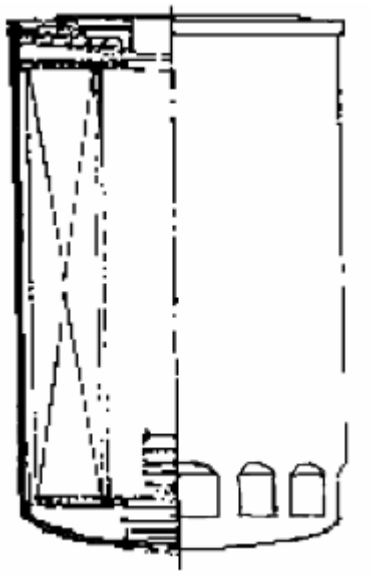
The signal of oil pressure warning is taken from oil gallery near to the oil cooler. The pressure should be no less than 0.15MPa at idle speed and no more than 0.6MPa at rated speed. If the oil pressure goes beyond the range above, the pressure could be adjusted through the oil pressure regulator valve assembly above the oil filter (in fact it is installed on the oil cooler cover).

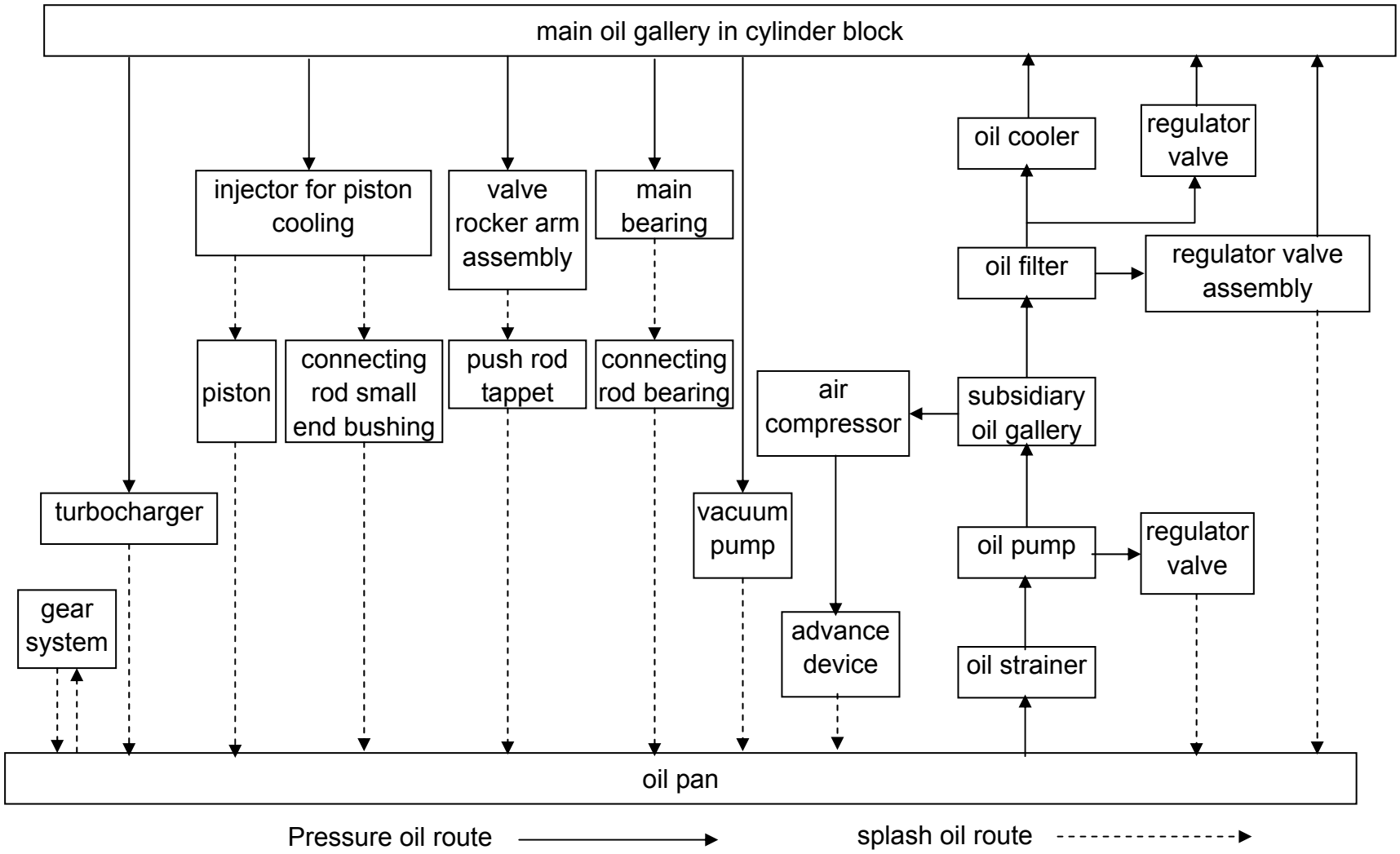
The oil level in the oil pan should be checked in regular to make sure it between upper and lower marks on the oil dipstick. Oil should be complemented when insufficient to proper amount. The oil should be replaced every 10000km (or accumulated 250 hours). The period of oil replacement should be shortened if the engine starts frequently or runs always at high speed and heavy load. The oil capacity of the oil pan is 10L, but it is 7.5L for the Model of F3400 engine. The oil drain screw plug is positioned at the side of oil pan to drain used oil. Be sure to check for the iron chippings on the magnet after oil-draining; and make sure to eliminate it before oil refueling. If there is any abnormal iron block, take to the local authorized YUCHAI service shop for the analysis and the correct solution before refueling the oil.



normal oil level too much oil too few oil

The oil filter is of paper element and rotation type. It should be replaced after every 10000 km (or accumulated 250 hours). During the installation of the oil filter, fill the new filter with clean oil, then lubricate the seal ring with less clean oil and install the filter manually.





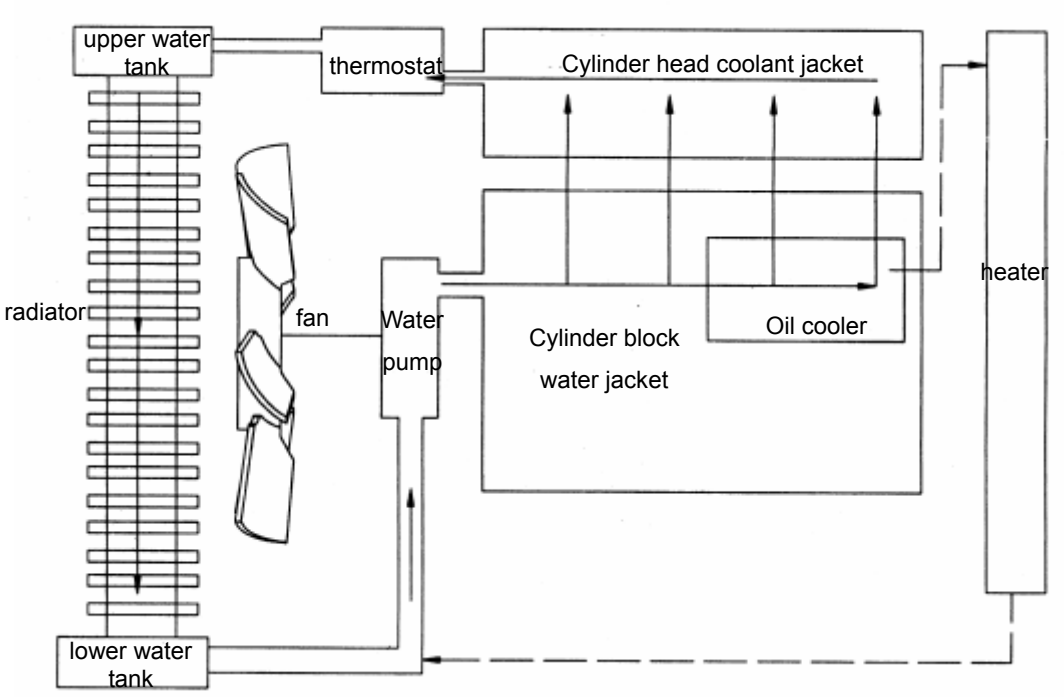
Route scheme for lubrication system in YC4F series diesel engine

2.7 Cooling system

The YC4F cooling system is of the closed water cooling system with pressurized circulation. The coolant should be anti-freeze and antirust. During the normal operation, the outlet coolant temperature is generally controlled from 80℃ to 95℃. The oil temperature is generally controlled from 90℃ to 110℃.

The water pump and fan are main parts in the cooling system. The rubber tube or steel pipe with good rigidity should be selected for the water pump's water inlet and the pipeline to the radiator in order to avoid deformation by suction. The fan is of axial flow with air suction type.

During the engine operation, thermostat should not be removed freely, otherwise it will detriment the engine's normal operation.

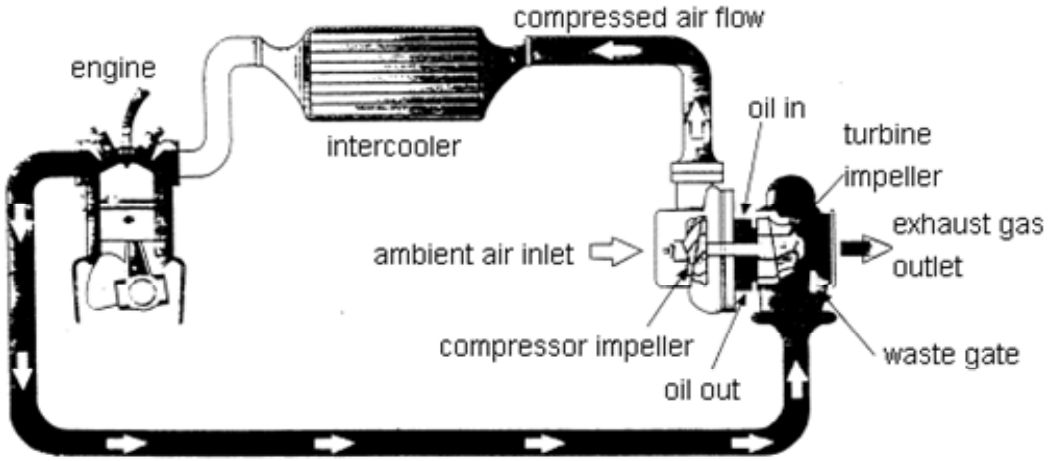


Circulation scheme for cooling system in YC4F series diesel engine

2.8 Turbocharger

YC4F turbocharged inter-cooler series engines adopt technology of turbocharged and air-to-air cooling, while the YC4F turbocharged series engines adopt technology on exhaust gas of turbocharged, re-circulating and catalyst converter.

The principle of turbocharger and intercooler is illustrated in the figure below.

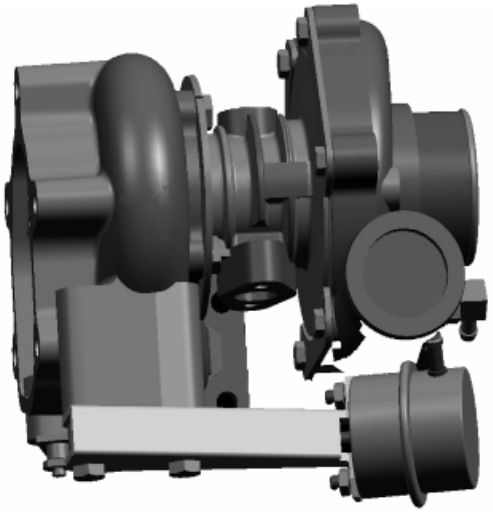


In the turbocharged engines, exhaust gas flows into the turbine housing. The turbine impeller converts the heat energy contained in the exhaust gas into the kinetic energy in the form of turbine spinning. Since the turbine is mounted on the same shaft as the centrifugal compressor, the compressor is forced to spin at the same time. The compressor sucks air and compresses it. Then the pressurized air goes into the intake manifold through pipe. The expanded and cooled exhaust gas leaving the turbine housing flows out of the exhaust system and into the environment.

The compressed air with increased density can make more fuel burn completely under the good matching with the fuel injection system. This increases engine power output and improves fuel economy.

Intercooler cools the compressed air, making the air more dense, which results in more air going into the cylinders and increases the power further and decreases the temperature in combustion chamber.

The outline and construction of the turbocharger is shown in the figure below. It includes a control device in the form of the waste gate. When the exactly calibrated waste-gate opens, some of the exhaust gas is bypassed directly into the exhaust manifold. This causes the turbine to reduce its speed, thereby reducing the speed of the compressor. This limits the boost pressure. The waste-gate can let the engine produce the highest boost pressure with the maximum turbo-charge correspondence. The waste-gate makes the turbocharger limit the excessive pressure (over turbo-charge) in the intake manifold when the engine runs at high speed or high load. By means of the waste-gate, the peak pressure in the cylinder can be limited to the mechanically permitted values.



The turbocharger belongs to a high precision assembly. It should not be dismantled manually. If a problem occurs, please send it to an authorized service center. Pay attention to the following points in turbocharged diesel operation:

- Before the oil pressure builds up, keeps the engine running at idle speed.
- Before the engine stops, make sure its temperature and speed decrease gradually from the maximum value.
- Lubricate the turbocharger in advance. After replacing oil and doing any maintenance (e.g. discharging the oil), the turbocharger needs lubrication in advance by cranking the crankshaft several revolutions before the engine starts. After starting the engine, keeps the engine running at idle speed for a while to build the oil pressure before running it at high speed.
- Pay attention when starting the engine in low temperatures. When the ambient air temperature is too low or the vehicle has not been run for a long time, building normal pressure and flow rate of the lubricating oil will take longer time than usual. In this case, the engine must run at idle speed for several minutes after starting until it operates normally.
- Engine sustained idling should be avoided.

2.9 Intercooler

All of YC4F series engines are equipped with intercoolers. The boosted air from the compressor does not directly enter the intake manifold, but is introduced through hoses to the air-to-air or water-air intercooler in front of the coolant radiator. The cooled compressed air is denser than non-cooled air. Since the air is packed tighter, the engine’s performance is increased.

The compressed air passes through the oblate tubes in the intercooler. Outside of the tubes are fins to boost heat exchange.

The main trouble of intercooler is air leakage which causes insufficient boost pressure,

increased exhaust temperature and power output loss. As a remedy, a leaky intercooler should be mended by soldering. A crack resulting in air leakage often appears at the position between the oblate tubes and fins, and at the soldered seams between case and collecting chamber. The best check method is to pressurize the intercooler to about 207kPa, spread it with the soap water and find out the exact position of air leakage.

2.10 Air compressor

The air compressors used in the YC4F series diesel engines are optional parts.

The air compressor is mounted directly on the gear chamber in front of fuel injection pump. It is driven by the crankshaft belt pulley through belt.

Since air compressor gears and transmission spline housing of steering pump are installed on the front end of air compressor shaft, when maintaining and re-installing, air compressor gears should be installed to air compressor shaft firstly, then transmission spline housing, and then those parts mentioned above into gear housing.

2.11 Steering pump

Steering pump is also an optional part in YC4F series diesel engine.

2.11.1 Points that need attention when dissembling

1. When dissembling, do not knock or crash the pump. Please do it tenderly.

2. When dismantling, installing and replacing the passage, please strictly keep them clean. Watch out that the sealing gasket between the passage and the pump's inlet and outlet should be smooth. If it has been deformed, replace it. Otherwise there will be oil leakage in the oil passage.

3. Special attention: Because the steering pump is of security part in vehicle and its manufacturing and assembling have strict requirements, nobody other than professionals can dismantle the interior parts of the steering pump.

2.11.2 Points that need attention when using steering pump

a) Oil should be filtered before filled into the oil container. (the oil must be filtered with mesh size of 25μm) (Watch out: New oil does not mean that it need not to be filtered.)

b) Steering pump should not operate without oil, which will shorten the lifespan of the pump.

c) The duration of the steering wheel at right or left extreme positions should not

exceed 30 second. Otherwise, the lifespan of the steering pump may be reduced.

d) After the 3000km mileage break-in period for a new steering pump and then after every 5000km, replace the oil timely. Please clean or replace the filter element in the oil container.

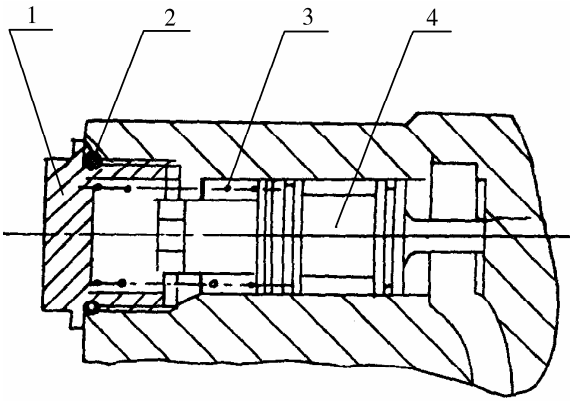
e) When using the steering pump, always check whether the oil level in the oil container is enough or not. Check whether oil deteriorates, or whether contaminants are excessive. If there is any abnormity, add or replace oil timely.

2.11.3 Common troubles and shooting

Phenomena	Probable causes	Remedies
Hard and slow steering	Oil is not enough in the oil container.	Add oil to the level required.
	Oil viscosity is too high.	Use the recommended oil (N32～N46).
	Oil suction is not smooth.	Clean the oil screen filter and pipeline. Check, clean and replace the filter timely, dependent on the operating condition.
	Oil passage has dead zone.	Fix the oil pipe to prevent from forming the dead zone.
Unstable oil pressure and noisy operation	Oil suction pipe leaks.	Replace the oil suction pipe or tighten the pipe clamp.
	Poor sealing of the oil suction.	Check the deformation of the copper sealing washer, remove dirt and burr, or replace the washer.
	Framed sealing ring is damaged.	Replace the framed sealing ring.
Oil leakage.	Poor sealing of the oil outlet.	Replace the sealing part.
	Poor sealing of the flow valve nut.	Replace the O-ring.
	Sealing ring of the rear cover is damaged.	Repair by professionals.
The steering oil pressure is not enough or lost fully.	Flow valve is blocked.	Polish the valve core surfaces with metallographic paper, clean the valve bore (refer to the construction of the flow valve)
	Interior parts are faulty.	Repair by professionals.

2.11.4 Construction of the flow valve:

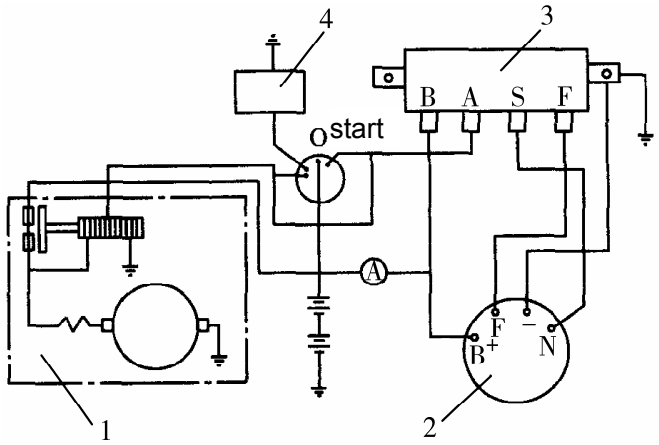
When checking and repairing the flow valve, polish the valve core 4 surfaces, clean the valve bore and make the valve core move freely in the bore. Pay attention to the O-ring, which is not allowed to be cut during assembling. Otherwise, the oil leakage will occur.



1. nut; 2.O ring; 3. spring; 4. valve core

2.12 Starter, electrical system, and indicators

The fundamental of the electrical system is shown in the figure below. The rated voltage of the generator is 28V (or 14V), and power is1kW. The earth electrode of the generator is negative. If the positive post of the engine is mistakenly connected to the earth, the generator will be burnt. (Attention: Circuit varies with different regulators used by different car makers. Car buyers should pay attention to respective manual brochure.)



Electrical system

1. starter; 2. generator; 3. regulator; 4. pre-heater

The starter used on F3000, F3100 and F7000 series diesel engines has an operating voltage of 24V and a maximum output power of 3.7kW. As for F3200, those are 12V and 3.7kW. Do not keep the starter running for more than 10 seconds at a time or it will be burnt. And if the engine fails to run after cranking, the cranking should not be repeated within at least one minute. When the engine begins operating, the key should be switched back to zero position. If not, the driving pinion will still engage the ring gear on the flywheel and the diesel engine will drive the starter at a high rotating speed and it will cause the starter to burn.

Special Notes: Do not use the starter to drive the engine while the gear is engaging, especially for those passenger cars equipped with the engine of Model F3400 series which installed a deceleration starter, otherwise, the operating performance and reliability of the starter would be damaged badly.

2.13 Exhaust gas recirculation system

Exhaust gas recirculation (for short EGR) system lets exhaust gas enter again into the combustion chamber with fresh air in order to decrease emission (especially for NOx) effectively. The re-circulated exhaust gas will decrease the combustion speed to make the boosted pressure rate slow and the NOx emission level will be low. In addition, the increased EGR rate will decrease the total exhaust gas flow rate and the whole emission will be improved.

EGR system should provide the optimized EGR rate at every engine operating condition in order to let the combustion process ideal and the emission level lowest.

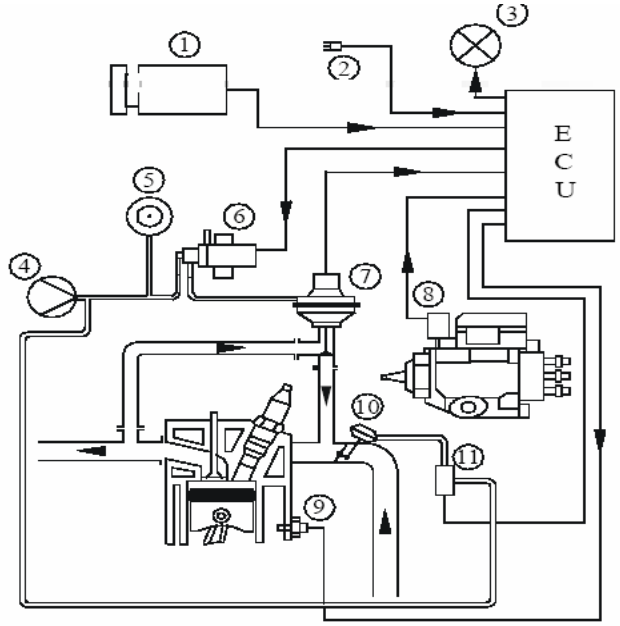


Fig. Scheme of EGR system principle

1. AC generator; 2.Diagnostic tool plug; 3. Indicator light; 4. Vacuum pump; 5. Vacuum vessel; 6. Vacuum regulator; 7. EGR valve; 8. Accelerator pedal sensor; 9. Coolant temperature sensor; 10. Throttle and diaphragm; 11. Throttle control valve

EGR system principle

1. Every optimized EGR rate for engine each operating condition is written into the ECU. The relevant EGR valve proper position is controlled continuously and monitored by ECU.
2. All the signals as follows must be provided to ECU in order to control EGR valve: engine load, speed, coolant temperature, EGR valve position feedback signal. These signals are collected by part 6, 7, 8, 9, 10 and 11. ECU will control EGR valve 7 by adjusting the vacuum in Vacuum regulator 6 according to the calibrated MAP in ROM. Thus the proper EGR rate can decrease the engine emission (especial NOx).
3. Generator 1 will charge to the battery and provide ECU power supply.
4. The diagnostic tool plug 2 is leaved to maintenance man during vehicle calibration. The vacuum in vacuum vessel 5 is supplied by the vacuum pump 4 installed after the

generator. It is the vacuum source of vacuum regulator 6.

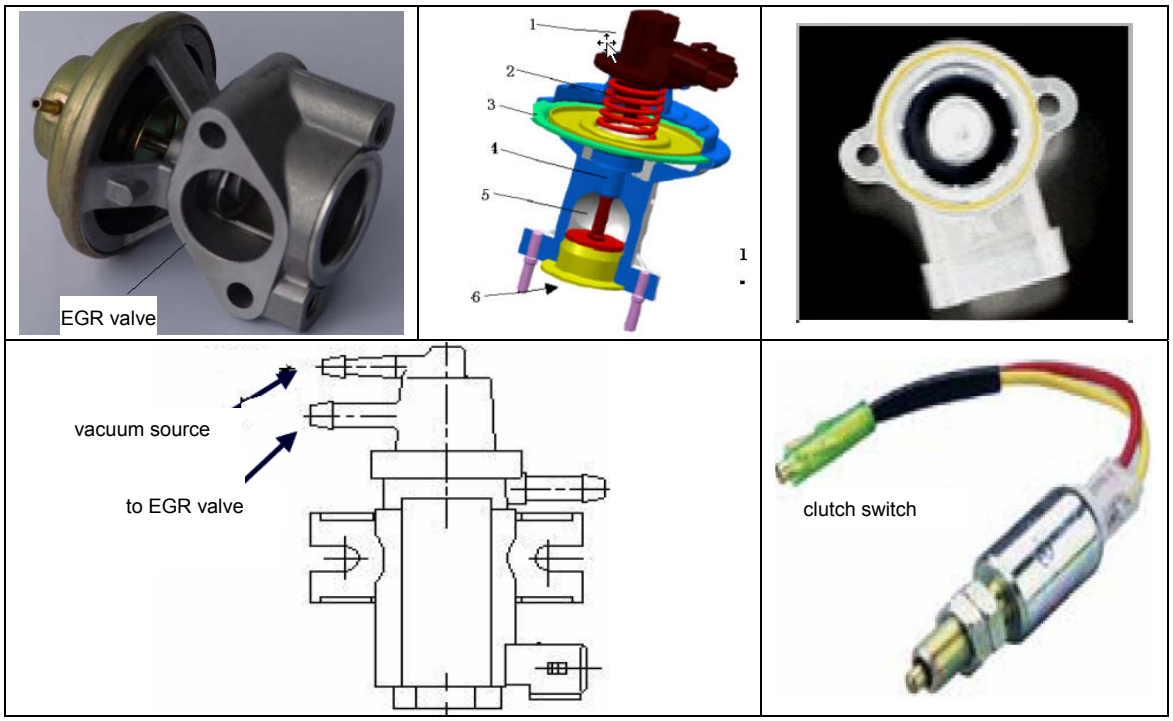
EGR system installation requirement

1. EGR valve: the inlet and outlet at EGR valve must not be mistaken during installation. The position sensor plug should face the engine power output end. EGR valve fastening torque is 45±5N.m. The valve's on-off action can let or block the exhaust gas entering into intake manifold by vacuum. The position sensor will feedback the valve's width to ECU in real time to implement EGR system closed-loop control.
2. Speed sensor: the speed sensor plug centerline should align with that of the signal socket during installation. The clearance is 1±0.25mm. 24 slots are set at the flywheel circumference. The screw fastening torque for speed sensor is 7±2 N.m. It is used to provide the engine speed signal to ECU.
3. Accelerator pedal position sensor: the rotation direction for the Accelerator pedal position sensor should be same as that for shaft of accelerator level on the fuel injection pump during installation. The screw fastening torque is 7±2 N.m. The ratio of the resistor value at idle state to that at maximum speed is 20%±5%. (The pin is R_{AB}/R_{AC}). This signal is used to provide the engine load state to ECU through the accelerator pedal position.
4. Coolant sensor: the fastening torque is 20±5N.m during installation. ECU will detect the signal to judge the coolant temperature while engine operating.
5. Vacuum regulator: It can endure temperature no more than 130℃. The thin tube parallel at the head of the vacuum regulator should be connected to those from the vacuum pump. The thick one is for EGR valve. It is installed on the vehicle generally and far away the exhaust pipe. On the engine test rig, the vacuum regulator must be installed and connected to distribute the vacuum from the vacuum pump by the duty cycle set by ECU according to the engine speed and load in order to control the EGR valve's width.
6. Clutch pedal switch: During installation, the clutch pedal switch should be compressed and the switch is off. While the clutch pedal switch is pushed, the switch is on. As the clutch pedal switch itself has free stroke, it should be compressed as possible during installation to avoid the 'empty connection' between the clutch pedal and the switch. It is used to judge the shift action by ECU and then control the EGR width.
7. ECU: Process and analyze the data from signals, output command to vacuum regulator, receive the feedback signal from EGR position sensor and control the EGR to be its proper position. The maximum environment temperature must be below 80℃.

EGR system troubleshooting

1. Check whether the vacuum regulator, speed sensor and coolant temperature sensor are in short circuit or open circuit state or not with special instruments.
2. Check the EGR valve failure state. Before engine starts, blow to the EGR valve after dismantling the vacuum tube. If it is not vented, the EGR valve is OK. After engine start, keep it at idle speed 800±50r/min, dismantle the vacuum tube on the EGR valve, man can feel the vacuum. Push the clutch and dismantle the vacuum tube, man can not feel the vacuum.

3. Vehicle check: turn the ignition switch on, check whether there is 12V between terminal 8 and 18. Check whether the main relay is OK. Check whether the clutch switch is on while no operation. Check whether the clutch is connected while operation. Check whether all sensors and ECU are in turn-on state.



Temperature requirement

1. Valve position sensor: 175℃
2. Spring : 200℃
3. Diaphragm: 180℃, short period: 220℃
4. Bushing: Upper: a) without sealing: 250℃; b) with sealing: 200℃
   Lower: 350℃
5. Inner chamber: 4050℃
6. EGR inlet/outlet: 650℃

Emergency solution and cautions in case of breakdown of EGR system

1. Since EGR shall have part of exhaust gas return into combustion chamber to re-burn, the working medium is gas of high temperature and high pressure, and this will cause high temperature of parts. If there is breakdown of EGR parts, it's better to pull over the car immediately and stop the engine right away. Examining and repairing work should be done only after normal cooling of the engine, and that work during engine's running is forbidden!
2. If there is gas leakage, water leakage, or out-of-control to circulation piping of engine's EGR, the engine will be defected dramatically. In that case, damaged parts shall be replaced after cooling of the engine. If no substitution part is available, blocks the EGR's air intake and air outlet temporary, that is, takes flanges to block the EGR's air intake flange mouth of the exhaust pipe and the air intake flange mouth of the air

intake pipe, then drives the car to the authorized YUCHAI service station for repair work or re-calibration.

3. EGR valve's working power depends on the vacuum of the vacuum control valve. And since the forming of the vacuum is done by the vacuum pump installed on the rear of the rechargeable alternator, if any leakage due to bad sealing or breakage happens to the vacuum pipe, the vacuum pump will draw in air from the outside into crankshaft case constantly, this shall result in severe air and oil leakage of the breather. In that case, please stop the engine and repair the leaky pipe. Serious

3 Operation and maintenance of the diesel engine

3.1 Operating the diesel engine

<table>
<tr><th>Item</th><th>Check items</th><th>Notes</th></tr>
<tr><td rowspan="5">Start</td><td>Check the oil in oil pan and oil pump</td><td rowspan="3">Starting procedure:
1. Make sure that the pedal is in middle position and the transmission is in neutral gear.
2. Turn on the ignition key</td></tr>
<tr><td>Check fuel level in fuel tank</td></tr>
<tr><td>Check water level in water tank</td></tr>
<tr><td>Electrical system should operate properly</td><td rowspan="2">Starting period should not be over 10 seconds and the next start should only be applied after at least 1 min.</td></tr>
<tr><td>Check and eliminate the air in fuel line</td></tr>
<tr><td rowspan="8">Running</td><td rowspan="2">Proper oil pressure</td><td>After cold start, there should be 5-min warm-up at idling or high-speed idling before hitting the road</td></tr>
<tr><td>Do not kick the pedal or floor it during cold start, engine speed should be revved up gradually.</td></tr>
<tr><td rowspan="2">Proper oil temperature</td><td>Engine could operate normally only when the water temperature rises up to 60 ℃.</td></tr>
<tr><td>Do not idling the engine over 10 min. during engine running.</td></tr>
<tr><td>Proper coolant temperature</td><td>“acceleration-- key-off—cruising without gear --- re-mesh the gear” can not be applied.</td></tr>
<tr><td rowspan="2">Operation without abnormal noises and vibration</td><td>Do no run the engine with malfunctions</td></tr>
<tr><td>2500 km break-in needed for new engine or after overhaul</td></tr>
<tr><td rowspan="3">Stop</td><td colspan="2">Idle the engine for about 3~5 min. before key-off, especially for engine that has just been in heavy-load and high-speed operations.</td></tr>
<tr><td colspan="2">Drain the water when environment temperature is below 5℃ and after long stay-put. This is not needed as for anti-freeze coolant.</td></tr>
<tr><td colspan="2">Generally, drain water after 3-week stay-put.</td></tr>
</table>

3.2. Maintenance of the diesel engine

3.2.1 Break-in of the diesel engine

New engine needs a 2500km/30 hours mileage break-in, which can improve performance of friction pair and is essential to ensure the operating reliability and lifespan of diesel engine. Pay attention to the followings points during break-in period:

1）Before running vehicle, keeping the engine warm-up at low and medium speed for at least 5 minutes.

2）When the vehicle is running, do not accelerate abruptly. Speed up slowly.

3）Do not keep diesel engine idling or running under full load with the break-in stop screw more than 5 minutes.

4）Always change the speed. Do not keep the engine running at an unchanged speed for a long time.

5）Transmit at proper time to prevent the engine from operating overload at low speed.

6）Always observe the oil and water temperature indicators and make sure that the engine operates properly.

7）Since there is no secondary throttle designed for the high-pressure pump of the Model YC4F series engine, don’t run the engine with full-load or over-load during break-in period. .

8）Avoid running engine with heavy load and at high speed.

9）After break-in period, the diesel engine can operate as normal.

10） Any change or alterations of the throttle stop screw are forbidden.

For the engine just after overhaul, there also must be a 2500km/30hours mileage break-in, which can improve performance of friction pair. After the 2500km/30hours mileage break-in, replace the oil and the filter element of the oil filter.

3.2.2 Maintenance

Item	Maintenance period	Maintenance items
Daily maintenance	every day	Check fuel level
		Check coolant level
		Check oil level in the oil sump (also check the fuel pump for the oil level for those engines with unforced-lubricate pump.
		Check leakage of water, oil, fuel or gases
First order maintenance	every 1500 ~2500km or every 50 hours	Every daily maintenance items
		Check oil filter and strainer of oil supply pump inlet
		Check the tension of the driving belt
		Check tightening nuts of cylinder block
		Check the clearance of valves,
		Check fuel pressure of injector
		Replace oil for new engine or after overhaul
		Check connections and leakages of the piping of the EGR system, do replacements when the vacuum rubber pipes get old or become leaky.
		Check the contacts of the electric lines and wires and make sure they are good contacted and water-proofed and keep them from contacting the high temperature parts as the exhaust pipe or the waste circulation pipe.
Second order maintenance	every 5000 ~6000km or every 150 hours	Every first order maintenance items
		Check fuel supply advance angle
		Replace oil filter every other second order maintenance
		Replace fuel filter every other three second order maintenance
		Check air cleaner
		Check sealing of valves
		Add grease to water pump
		Check connections of wiring
		Check tightening of main bolts and nuts
		Removing scaling in cooling system if needed
		Clean the filter screen of the breather
		Replace oil
Third order maintenance	every 30000 ~40000km or every 800~1000 hours	Every second order maintenance items
		Dismantle and clean the engine assembly. Remove carbon deposit, sludge and varnish
		Check wear conditions of friction pairs and moving parts
		Check working condition of fuel pump
		Check working condition of fuel injector
		Check working condition of oil pump

		Check the generator and the starter. Clean components, bearings, and add new lubricating grease
		Check cylinder gasket and other gaskets and washers
		Make sure no other malfunctions
		Replace oil

After third order maintenance, there should be 2500km break-in and the engine can not run into high speed and heavy load operations in case of shortening lifespan of the engine.

3.3. Troubleshooting

3.3.1 Diesel engine can not start

Possible causes	Remedies
(1) Too low starting speed	Check the starting system and assure the starting speed is not lower than 110rpm.
(2) Air exists in the injection system	Check the looseness of the joints of the feed line. Unscrew the de-aeration bolt on the fuel filter assembly, then press fuel with hand priming pump until the fuel overflows without air bubbles.
(3) Fuel line clogged	Determine the location of the clog and clear it.
(4) Fuel filter choked	Replace the screw-on filter element of fuel filter assembly.
(5) Fuel supply pump does not supply fuel or supplies fuel irregularly	Check for leakage in the fuel inlet pipe and clogging of the fuel supply pump filter and fix or replace.
(6) Insufficient fuel injection, without fuel injection or low injection pressure	Check the injector atomization and inspect whether the injector plunger and delivery valve is worn-out or seized, and if the plunger spring and delivery valve spring is broken. Check and adjust injection pressure to the prescribed range.
(7) Starting system problems;	
Incorrect terminals connection or bad contact;	Check the connection to be correct and reliable.
Insufficient battery charge;	Charge the battery.
Bad contact between the brush and communicator of the starter	Repair or replace the brush and clean the surface of communicator with soft sand paper and blow off.
(8) Insufficient compression pressure;	Replace the piston ring and press in the cylinder sleeve if necessary.
Piston ring worn-out; Blow-by valve	Check valve clearance, valve spring, valve guide, and valve seat. Grind the valve seat if necessary.
(9) The fuel cut off solenoid valve joint is loose, dirty or corroded	Tighten and wash or replace.

(10) Too low winding voltage of fuel cut off solenoid valve;	The minimum voltage should be 9V, if it is insufficient, repair or replace the winding.
(11)Incorrect fuel injection advance angle	Check and adjust it.

3.3.2 Insufficient power output

Possible causes	Remedies
(1) Intake blocked	Check the air cleaner, intake pipe, and clean or replace air cleaner filter elements.
(2) Too high exhaust back pressure	Check valve timing, adjust it if necessary; clean exhaust pipe.
(3) Insufficient boost pressure of turbocharged system	Check and eliminate the leakage in the pipe and joints.
(4) Turbocharger is out of order: Compressor and turbine passages are polluted, clogged or damaged;	Clean or replace the compressor casing and turbine housing.
Bearing failure;	Replace it.
Carbon deposit and sludge in the back of turbine and compressor impellers.	Clean it.
(5) Inter-cooler damage and leakage	Repair and replace it.
(6) Fuel line blocked or leaky	Check the seal of fuel line and fuel filter choking, or replace screw-on filter element. Check and replace it.
(7) Injection pump piston much worn-out	Check and replace it.
(8) Smoke limiter diaphragm break	Replace it.
(9) Vacuum hose damage and leakage	Replace it.
(10) Bad atomization of injector	Check injection pressure, remove carbon deposit; adjust and repair it.
Incorrect valve timing	Check and adjust valve timing and valve clearance.
Incorrect injection timing	Check and adjust it.
Governor high-speed is adjusted too low	Check and adjust it.
Cylinder gasket leakage	Tighten cylinder head bolts in order to prescribed torque or replace cylinder gasket.

Bad valve sealing	Grind or replace it.
Overheat engine or too high coolant temperature	Check and repair radiator, thermostat, and adjust fan belt tension.
Piston ring over worn-out or broken	Replace it.
Exhaust recirculation connecting pipe leakage	Replace the leaky pipe or parts.

3.3.3 Abnormal noise during engine operation

Possible causes	Remedies
(1) High frequency metallic knock noise in cylinder : too advanced injection timing	Adjust static injection advance angle.
(2) Low frequency, dull knock in cylinder : retarded injection timing	Adjust static injection advance angle.
(3) Connecting rod bearing bushing and main bearing bushing worn-out and clash in crankcase	Dismantle and check bushing and, if necessary, replace it and keep prescribed clearance.
(4) Crankshaft thrust bearing worn-out and axial rattle of crankshaft at idle operation	Replace parts and keep specified axial clearance
(5) Damper damaged and invalid	Check connecting bolts and the damper and, if necessary, replace them.
(6) Valve touches piston	Check and adjust valve timing
(7) Driving and driven gears worn-out and too large clearance. Slap can be heard near timing gear housing	Check gear backlashes and replace then if necessary.
(8) Too large clearance between piston and cylinder and clap in cylinder when operating	Replace cylinder, use repair bushing if necessary. Keep piston to cylinder clearance.
(9) Turbocharger surging	Clear carbon deposit and contaminants in compressor and exhaust passages.
(10) Turbocharger bearing is damaged and impellers touch housing	Replace turbocharger assembly.
(11) Too large valve clearance and heavy noise around cylinder head	Adjust valve clearance

3.3.4 Exhaust with black smoke

Possible causes	Remedies

(1) Intake clogged	Check and clean air cleaner and intake passage.
(2) Poor fuel quality	Use prescribed fuel.
(3) Incorrect injection or valve timing	Adjust according to prescription.
(4) Bad atomization of injector	Check and repair or replace.
(5) Too much fuel supply of injector	Check and adjust according to prescription.
(6) Insufficient boost pressure of turbocharged system	Check and repair leak in pipe line and joints.
(7) Faulty turbocharger	Check and replace assembly.
(8) Inter-cooler damage or leakage	Repair or replace it.
(9) Incorrect functioning point of smoke-limiter	Readjust it.

3.3.5 Exhaust with white and blue smoke

Possible causes	Remedies
(1) Poor quality fuel and too much water in fuel	Replace fuel.
(2) Too low coolant temperature	Check the working temperature of the thermostat, replace it if necessary.
(3) Incorrect valve timing and injection timing	Check and adjust.
(4) Low compression pressure and incomplete combustion	Check piston rings and cylinder gasket and, if necessary, replace them.
(5) Incorrect installing orientation of piston rings	Check and reinstall correctly.
(6) Running at low load for long time	Operate at proper speed and load
(7) Seal ring of turbocharger worn-out	Check and replace it.
(8) Thrust bearing of turbocharger worn-out	Check and replace it.
(9) Oil return pipe of turbocharger blocked	Clean or repair it.

3.3.6 Too low oil pressure

Possible causes	Remedies
(1) Diluted or incorrectly selected brand oil	Select proper oil.
(2) Inner and outer rotors of oil pump worn-out or too large assembly clearance	Replace rotors and adjust clearance.
(3) Oil filter choked	Replace screw-on filter element.
(4) Failure of oil filter pressure control	Repair it.
(5) Gear of oil pump damage	Replace it.
(6) Inlet oil tube of fuel pump crack	Repair or replace it.
(7) Fixing bolt of oil pump inlet oil tube loose	Tighten to prescribed torque.
(8) Too large bearing bushings clearance	Check and replace it.

3.3.7 Too high oil pressure

Possible causes	Remedies
(1) Too low ambient temperature and too high oil viscosity	Select required grade engine oil. Operate at low speed after starting, and then check it when the oil temperature is normal.
(2) Over-flow valve clogged	Check and clean it.

3.3.8 Too high oil temperature and oil consumption

Possible causes	Remedies
(1) Leakage in the exterior oil line	Check and repair it.
(2) Too high diesel engine load	Decrease load.
(3) Incorrect engine oil grade	Select oil according to prescription.
(4) Piston ring stuck or seriously worn	Check and repair. If necessary, replace it.
(5) Cylinder bore seriously worn out	Bore the cylinder and use oversized piston rings or press in cylinder repair sleeve.
(6) Valve guide seriously worn out and failed seal of valve stem	Check and replace.

Appendix: Anti-freeze solution and its application guide

Anti-freeze solution is commonly used in winter, and can prevent the coolant from freezing. It is an ideal coolant due to overcoming many of the disadvantages of water, and can be used in all four seasons. Anti-freeze solution should be used in YC6M series engines.

1. What is anti-freeze solution

The development anti-freeze solution and its application already have a long history. At first, inorganic salts were added to water to lower the freezing point and raise the boiling point. Then, organic alcohols (such as ethanol, methanol, etc) were used. Today, glycol and glycerol based anti-freeze solutions are in common use. The popularity of glycerol based solutions is limited by its high price, and so glycol based anti-freeze solutions have received wide application.

Anti-freeze solution is made up of raw alcohol, water and additives. The alcohol used is glycol and the water is distilled. Additives include antirust agents, anti-toxicity agents, PH regulating agents (buffering agents), antifoam agents, and other performing enhancing chemicals.

Table 1 Physical and chemical property of glycol

Density(@20℃)	1.113 g/mL
Flash point	116℃
Freezing point	-13℃
Specific heat capacity(@20℃)	2349J/(g • k)
Boiling point (@760mmHg)	197℃
Vapor pressure (@20℃)	8 Pa
Vapor pressure (@100℃)	2133 Pa
Thermal conductivity (@20℃)	2.889 * 0.004 [W/(cm*s*℃)]

Table 2 Glycol concentration, density and freezing point with anti-freeze solution

Freezing point ℃	Glycol concentration %	Density (@20℃)	Freezing Point(@℃)	Glycol concentration%	Density (@20℃)
-10	28.4	1.0340	-40	54	1.0713
-15	32.8	1.0426	-45	57	1.0746
-20	38.5	1.0506	-50	59	1.0786
-25	45.3	1.0586	-45	80	1.0958
-30	47.8	1.0627	-30	85	1.1001
-35	50	1.0671	-13	100	1.1130

There are two types of anti-freeze solution. The first is the direct-use type; the other is the concentrate type. Concentrate type cannot be used directly. It must be diluted to a particular concentration complying with the specifications in Table 2 according to temperature.

If a new type of long life anti-freeze solution shows up on the market, it is important to be able to judge its utility. Glycol is still the basis for long life anti-freeze solutions. Glycol is an indispensable component in inhibiting water freezing and boiling. Furthermore, it is the key in keeping the heat transfer capability of the anti-freeze solution. The differences between types of glycol-based solutions are as follows:

Characteristic	Conventional green coolant	Long life orange coolant
Color	Green or green-blue	Orange or red
Standard PH value	10.5	8.5
Anticorrosion agents	Adding metal anticorrosion agents (e.g. tolyltriazole) to borate, phosphate and silicate.	Adding tolyltriazole to organic salts, such as Monocarboxylate and dicarboxylate，(e.g. sebacic acid and octoic acid)
Sensitivity to pollution	Hard water	Conventional green coolant
Average maintenance life	2 to 3 years	4 to 5 years

Thus, the differences between them lie in the added anticorrosion agents. Because long life anti-freeze solution is made up of organic acid salts, it has more chemistry stability and longer life.

2. Five functions of good anti-freeze solution

    1. Anticorrosion—Anti-freeze solution contains a group of good, long-lasting corrosion inhibitors. It can achieve the equilibrium between reagents and metal, and form a protective film on the surface of the metal. Moreover, it can shell off the original corrosion in the cooling system and prevent further corrosion. Experiments indicate that corrosion by anti-freeze solution is 50 to 100 times lower than that by water.

    2. Anti-cavitation erosion—Cavitation erosion is caused by air bubbles colliding with metal. Experiments indicate that corroding rate of hard water containing salts and alkalis is several tens times than that of clean soft water. Anti-freeze solution does not contain hard water, and anti-foaming agents added can prevent the formation of foam.

    3. High boiling point— Anti-freeze solution boils at 105 to 110℃, which makes it more difficult to boil than water.

    4. Anti-sludge—Good anti-freeze solution is composed of distilled water and contains anti-sludge agents, so scaling is inhibited.

    5. Anti-freeze—The freezing point of anti-freeze solution can be adjusted, and is determined by the ambient temperature in different operating locations. Usually it freezes from -15 to - 68℃.

Good anti-freeze solution is transparent, clean and without irritating odor. Performance criteria are as follows:

1. Good anti-freeze performance.
2. Anticorrosion and antirust performance.
3. No swelling and erosion caused to rubber parts.
4. Prevent cooling system from scaling.
5. Antifoam performance.
6. Low viscosity at low temperatures.
7. Stable chemical property.

3. How to select and use anti-freeze solution correctly

Anti-freeze solution is in common use at the present. Being short of knowledge of its performance in service, requirements, and methods of application may cause a variety of problems for a vehicle. Difficulty starting, leaky pipe joints, hose cracks, water not being added, radiator corrosion, and cylinder sleeve cavitations erosion are some of the troubles which may be experienced.

[1] Guide to anti-freeze solution selection

1) Select an anti-freeze solution with different freezing points with regards to ambient temperature. The freezing point of an anti-freeze solution should be approximately 10℃ lower than the historically lowest temperature in the operating area.

2) Select it in terms of the amount of vehicles to be maintained. Departments which have many and relatively centralized vehicles can select small packages of anti-freeze solution concentrate, because it is stable, and small packages are convenient to transport and store. In addition, the flexible preparation of operational anti-freeze solutions in light of ambient circumstances and working requirements is more economical and practical. Conversely, if the number of vehicles is few or dispersed, the direct-use type can be selected.

3) Select a high-grade anti-freeze solution, and do not use a low-grade anti-freeze solution. High-grade anti-freeze solution is generally a qualified brand approved by a national authentication center. It is transparent, clean and without irritating odor. Detailed producer information, product description and detailed directions for use are displayed on the external package. Low-grade anti-freeze solutions not only do not inhibit freezing and boiling, but also accelerate the corrosion of the cooling

system.

4) Select an anti-freeze solution compatible with rubber sealing components. Anti-freeze solution should not bring undesired side effects, such as swelling, erosion to rubber, etc.

[2] How to use anti-freeze solution correctly.

1) Be sure to wash the cooling system completely before adding anti-freeze solution, otherwise its antirust effect may be weakened. The washing sequence is as follows: (1) First, start and then stop the engine when the temperature of anti-freeze solution rises to the opening temperature of the thermostat. Then, drain the anti-freeze solution. (2) Make the engine operate at high speed for 5 minutes with a water solution of 10% caustic sodium as coolant, and then drain it after soaking for an hour. (3) Make the engine operate for 10 minutes after adding soft water, and then drain. Repeat (3) several times until the drained water is uncontaminated.

2) Be sure to check for leakage in the cooling system before adding anti-freeze solution. Add it only after stopping any leak. Glycol easily seeps through cracks due to its low surface tension. Therefore, it is necessary to check the whole cooling system, especially the pipe lines and connection joints to avoid leakage before replacing the anti-freeze solution.

3) The expansion coefficient of anti-freeze solution is greater than that of water. If there is no expansion tank, anti-freeze solution can only be added to 95% the volume of the cooling system.

4) Be sure not to add anti-freeze solution concentrate directly or mix the solution with hard water.

5) Periodic checking of the operation of anti-freeze solution is necessary. Anti-freeze solution may decrease in quantity after being used for a period of time. Its density should be checked first. If its density has not increased and any decrease is the result of leakage, the same brand anti-freeze solution should be added. If density decreases, the same brand solution concentrate should be added. If density increases, or any decrease is caused by water evaporation, distilled-water or de-ionized water should be added. After adding distilled water or concentrated solution, check the density of anti-freeze solution after mixing thoroughly until it reaches the density corresponding to desired freezing point. Do not use common water (such as river water, lake water, pool water, well water, tap water, etc), because these kinds of water contain impurities, which would decrease the anticorrosion performance of the solution.

6) Do not mix different brands of anti-freeze solution to avoid disabling the action of

complex anti-corrosion agents.

7) The service term for long life anti-freeze solution is generally one to two years. Replace it when it becomes due. If the PH value is higher than 5.5, it can continue to be used; if the PH value is lower than 5.5, it should be replaced, otherwise it would accelerate corrosion in cooling system. A validity extending agent can be added to anti-freeze solution whose PH value is lower than 5, which can prolong its use term up to one year.

8) Glycol is poisonous and harmful to the human liver. Do not ingest it. Washing is necessary if it contacts skin. Sodium nitrite is a carcinogenic substance. Do not dump the exhausted solution to prevent pollution to the environment.

4. The required replacement of the anti-freeze solution

Requirement	Mileage a year (km)	Replacement times
Using in whole year	⩾40000	Once every year
	20000 ～ 30000	Once every two years
	⩽10000	Once every three years