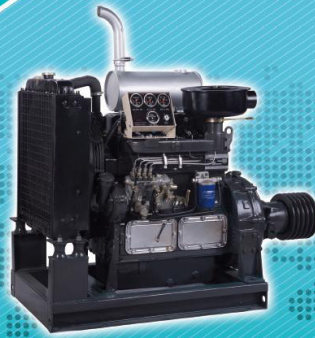




**495/4100/4102 SERIES DIESEL ENGINE
OPERATION AND MAINTENANCE MANUAL**



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Preface

HUAFENGDONGLI brand 495 series diesel engine is a four-cylinder, four-stroke, vertical, water-cooled, swirl combustion or direct injection chamber, high speed diesel engine. In 1980', our company adopted the comet V combustion system and diesel engine design technology from Ricardo Consulting Engineering Company and had made great improvement in design. Thus, the power, economy, reliability and life reached an advanced level among the same kind of products all over the country. Our products have got "High Quality Products" honor, passed reliability testing from National Mechanical Industrial Ministry, named as "Energy-saving Internal Combustion Engine" .

HUAFENGDONGLI brand 495 series diesel engine was prized by the National Science Congress, and it's easy to get adaption. According to the different application, some parts are changed accordingly. It can be matched with middle-sized tractors, construction machinery, middle-sized vehicles, generating sets, irrigating machines and agricultural products process machines etc. The output range of 495 series diesel engine and its various version is 26.5-55KW, and rated speed is 1500-2800r/min.

Model K4100 is developed from Model 495 through cylinder expansion. Thus, the output range has been enlarged.

Model K4102 is developed from Model K4100 through cylinder expansion. Main spares are optimized with strengthen structure. Electrical System, Air-Inlet System, Exhaust system, Cooling System, etc., are greatly improved, to enlarge the output range.

ZH4100 is developed from K4100. It adopts the direct injecting combustion chamber, and improved its economy further.

ZH4102 is developed from ZH4100. It adopts the direct injecting combustion chamber, and improved its economy further.

The common engine model make-up rule and the meaning of the symbol for every type is as follows:

ZH 4 100 □ □ □—□

K 4 100 □ □ □—□

4 100 □ □ □—□

⑦ ⑥ ⑤ ④ ③ ② ①

① : Distinguish symbol, expressed with number sequence

② : Version symbol, expressed with number sequence

③ : Application feature symbol, expressed with alphabet no alphabet: for common use; T:for tractor; G:for engineering machinery; Q:for vehicle; D:for generating set; C:for marine use; P:for power takeoff unit; Y: for transporting vehicle use.

④ : Air intake feature symbol, expressed with alphabet; no alphabet: for natural aspirated model; Z:for turbocharged model.

⑤ :Cylinder bore(mm)

⑥ : Cylinder number

⑦ : K:cylinder expanded ;ZH: Direct injecting combustion chamber

The national Tier II off-road engine model make-up rule and the meaning of the symbol for every type is as follows:

ZH B Z G 2- 5

⑥ ⑤ ④ ③ ② ①

① : Symbol for product minor structure variation or customer special requests

② : Symbol for product larger structure variation, larger performance variation, like power, speed etc.

③ : Application feature symbol, expressed with alphabet no alphabet: for common use; T:for tractor; G:for engineering machinery; Q:for vehicle; D:for generating set; C:for marine use; P:for power takeoff unit; Y: for transporting vehicle use.

④ : Air intake feature symbol, expressed with alphabet; no alphabet: for natural aspirated model; Z:for turbocharged model.

⑤ : Cylinder bore:A-100mm B-102mm

⑥ : ZH: Direct injecting combustion chamber

In order to keep the diesel engine in good condition in most time, prolong the guarantee period maximally, reduce the cost of usage, we compiled this manual on the basis of the "National Rated 495 Diesel Engine Manual" and the change and improvement of the products to introduce the operation and maintenance knowledge to the customers.

This operation manual mainly introduces common usage type. For the products is changing and improving continually, there may be some slight difference between the produces and that described in this manual and the users are advised to notice it kindly.

The manual is edited by Fu Shuguang,Zhou Maosen,Xu Chuanjiang,Sun Changyi,Tong Shunbo,Shao Mingpeng,Hu Laibin,Wang Guohui,Liu Weiyan,Zheng Yan,Fu You, reviewed by Dou Yuxiang, and finally approved by Bao Zhichao.

For the limit of the compilers, there may be mistakes in the manual, and it would be appreciated if you give us your suggestions.

The Editor
Aug, 2013

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Attention

1. The diesel engine operators must familiarize themselves with this manual as well as engine construction and strictly follow the procedures of operation and maintenance especially the regulations for safety operation described in this manual.
2. Before operating an engine at full load, the 60 hours running in should be carried out as specified in the manual.
3. Increase its speed gradually after starting a cold engine, never let it run at high speed abruptly, also don't let the engine running long time without load.
4. If the ambient temperature falls below +5°C, drain the cooling water out of the radiator, the lubricating oil cooler and the diesel engine itself completely after stopping the engine. Continuous keeping the water in the oil cooler should be forbidden.
5. Never run the diesel engine without an air cleaner so as to prevent the unfiltered air from entering the cylinders.
6. The engine must be filled with specified grade fuel and lubricating oil, and a special and clean container for each oil should be used. The fuel should be settled for 72 hours and filtered before using.
7. The inspection and repair of the components in electrical system must be carried out by the person who has a good knowledge of electricity.
8. The working environment of the diesel engine should be well ventilated to avoid being polluted by waste gas or smoke.
9. The power rating and amending of the diesel engine is according to Reciprocating internal combustion engines-Performance -Part 1:STANDARD reference conditions, declarations of power, fuel and lubricating oil consumptions, and test methods. Power deration refer to table(1)
10. The manufacturing of the diesel engine is according to the common technical requirement for low and middle level powered diesel engine in JB/T8895-1999 and Q/0700WHF 002—2011 495 series diesel engine enterprise standard.
11. The No. of production license of this series diesel engine is: XK06—002 — 00228.
12. The position of safety warning marks:
 - (1) There's a "guard against burning" mark at the rear end of the cylinder cover which is beside the exhaust manifold of the diesel engine.
 - (2) There's a "guard against fire" mark at the oil filler.
 - (3) There's instruction for fan adjustment on gear case cover at back side of fan
 - (4) There's "guard against being entangled into rotating parts" marks on charging alternator

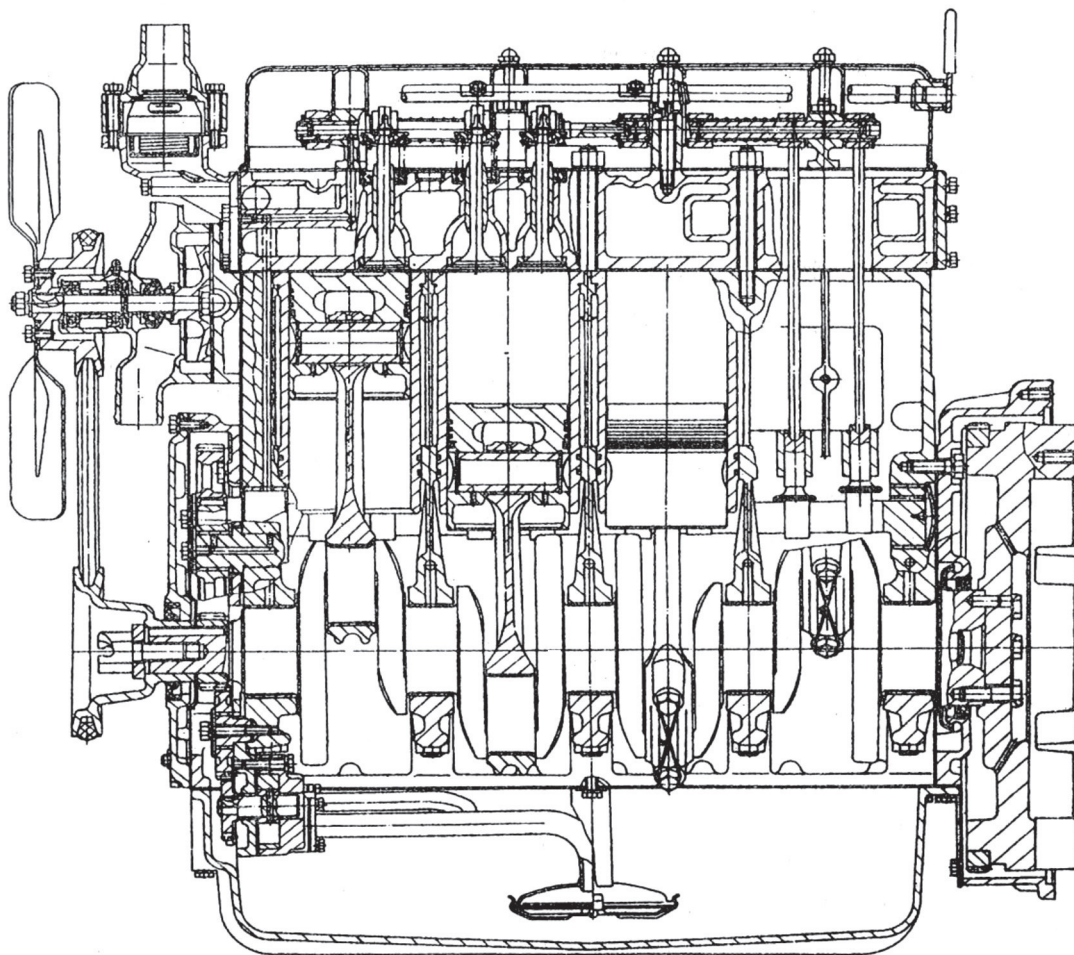


Fig.1 Longitudinal and sectional drawing for 495、4100、4102 diesel engine

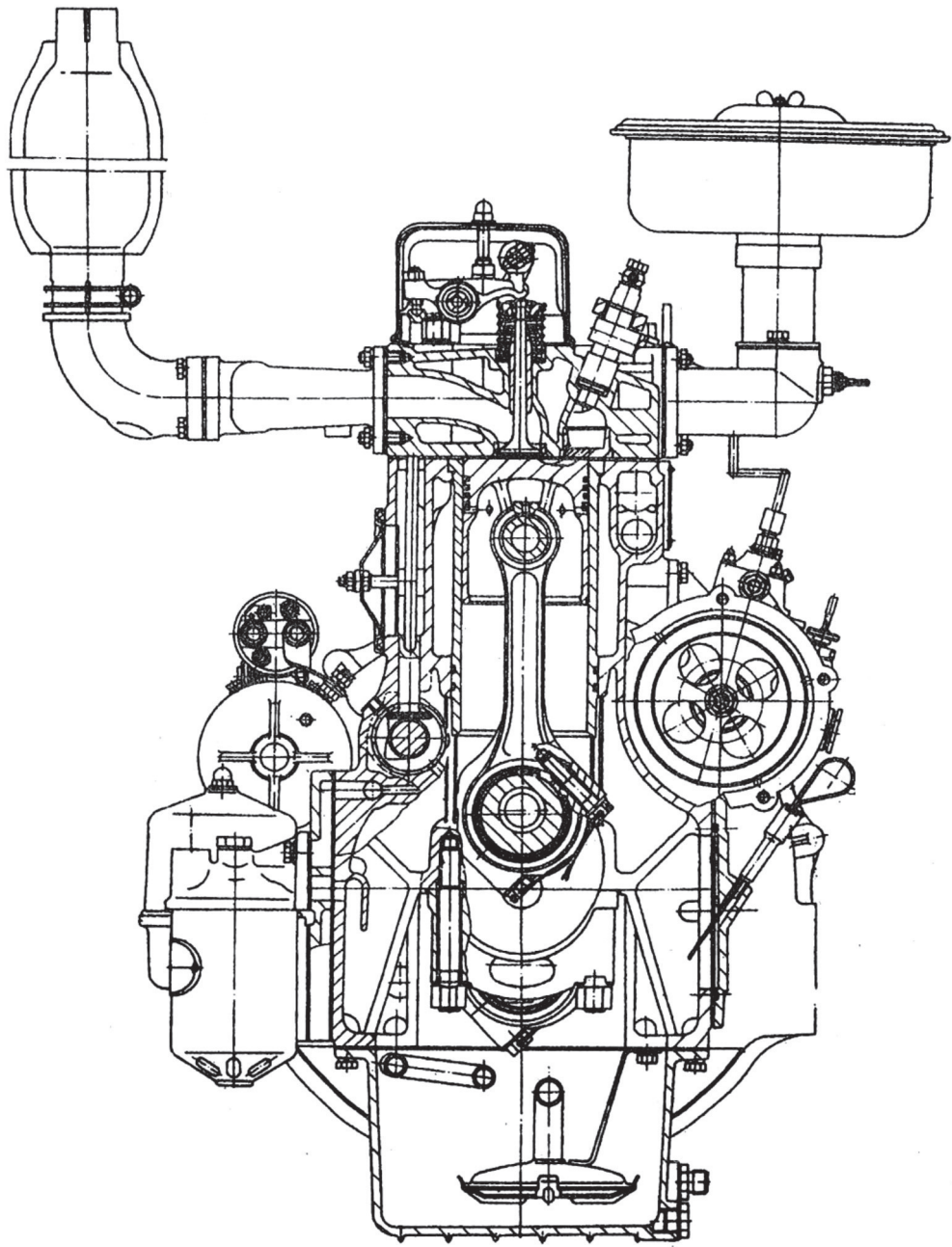


Fig.1 Longitudinal and sectional drawing for 495、4100、4102 diesel engine

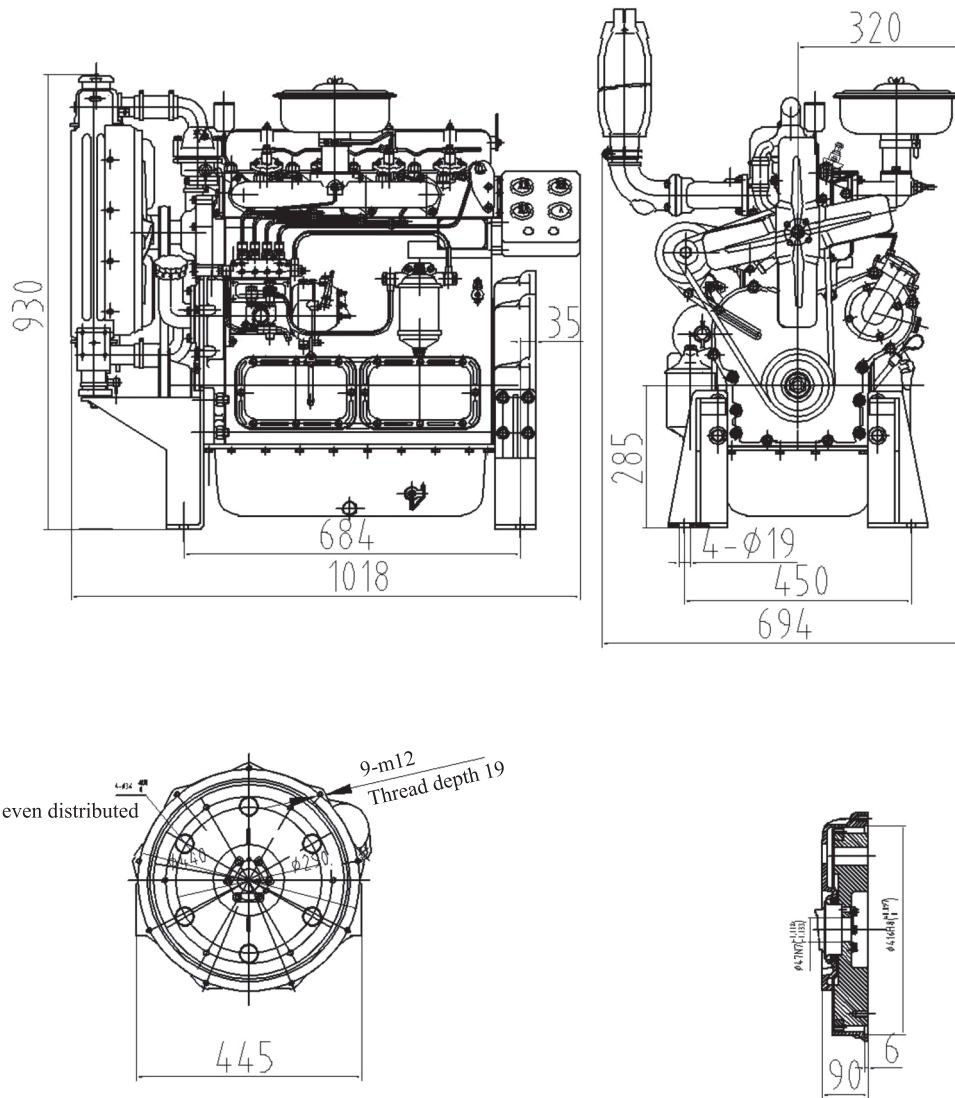


Fig 2 Outline drawing for 495D diesel engine

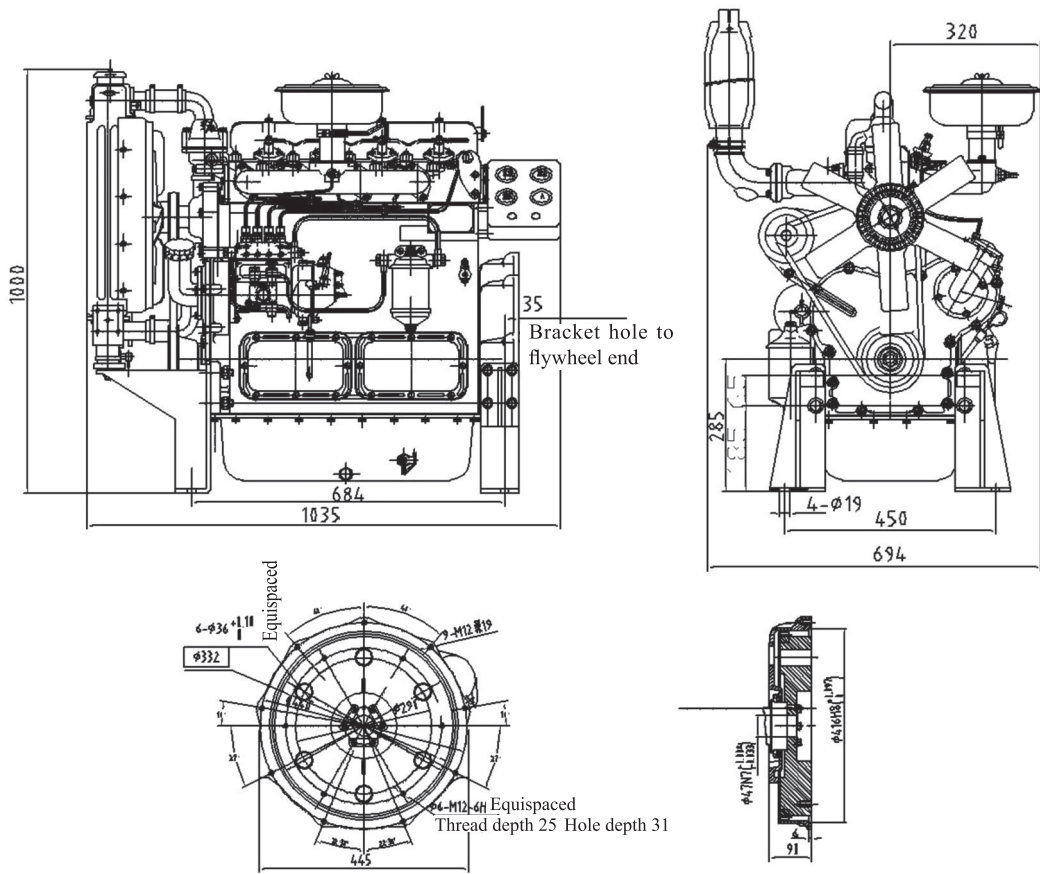


Fig 3 Outline drawing for K4100D diesel engine

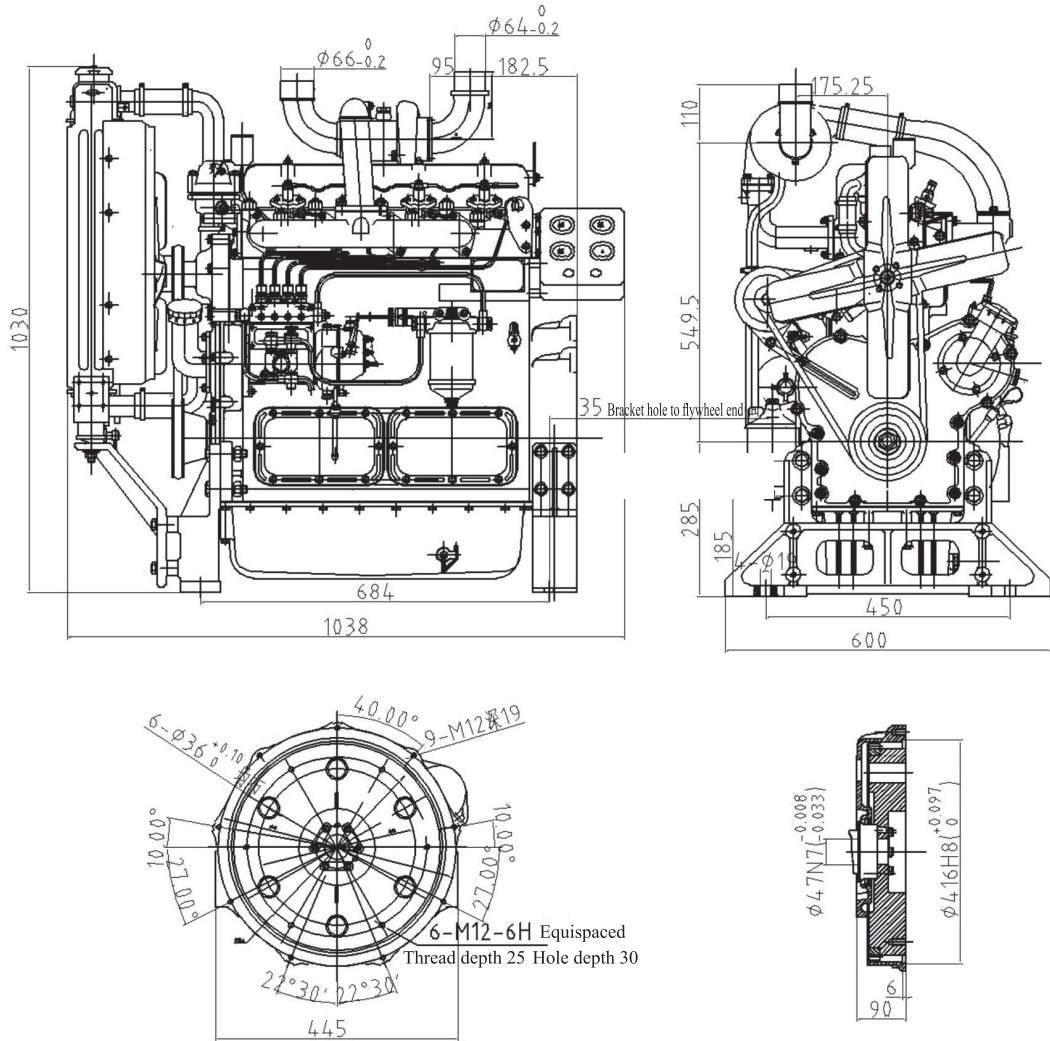


Fig 4 Outline drawing for K4100ZD diesel engine

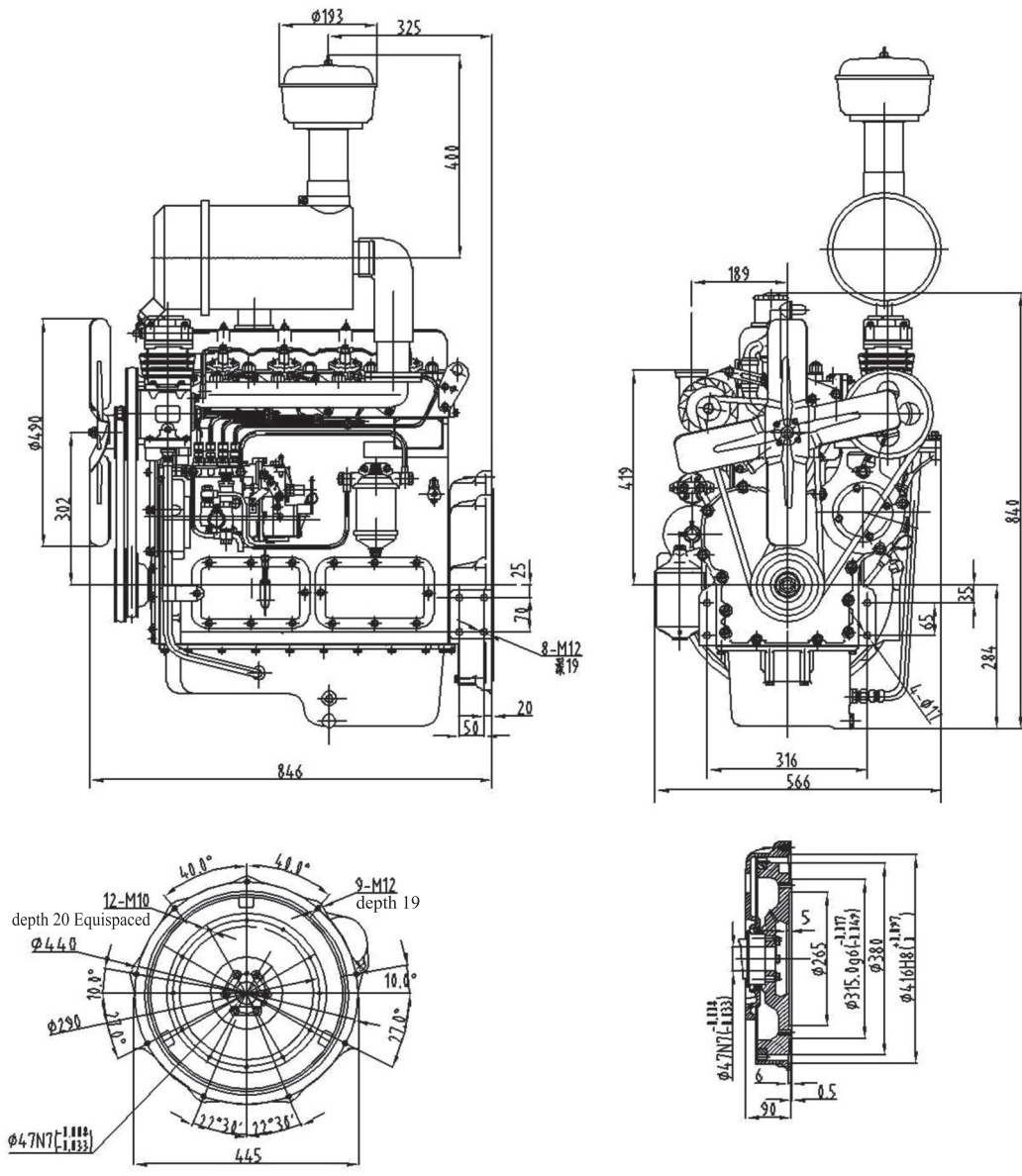


Fig 5 Outline drawing for ZHAG2-5D diesel engine

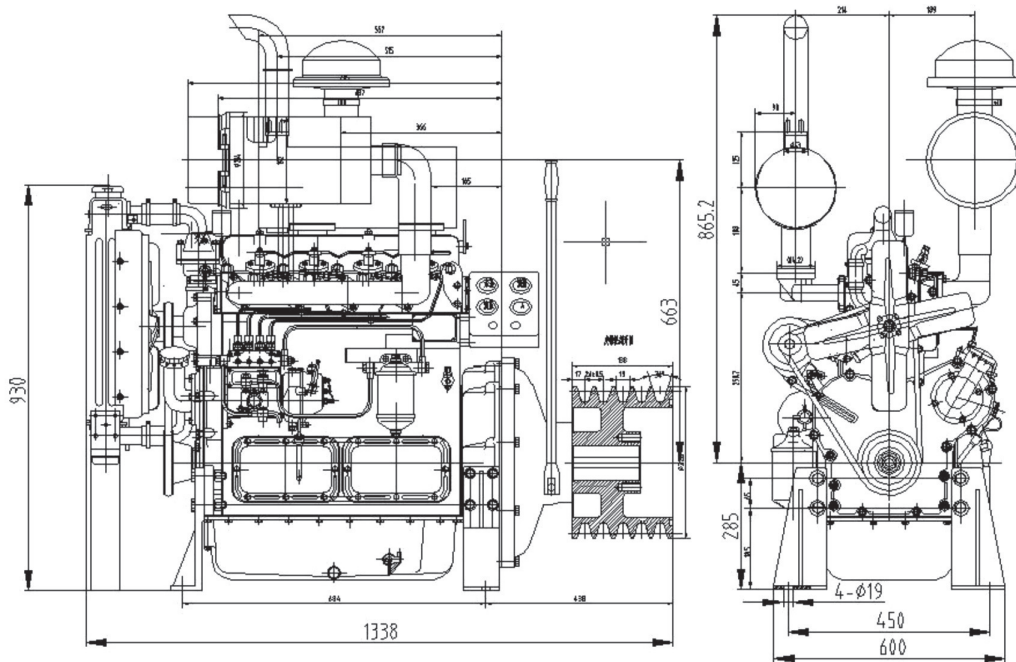


Fig 6 Outline drawing for ZHBP4 diesel engine

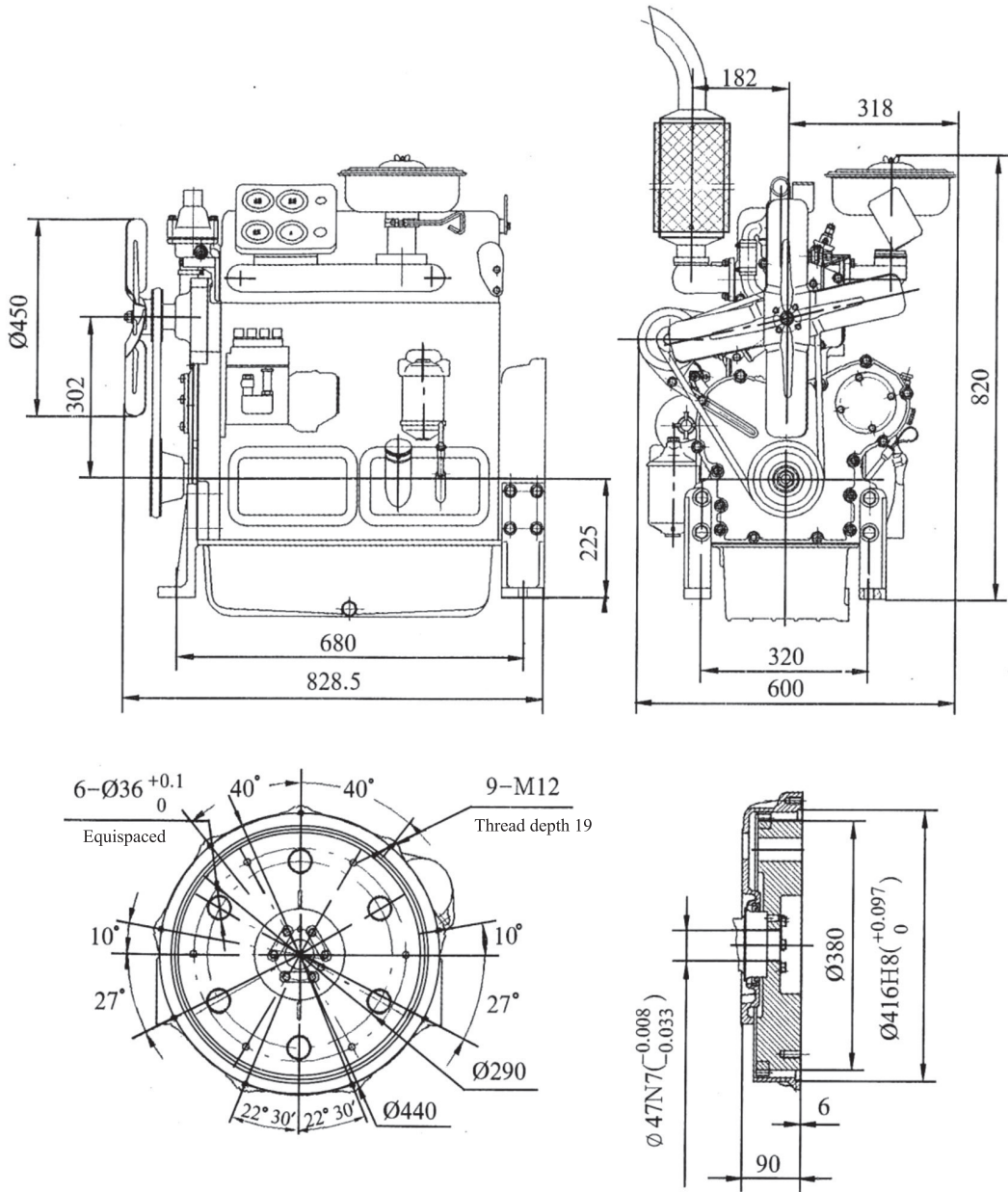


Fig 7 Outline drawing for K4102D diesel engine

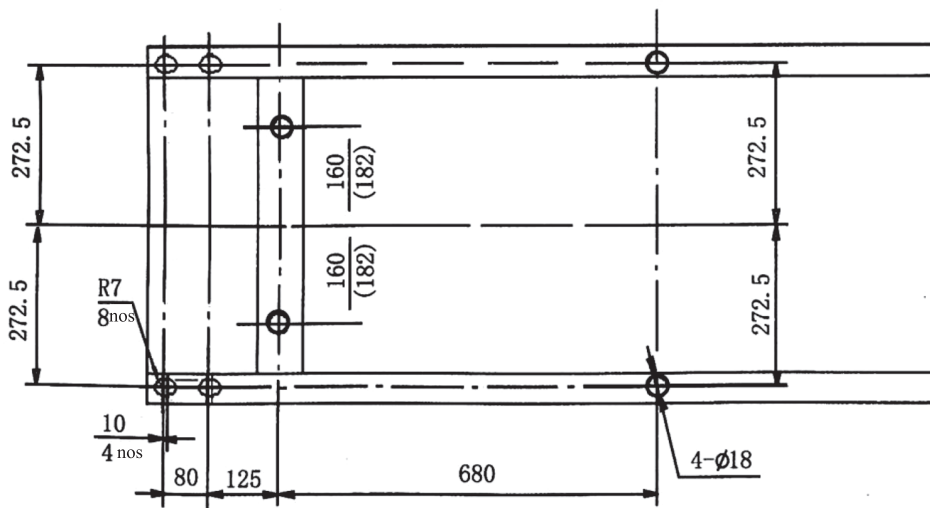
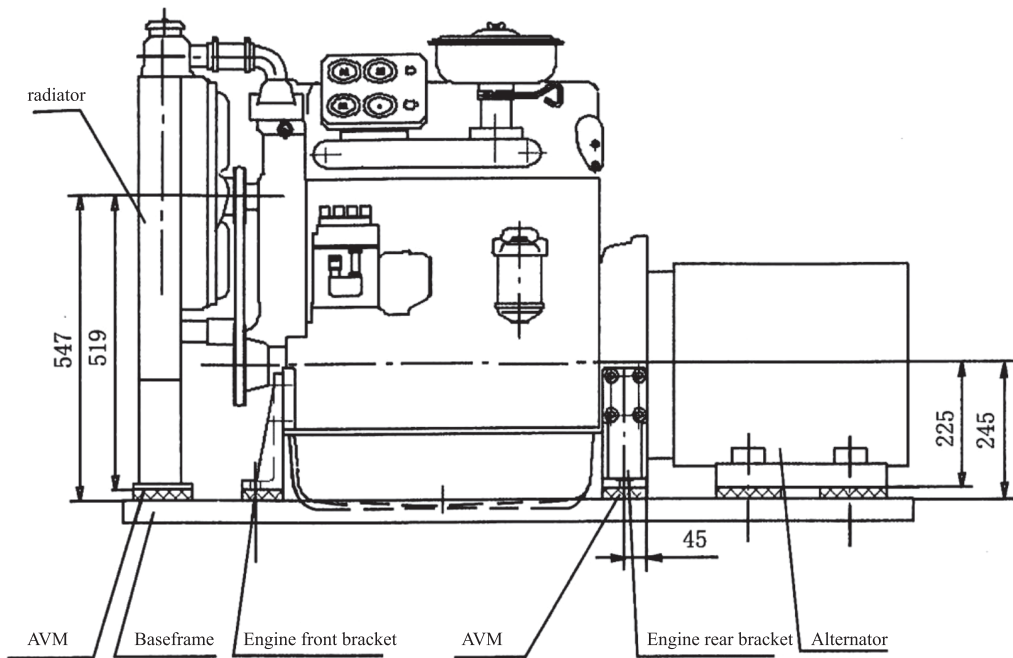


Fig 8 Installation diagram of base-frame with radiator for 4102D generator engine

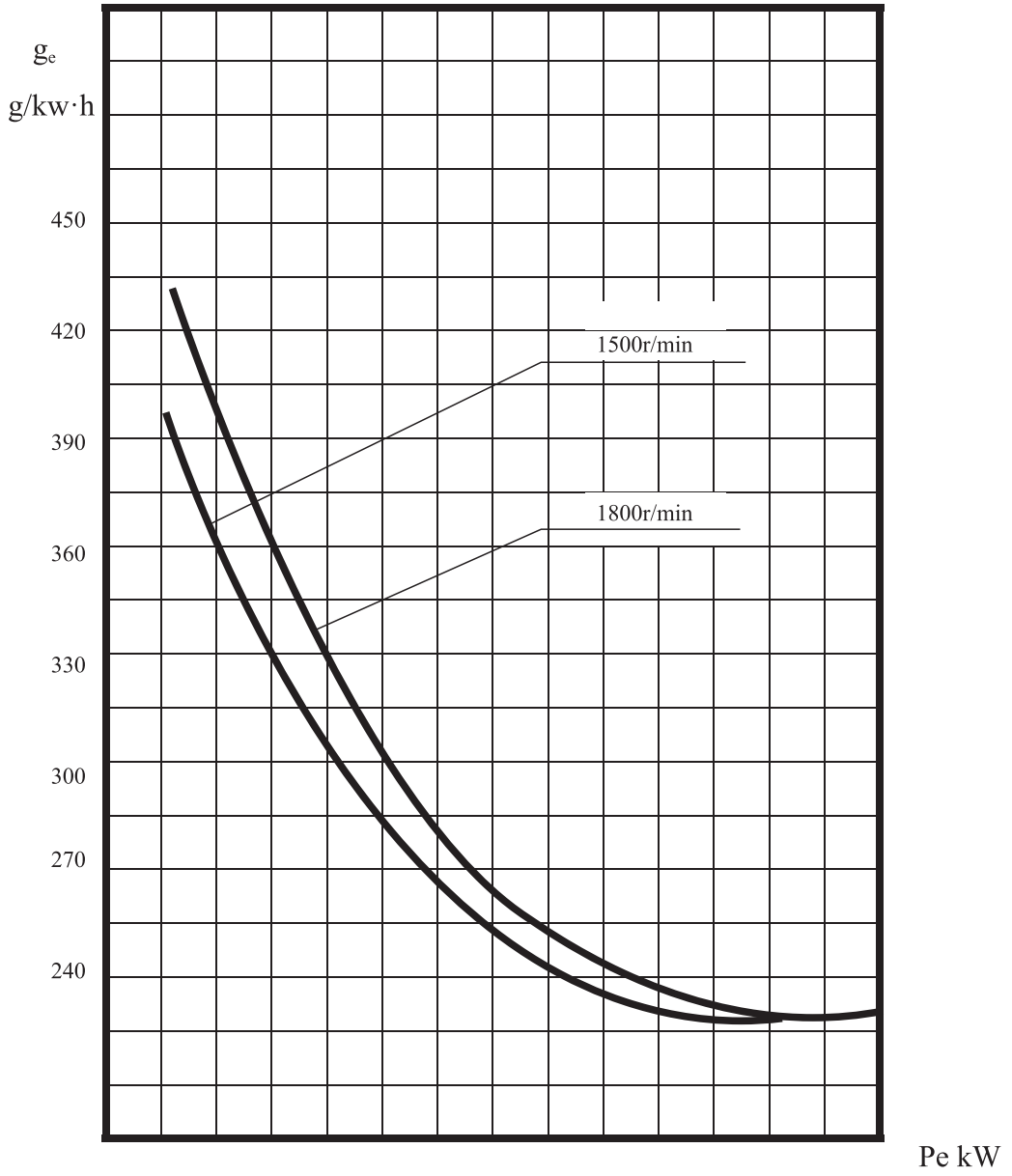


Fig 9 Load characteristic curves for 495、K4100 diesel engine

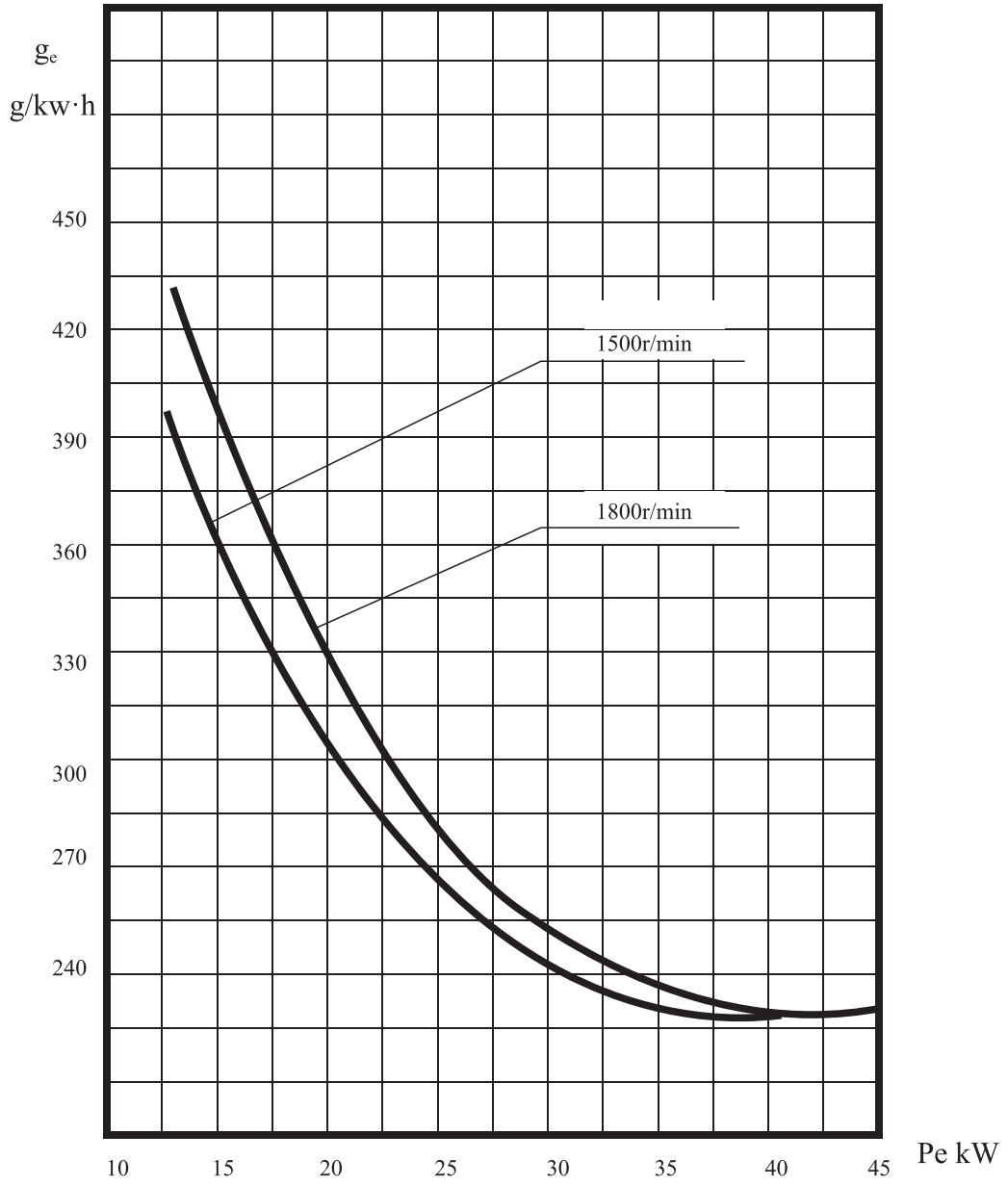


Fig.10 Load characteristic curves for turbocharged diesel engine

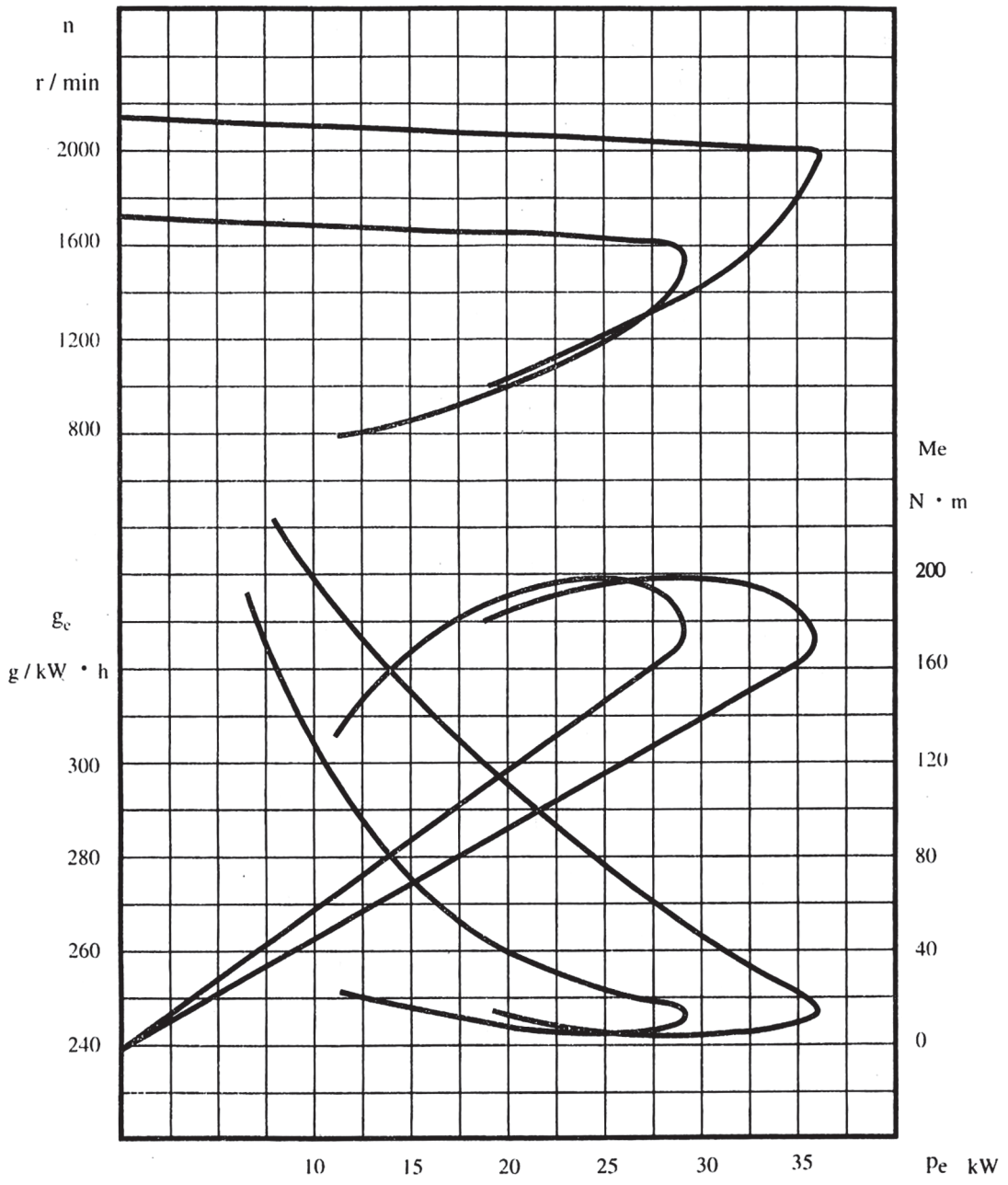


Fig.11 Speed governing characteristic curves for tractor engine

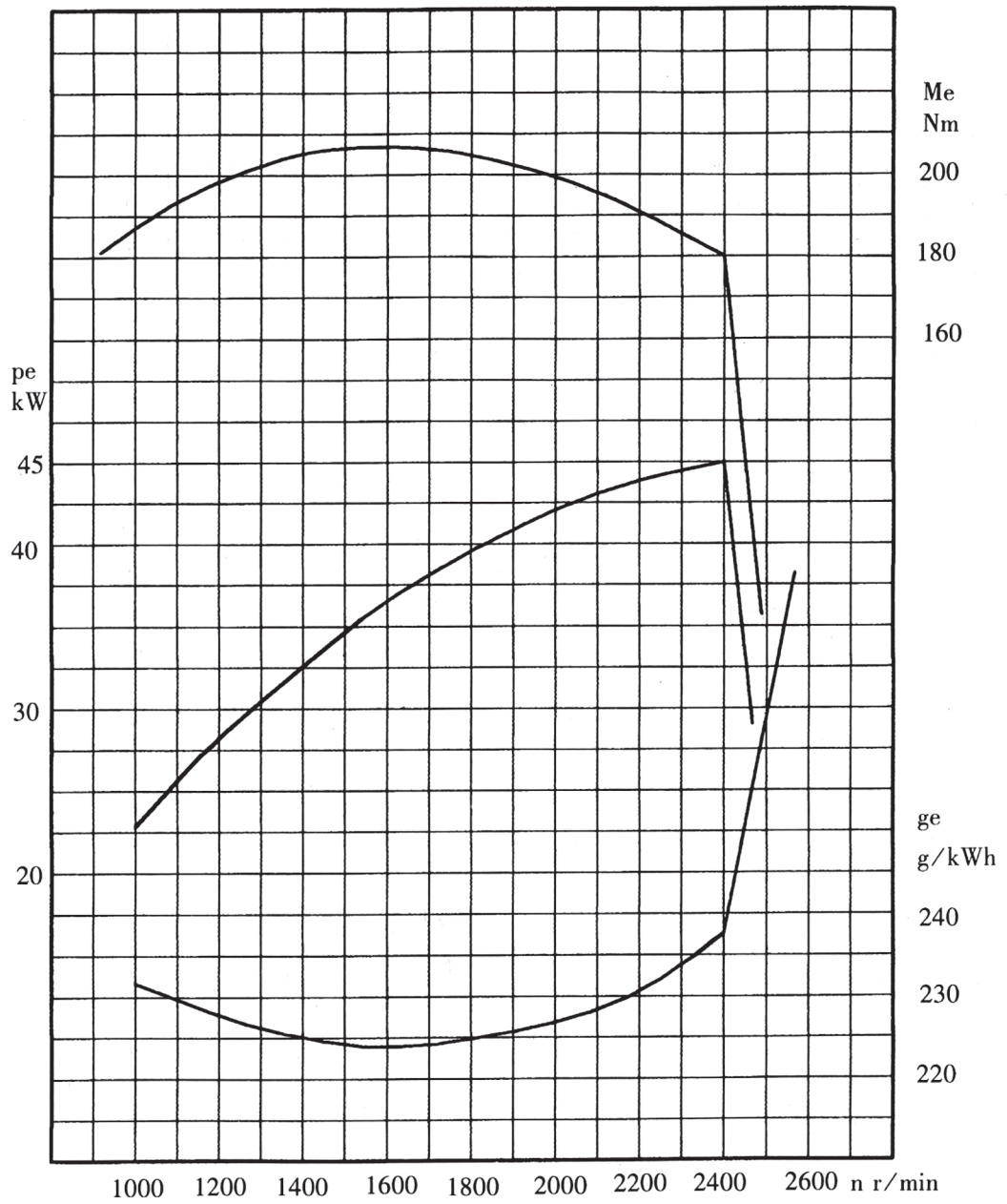


Fig.12 Speed governing characteristic curves and speed variation characteristic curves for construction engine

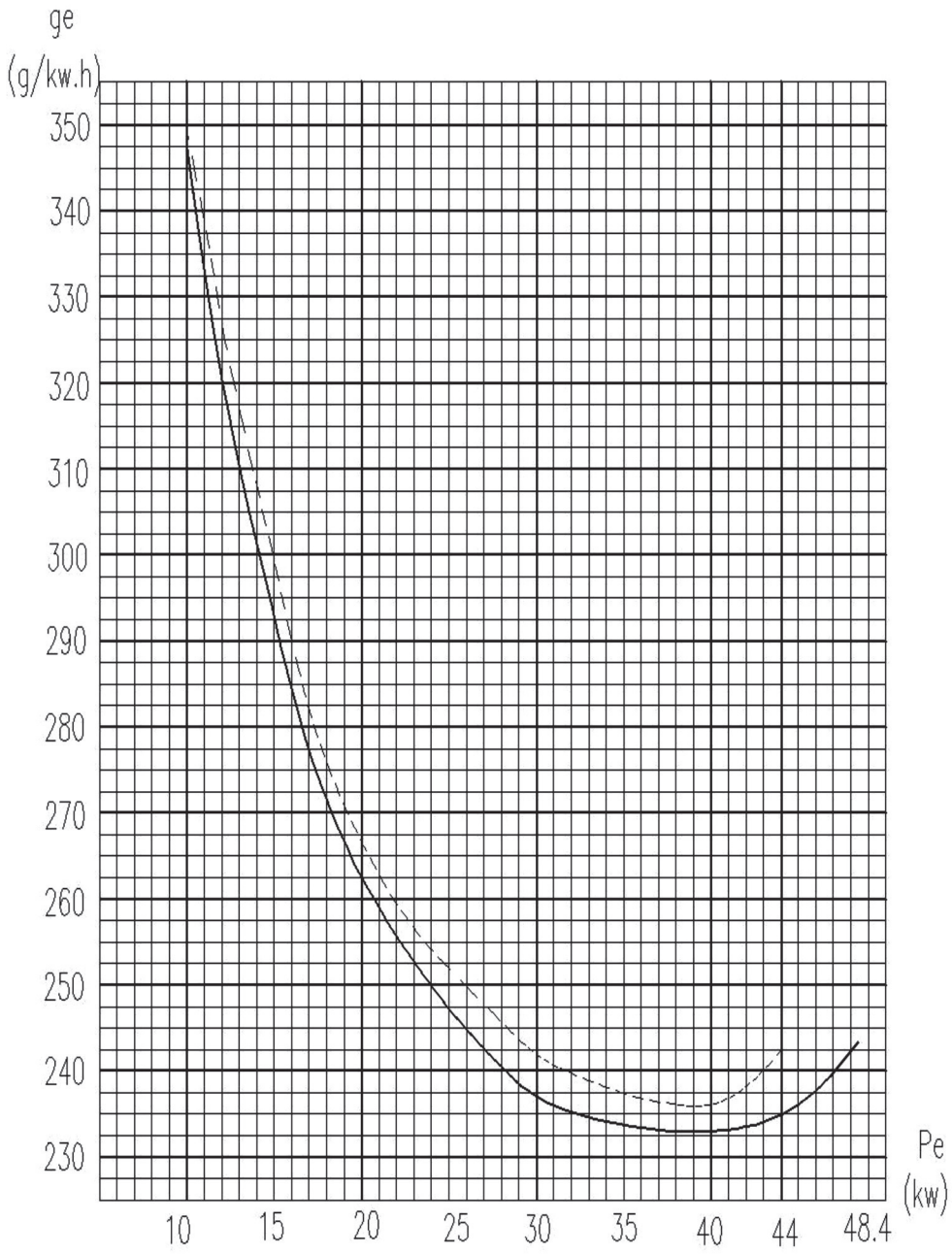


Fig.13 Load characteristic curves for ZH4100P、ZH4102P series 2000rpm diesel engine

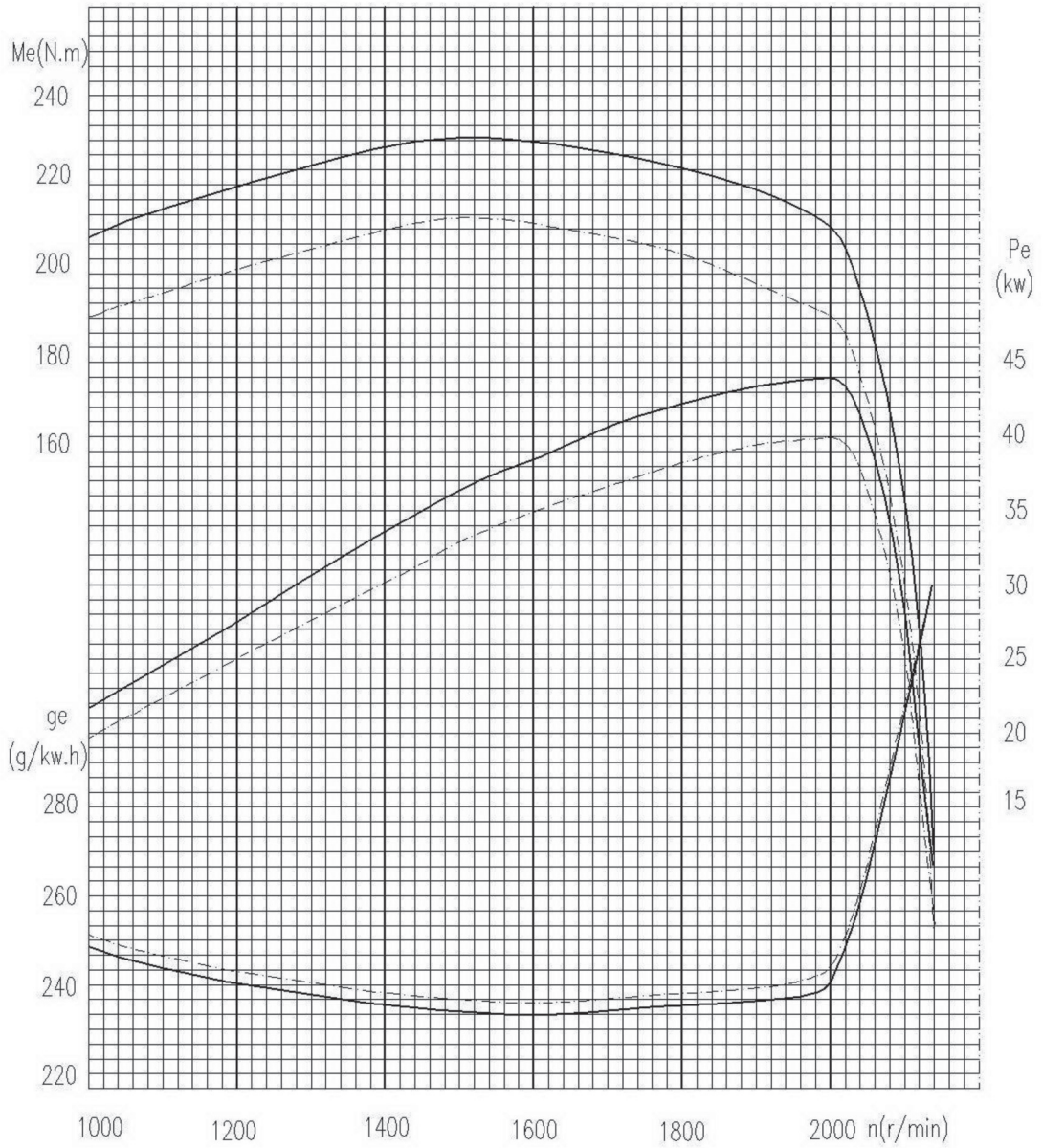


Fig.14 Speed governing characteristic curves and speed characteristic curves for diesel engine applied for bulk particle transportation vehicle

CHAPTER 1 Main Technical Specification and Data of Diesel Engine
§ 1 Main Technical Specification

No.	Item		Model			
			495	495T	495C1	495D
1	Type		Four-stroke, water-cooled, inline, swirl bowl			
2	Cyl.Nos-B × S (mm)		4-95 × 115			
3	Total Displacement (L)		3.26			
4	Compression Ratio		19:1			
5	Firing order		1-3-4-2			
6	Air intake method		Natural Aspirated			
7	Standard Reference Condition	15min Power (kW/r/min)				
		1h Power/Speed (kW/r/min)	38.8/2000			29/1500
		12h Power/Speed (kW/r/min)	35.3/2000	35.3/2000	32/2000	26.5/1500
8	Highest Idling Speed (r/min)		≤ 2160			≤ 1575
9	Lowest Idling Speed (r/min)		≤ 600	≤ 700		
10	Max Torque/Speed (N · m/r/min)		194/1500			
11	Standard Reference Condition	BMEP (kPa)	650		667	662
12		SFC (g/kW · h)	≤ 258.4		≤ 251.6	≤ 258.4
13		Oil Consumption (g/kW · h)	≤ 2.04			
14		Exhaust Temp. (°C)	≤ 470			
15	Crankshaft Rotation		Counter-clockwise(From flywheel end)			
16	Cooling Method		Forced Water-cooled			
17	Lubrication Method		Compound type with pressure and splash			
18	Starting Method		Electrical			
19	Net Weight (kg)		320	360	370	

No.	Model Item		K4100	K4100D	K4102	K4102D
			1	Type	Four-stroke, water-cooled, inline, swirl bow	
2	Cyl.Nos-B × S (mm)	4-95 × 115		4-102 × 115		
3	Total Displacement (L)	3.26		3. 76		
4	Compression Ratio	19:1				
5	Firing order	1-3-4-2				
6	Air intake method	Natural Aspirated				
7	Standard Reference Condition	15min Power (kW/r/min)				
		1h Power/Speed (kW/r/min)	43/2000	33/1500	44/2000	36. 6/1500
		12h Power/Speed (kW/r/min)	39/2000	30.1/1500	40/2000	33/1500
8	Highest Idling Speed (r/min)	≤ 2160	≤ 1575	≤ 2160	≤ 1575	
9	Lowest Idling Speed (r/min)	≤ 550				
10	Max Torque/Speed (N · m/r/min)	215/1500		219/1500		
11	Standard Reference Condition	BMEP (kPa)	650	650	650	702
12		SFC (g/kW · h)	≤ 258.4			
13		Oil Consumption (g/kW · h)	≤ 2.04			
14		Exhaust Temp. (°C)	≤ 470		≤ 600	
15	Crankshaft Rotation	Counter-clockwise(From flywheel end)				
16	Cooling Method	Forced Water-cooled				
17	Lubrication Method	Compound type with pressure and splash				
18	Starting Method	Electrical				
19	Net Weight (kg)	370		380		

No.	Model Item		ZH4100	ZH4100D	ZHAG1	ZH4100L
			1	Type	Four-stroke, water-cooled, inline, direct injection	
2	Cyl.Nos-B × S (mm)	4-100 × 115				
3	Total Displacement (L)	3.61				
4	Compression Ratio	19:1				
5	Firing order	1-3-4-2				
6	Air intake method	Natural Aspirated				
7	Standard Reference Condition	15min Power (kW/r/min)				
		1h Power/Speed (kW/r/min)	44/2000		45/2400	
		12h Power/Speed (kW/r/min)	40/2000	31/1500		43/2200
8	Highest Idling Speed (r/min)	≤ 2160	≤ 1575	≤ 2640	≤ 2380	
9	Lowest Idling Speed (r/min)	≤ 550				
10	Max Torque/Speed (N · m/r/min)	220/1500		206/1680	210/1600	
11	Standard Reference Condition	BMEP (kPa)	660	680	620	650
12		SFC (g/kW · h)	≤ 248.8		≤ 270	≤ 248.8
13		Oil Consumption (g/kW · h)	≤ 2.04		≤ 1.4	
14		Exhaust Temp. (°C)	≤ 500		≤ 580	≤ 580
15	Crankshaft Rotation	Counter-clockwise(From flywheel end)				
16	Cooling Method	Forced Water-cooled				
17	Lubrication Method	Compound type with pressure and splash				
18	Starting Method	Electrical				
19	Net Weight (kg)	320	380	340	360	

No.	Model Item		ZHAG2-5A	ZHAG2-5D	ZHAG60	ZHAP10
			1	Type	Four-stroke, water-cooled, inline, direct injection	
2	Cyl.Nos-B × S (mm)	4-100 × 115				
3	Total Displacement (L)	3.61				
4	Compression Ratio	19:1				
5	Firing order	1-3-4-2				
6	Air intake method	Natural Aspirated				
7	Standard Reference Condition	15min Power (kW/r/min)				
		1h Power/Speed (kW/r/min)	44/2400		45/2400	
		12h Power/Speed (kW/r/min)				40/2000
8	Highest Idling Speed (r/min)	≤ 2640		≤ 2688	2160	
9	Lowest Idling Speed (r/min)	≤ 700	≤ 650		≤ 650	
10	Max Torque/Speed (N · m/r/min)	206/1680		211/1680		
11	Standard Reference Condition	BMEP (kPa)	660			
12		SFC (g/kW · h)	≤ 270	≤ 270	≤ 270	
13		Oil Consumption (g/kW · h)	≤ 1.4			
14		Exhaust Temp. (°C)	≤ 580			
15	Crankshaft Rotation	Counter-clockwise(From flywheel end)				
16	Cooling Method	Forced Water-cooled				
17	Lubrication Method	Compound type with pressure and splash				
18	Starting Method	Electrical				
19	Net Weight (kg)	380	380	380	450	

No.	Model Item		ZHBG1	ZHBG2	ZHBZG1	ZHBP10	ZH4102D
			1	Type	Four-stroke, water-cooled, inline, direct injection		
2	Cyl.Nos-B × S (mm)	4-102 × 115					
3	Total Displacement (L)	3.76					
4	Compression Ratio	19:1		17:1		19:1	
5	Firing order	1-3-4-2					
6	Air intake method	Natural Aspirated		Turbocharged	Natural Aspirated		
7	Standard Reference Condition	15min Power (kW/r/min)					
		1h Power/Speed (kW/r/min)	48/2400	44/2200	55/2400	44/2000	36. 3/1500
		12h Power/Speed (kW/r/min)					33/1500
8	Highest Idling Speed (r/min)	≤ 2688	≤ 2464	≤ 2640	≤ 2160	≤ 1575	
9	Lowest Idling Speed (r/min)	≤ 700			550	550	
10	Max Torque/Speed (N · m/r/min)	221/1680	221/1540	254/1680	219/1500		
11	Standard Reference Condition	BMEP (kPa)	650	650	680	670	702
12		SFC (g/kW · h)	≤ 270		≤ 270	≤ 270	≤ 258.4
13		Oil Consumption (g/kW · h)	≤ 1.4				≤ 1.63
14		Exhaust Temp. (°C)	≤ 600				
15	Crankshaft Rotation	Counter-clockwise(From flywheel end)					
16	Cooling Method	Forced Water-cooled					
17	Lubrication Method	Compound type with pressure and splash					
18	Starting Method	Electrical					
19	Net Weight (kg)	380	380	390	450	380	

2. Various temperature and pressure range for 495,4100,4102

Lubrication Oil Temp.	T.C. \leq 100°C N.A. \leq 95°C
Outlet cooling water temperature	T.C. \leq 98°C N.A. \leq 90°C
Lub oil pressure	0.2 ~ 0.4MPa Idling \geq 0.05 MPa Cold start 0.6 MPa is allowable
Fuel injection pressure	12~13MPa (Direct injection 18~19MPa)

3. Main bolts tightening torque for 495,4100,4102

Cylinder head bolt	160~180N.m(Directinjection190~210)
Main bearing bolt	160~180N.m
Connecting rod bolt	130~140N.m
Flywheel tightening bolt	100~120N.m

4. Main adjusting data

Valve lash(cold state)	
Air intake & exhaust valve	0.35~0.45mm
Valve timing:(crankshaft rotating angle) Air intake valve open Air intake valve close Exhaust valve open Exhaust valve close	12° \pm 3° before top dead center 36° \pm 3° after bottom dead center 56° \pm 3° before bottom dead center 12° \pm 3° after top dead center
Compression Clearance	1—1.2mm
Lift of Pressure Releasing shaft	1~1.5mm (NA for Direct injection model)
Fuel delivery advance angle: 1500~1600r/min 1800~2000 r/min 2400 r/min 2800 r/min	15° \pm 2° before top dead center 17° \pm 2° before top dead center 18° \pm 2° before top dead center 20° \pm 2° before top dead center
For Tier II Model	13° \pm 2° before top dead center

5. Matched clearance and wear limit of main parts for 495

No.	Matched parts	Standard size	Matched clearance	Wear limit
1	Crankshaft main journal neck and main bearing	Shaft $\phi 75 \begin{matrix} 0 \\ -0.019 \end{matrix}$ Hole $\phi 75 \begin{matrix} +0.135 \\ +0.070 \end{matrix}$	0.08~0.164	0.30
2	Crankshaft thrust ring and crank shaft		axile clearacne 0.07~0.25	0.50
3	Crankshaft&connecting rod journal neck and connecting bearing	Shaft $\phi 65 \begin{matrix} 0 \\ -0.019 \end{matrix}$ Hole $\phi 65 \begin{matrix} +0.093 \\ +0.050 \end{matrix}$	0.050~0.118	0.30
4	Connecting rod big end and crankshaft	Shaft $\phi 38 \begin{matrix} -0.17 \\ -0.33 \end{matrix}$ Hole $\phi 38 \begin{matrix} +0.10 \\ 0 \end{matrix}$	axile clearacne 0.17~0.43	0.70
5	Piston skirt and cylinder line	Shaft $\phi 95 \begin{matrix} -0.160 \\ -0.190 \end{matrix}$ Hole $\phi 95 \begin{matrix} +0.035 \\ 0 \end{matrix}$	0.160~0.225	0.50
6	Piston pin and connecting rod bushing	Shaft $\phi 35 \begin{matrix} 0 \\ -0.011 \end{matrix}$ Hole $\phi 35 \begin{matrix} +0.034 \\ +0.009 \end{matrix}$	0.009~0.045	0.15
7	The first compression ring and ring grave	Ring $\phi 3 \begin{matrix} 0 \\ -0.012 \end{matrix}$ Grave $\phi 3 \begin{matrix} +0.075 \\ +0.050 \end{matrix}$	0.050~0.087	0.40
8	The second,third compression ring and ring grace	Ring $\phi 3 \begin{matrix} 0 \\ -0.012 \end{matrix}$ Grave $\phi 3 \begin{matrix} +0.050 \\ +0.030 \end{matrix}$	0.030~0.062	0.30
9	oil ring and ring grace	Ring $\phi 6 \begin{matrix} 0 \\ -0.012 \end{matrix}$ Grave $\phi 6 \begin{matrix} +0.050 \\ +0.030 \end{matrix}$	0.030~0.062	0.25
10	Gap of first compression ring in cylinder	Gauge within $\phi 95.00$	0.20~0.40	3.00
11	Gap of second&third compression ring in cylinder	Gauge within $\phi 95.00$	0.15~0.35	3.00
12	Gap of oil compression ring in cylinder	Gauge within $\phi 95.00$	0.15~0.35	3.00
13	Camshaft journal neck and bushing	Shaft $\phi 50 \begin{matrix} -0.080 \\ -0.105 \end{matrix}$ Hole $\phi 50 \begin{matrix} +0.025 \\ 0 \end{matrix}$	0.080~0.130	0.25
14	Camshaft thrust plate and camshaft	Shaft $\phi 12 \begin{matrix} -0.050 \\ -0.120 \end{matrix}$ Hole $\phi 12 \begin{matrix} +0.100 \\ 0 \end{matrix}$	0.050~0.220	0.40

15	Cylinder liner over the cylinder block surface	Shaft ϕ 10 $\begin{matrix} +0.050 \\ 0 \end{matrix}$ Hole ϕ 10 $\begin{matrix} 0 \\ -0.050 \end{matrix}$	Selective fitted 0.030~0.080	
16	Valve push rod and push rod hole	Shaft ϕ 16 $\begin{matrix} -0.016 \\ -0.034 \end{matrix}$ Hole ϕ 16 $\begin{matrix} +0.018 \\ 0 \end{matrix}$	0.016~0.052	0.20
17	Idler shaft and idler shaft bushing	Shaft ϕ 26 $\begin{matrix} -0.020 \\ -0.041 \end{matrix}$ Hole ϕ 26 $\begin{matrix} +0.021 \\ 0 \end{matrix}$	0.020~0.062	0.20
18	Air intake valve and valve guide	Shaft ϕ 9 $\begin{matrix} -0.030 \\ -0.050 \end{matrix}$ Hole ϕ 9 $\begin{matrix} +0.022 \\ 0 \end{matrix}$	0.030~0.072	0.25
19	Exhaust valve and valve guide	Shaft ϕ 9 $\begin{matrix} -0.040 \\ -0.060 \end{matrix}$ Hole ϕ 9 $\begin{matrix} +0.022 \\ 0 \end{matrix}$	0.040~0.082	0.25
20	Rocker arm shaft and bushing	Shaft ϕ 16 $\begin{matrix} -0.016 \\ -0.034 \end{matrix}$ Hole ϕ 16 $\begin{matrix} +0.018 \\ 0 \end{matrix}$	0.016~0.052	0.25
21	Idler and idler shaft		axile clearacne 0.10~0.35	
22	Contacting clearance of various timing gear		clearance of tooth flank 0.130~0.170	
23	Oil pump rotor and pump block surface		adjusting clearance 0.050~0.100	
24	Contacting clearance between the internal and external rotor of the oil pump		0.060~0.188	0.50
25	Water pump impeller and pump body		back clearance 0.20~0.70	
26	Water pump impeller and packing block		adjusting clearance 0.40~0.80	

6. Matched clearances and wear limit of main parts for 4100

No.	Matched parts	Standard size	Matched clearance	Wear limit
1	Piston skirt and cylinder liner	Shaft ϕ 100 $\begin{matrix} -0.140 \\ -0.170 \end{matrix}$ Holet ϕ 100 $\begin{matrix} +0.035 \\ 0 \end{matrix}$	0.140– 0.205	0.50
2	The first compression ring and ring grave	Shaft ϕ 2.5 $\begin{matrix} 0 \\ -0.012 \end{matrix}$ Holet ϕ 2.5 $\begin{matrix} +0.07 \\ +0.05 \end{matrix}$	0.050–0.082	0.40
3	The second, third compression ring and ring grave	Shaft ϕ 2.5 $\begin{matrix} 0 \\ -0.012 \end{matrix}$ Holet ϕ 2.5 $\begin{matrix} +0.05 \\ +0.03 \end{matrix}$	0.030–0.062	0.30
4	Oil ring and ring grave	Shaft ϕ 5 $\begin{matrix} 0 \\ -0.012 \end{matrix}$ Holet ϕ 5 $\begin{matrix} +0.05 \\ +0.03 \end{matrix}$	0.030–0.062	0.25
5	Gap of the first, second and third compression ring in cylinder	Gauge within ϕ 100.00	0.35– 0.50	3.00
6	Gap of oil compression ring in cylinder	Gauge within ϕ 100.00	0.35– 0.45	3.00
Except these listed in the above table, all the others are the same as Model 495.				

7. Matched clearances and wear limit of main parts for 4102

No.	Matched parts	Standard size	Matched clearance	Wear limit
1	Piston skirt and cylinder liner	Shaft ϕ 102 $\begin{matrix} -0.140 \\ -0.170 \end{matrix}$ Holet ϕ 102 $\begin{matrix} +0.035 \\ 0 \end{matrix}$	0.140~0.205	0.50
2	The first compression ring and ring grave	Ring ϕ 3 $\begin{matrix} 0 \\ -0.015 \end{matrix}$ Gravet ϕ 3 $\begin{matrix} +0.100 \\ +0.008 \end{matrix}$	0.080~0.115	0.40
3	The second ring and ring grave	Ring ϕ 2.5 $\begin{matrix} 0 \\ -0.015 \end{matrix}$ Gravet ϕ 2.5 $\begin{matrix} +0.06 \\ +0.04 \end{matrix}$	0.040~0.075	0.30
4	Oil ring and ring grave	Ring ϕ 5 $\begin{matrix} 0 \\ -0.015 \end{matrix}$ Gravet ϕ 5 $\begin{matrix} +0.05 \\ +0.03 \end{matrix}$	0.030~0.065	0.25
5	Gap of the first compression ring in cylinder	Gauge within ϕ 102.00	0.25~0.50	3.00
6	Gap of the second compression ring in cylinder	Gauge within ϕ 102.00	0.20~0.045	3.00
7	Gap of oil compression ring in cylinder	Gauge within ϕ 102.00	0.20~0.045	3.00
Except these listed in the above table, all the others are the same as Model 495.				

Chapter II Main Construction, Adjustment and Maintenance of the Diesel Engine

1. Cylinder Block Assembly

Cylinder block is of a rectangle gantry type. Cylinder liners of wet type are fitted in the cylinder block and rested at its upper shoulder. The top surface of the liners should be higher than the top surface of the block 0.05–0.13mm.

The main bearing caps are located by locating sleeves and machined in pair with the corresponding bearing seats on the crankcase, so that the caps can't be interchanged or turned inside out. Therefore, the bearing cap is marked with number and arrowhead, and the direction of the arrowhead is forward. The main bearing is made of steel-backed aluminum alloy which is very thin, so it can't be lapped. Before assembly, adequate clean engine oil shall be applied on the crankshaft.

The two bolts on the same main bearing cap should be tightened evenly by many times step by step till regulated torque.

During engine operation, crankshaft shall be paid attention not putting on additional axial force.

2. Cylinder Head Assembly

Cylinder head is a single piece casting structure, with independent intake and exhaust ports on both sides. The combustion chamber of 495、K4100、K4102 model is whirl chamber, and there is an insert embed at the bottom; Turbocharged model is different, which shall be paid attention during repairing. There is a long slant injection hole and a small conical starting hole inside the insert. The small conical hole should be aligned with the nozzle center line during assembly. ZH4100、ZH4102 model is special direct injection cylinder head

Intake & exhaust valve and valve seat have been run-in when using, so remember the number of cylinder when disassembly and assembly. When sealing condition between valve and valve seat is not good, lapping is necessary, and should be cleaned before assembly. After long time operation, the width of valve seat contacting area may be over 2.5mm, we can ream the valve seat by means of a 15° and 75° special reamer with a guide rod of 9mm in diameter (Please refer to Fig. 1.) and 45° reamer articulated contact area when necessary (ZH4100 intake valve seat ring should adopt 60° reamer) . The valve seat must be renewed if the level of the valve head is lower than that of the cylinder head bottom surface by

more than 3.5mm after the valve seat being reconditioned. Before a new valve seat is pressed into the cylinder head, a interference of 0.086–0.150mm in diameter should be kept, and the cylinder head should be heated integrally to about 200 °C when assembly. Then the valve seat can be in-laid, and ream and lap it at the contact area to make it at 1.3–1.5mm in width, valve recession value is 1.2–1.6mm down.

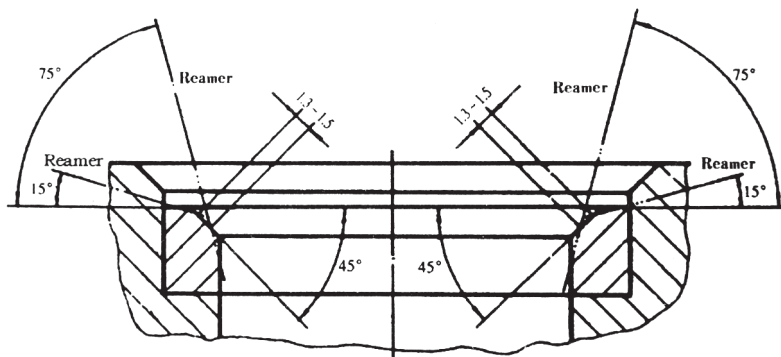


Fig. 1 Diagram of reconditioning valve seat

There are cylinder head gaskets between the cylinder and the cylinder block. And the cylinder head is fastened to the cylinder block by 18 bolts. The cylinder head bolts should be tightened evenly by three times one by one in regulated order and torque. (Please refer to Fig. 2.)

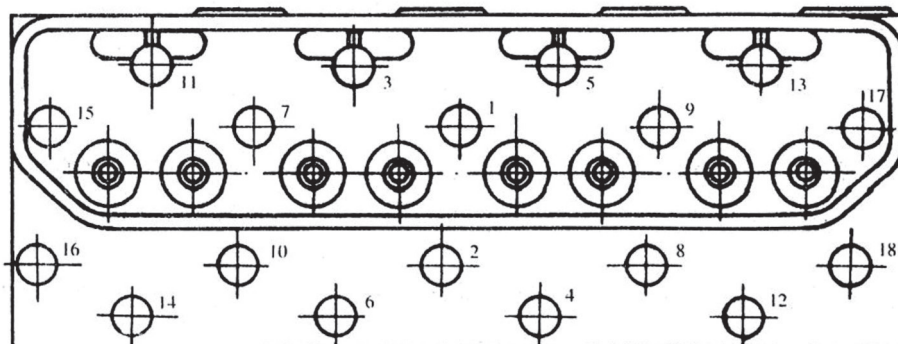


Fig. 2 The sequence of tightening cylinder head bolts

3. Piston and Connecting Rod Assembly

The piston and connecting rod assembly are constituted by piston, piston ring, piston pin, connecting rod, connecting rod bearing and connecting rod screw.

For 495,4100 model, each piston has three compression rings and one oil scraper ring. The first compression ring is barrel chrome-plate ring of modular cast iron, to improve the abrasive resistance under high temperature. The second ring is taper-face ring with the word "top" on the side which should be upward when assembled. The third compression ring is distorting ring. The side with distorting groove should be faced downward. The scraper ring is a component with inner spiral spring. As assembling scraper ring, the opening of the inner spiral spring maintaining reed should be at the opposite side of the opening of scraper ring. As assembling piston ring, first it should be put in cylinder liner, then be checked with clearance gauge to find out if the opening clearance is in the specified scope. If clearance is too small, repair with file. The three piston rings should be staggered 120° with each other, and meanwhile avoid the direction of piston pin hole. See Fig. 3. For 4102 model, each piston has two compression rings and one oil scraper ring.

The big end of connecting rod has a 45 ° inclined cut. Connecting rod body and connecting rod cap have marking numbers at same side. When assembled, the number must be registered. The small end of connecting rod has a copper bushing. The oil hole on the bushing should be right aligned to the oil gathering hole at the top of connecting rod small end, to lubricate piston pin and bushing. Connecting rod bolts are self-locked by friction force. The mass difference of connecting rod for one same diesel engine is less than 20g, and that of piston and connecting rod assembly for one same diesel engine is not bigger than 30g.

The connecting rod bearing is usually made of thin steel-backed aluminum alloy material, so it can't be lapped.

When we assembling the connecting rod, the short side on the 45° inclined face should be at the same side with the groove of the combustion chamber on the top of the piston. When the

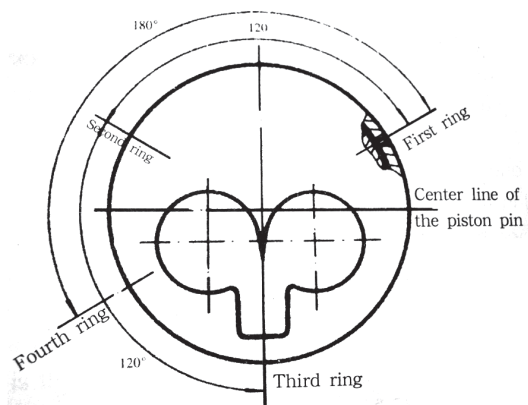


Fig. 3 The opening gap of piston rings in cylinder liner for 495

piston is installed in the cylinder liner, the combustion chamber should be at the same side with the nozzle.

4. Crankshaft And Flywheel Assembly

The crankshaft and the flywheel assembly is constituted by crankshaft, flywheel, crankshaft timing gear, crankshaft pulley and starting dog etc.

The crankshaft is made of modular cast iron and has four connecting rod shaft neck and five main shaft necks. All the surface of shaft necks is quenched or intruded, to improve the wearing resistance.

The front and rear end are sealed by skeleton structure rubber oil seal. There's a retainer ring installed in front of the oil seal to assure the seal liability.

Flywheel is positioned by dowel pin, and fastened on the rear end of crankshaft by six high strength bolts. Flywheel bolts should be tightened gradually according to the sequence shown in Fig. 4.

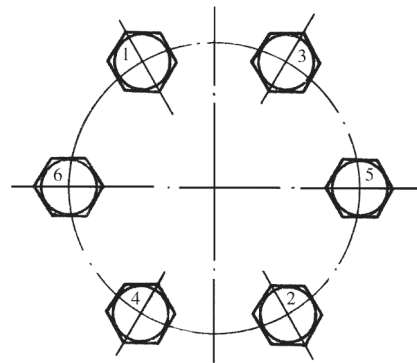


Fig. 4 The tighten sequence of flywheel

The outside of flywheel is marked TDC point, and also the scale range of 10–30° advanced. Each scale means 2° crankshaft angle of turn.

5. Intake & Exhaust System and Turbocharger

The turbocharger is of H1A, H2B or J65 type. In the process of using, the whirl shell and the vane groove of the turbocharger are easy to accumulate greasy dirt and charcoal, so we should clean them regularly.

According to the requirements of application, the air cleaner has K2007, K1317, KW1532, KW2410 and oil showering (Shanghai 495A) type etc. In the process of using, you mustn't discharge the air cleaner and air cleaner wick to avoid the early damage to the cylinder liner and other parts. The air cleaner should be maintained regularly.

According to the customers' requirements, we can install exhaust silencer before delivery.

IMPORTANT

- 1). The air cleaner element must be changed when damaged.
- 2). During maintenance, be sure not pollute the inside of the air cleaner element.
- 3). Do not run the engine without air cleaner or air cleaner element.

6. Fuel System

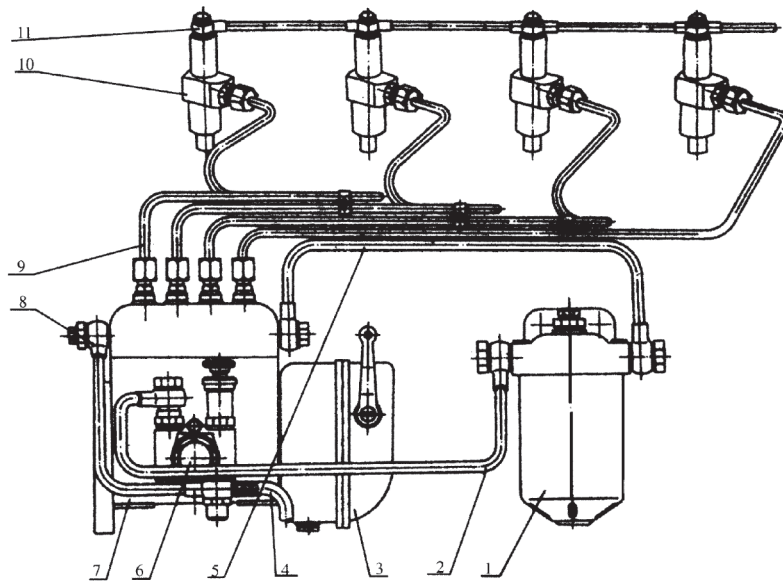
The fuel system consists of fuel tank, fuel delivery pump, fuel filter, fuel injection pump, governor, high pressure fuel pipe, injector and low pressure pipe etc. (Fig. 5).

According to the requirements of application, two kinds of fuel system have been designed: One is the extra fuel of the fuel pump enters into the inlet pipe through the fuel return valve and then the fuel delivery pump, and the fuel that the injector needle valve mate leaks flows back to the fuel tank through the fuel return pipe(Fig 5 a); the other is the extra fuel passes the fuel filter return valve with the fuel that the needle valve mate leaks flow back to the fuel tank together(Fig 5 b).

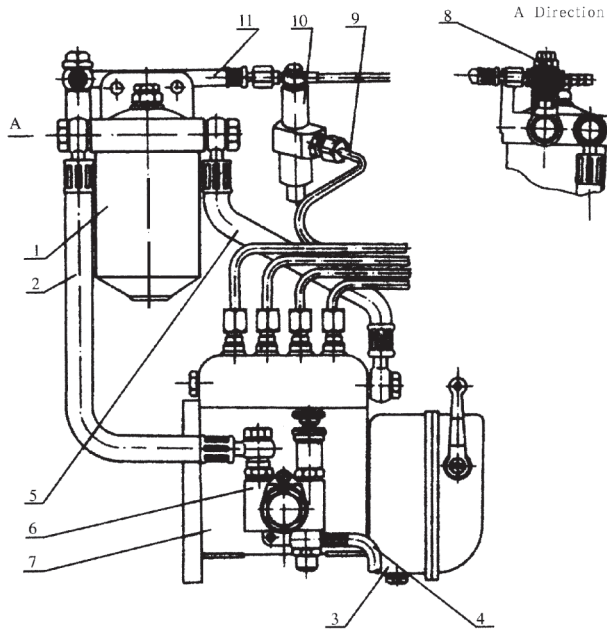
Fuel delivery pump is of a piston type. Use the hand press to make the fuel delivery system full of fuel and wipe off air before the engine starts. When the engine is not at working situation, the handle nut should be tightened.

The fuel filter is Model CXZ0708. It has two types: single class and double class, which can be chosen according to the requirements of application. The filter wick should be maintained regularly.

The fuel injection pump is of a four plunger pump. The governor is of a full range type. The governor has been adjusted to the best condition and lead sealed before delivery. The customers shouldn't adjust it privately.



a.Fuel injection pump fuel returning



b.Fuel filter fuel returning

Fig. 5 Fuel System

- 1.Fuel filter 2. Fuel filter inlet pipe 3. Governor 4. Fuel delivery pump inlet pipe
- 5. Fuel injection pump 6. Fuel delivery pump 7. Fuel injection pump
- 8. Return pipe 9. High pressure fuel pipe 10. Injector 11. Injector fuel return pipe

The fuel injection of injector should be atomized evenly after being sprayed, and the fuel stopping should be functioned at once, no fuel late drops or leakage. When the fuel atomized not well, the injector should be tested and adjusted on the injector test bench.

The needle valve mate is matched mate, never exchanged when dismantled.

When the injector is installed on the cylinder head, there is a copper washer on the front, this can assure the tightness.

7. Lubricating System

The engine is lubricated by pressure oil combined with splash oil, the layout of lubricating system is shown in Fig. 6. The fuel injection pump should be added engine oil separately.

IMPORTANT

When changing the engine oil, the oil filter element or oil filter should be changed at the same time.

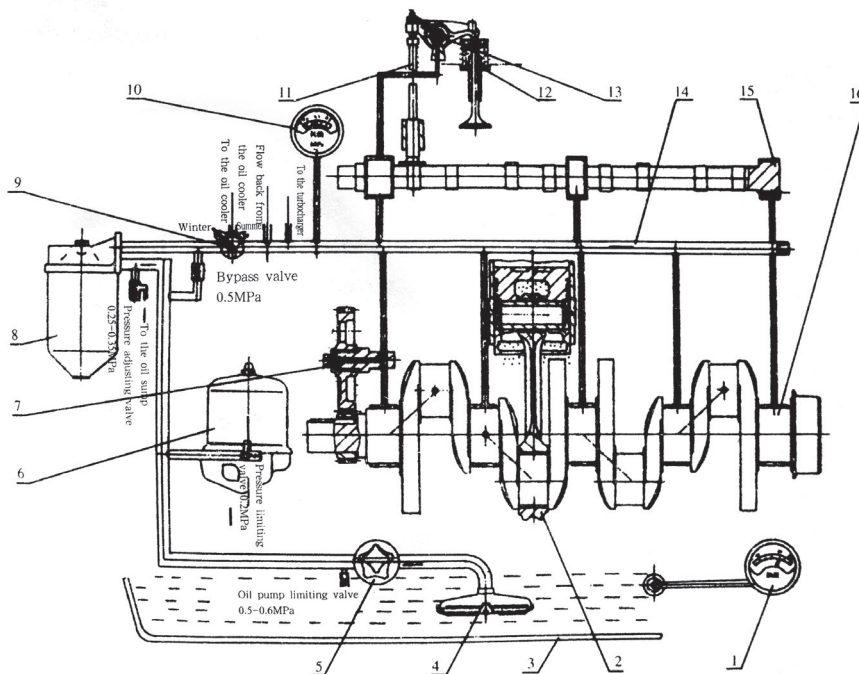


Fig. 6 Layout of lubricating system

1. Oil temperature gauge
2. Piston and connecting rod assembly
3. Oil sump
4. Sump strainer and oil suction pipe
5. Oil pump
6. Centrifugal bypass type oil filter
7. Idling gear shaft and bushing
8. Oil filter
9. Rotating valve
10. Oil pressure gauge
11. push rod, valve tappet and cylinder block valve tappet hole
12. Valve and valve guide
13. Rocker arm and its shaft
14. Main oil passage
15. Camshaft and bearing
16. Crankshaft and upper & lower main bearing

To low down the oil temperature, an engine oil radiator or cooler can be added to the diesel engine. There's a "Winter & Summer" valve on the connecting panel of the oil filter. When the oil temperature goes too high, we should turn the valve to "Summer" end, and when the oil temperature is normal, we should turn it to "Winter" end. The engine oil enters into the main oil passage through the oil filter without cooling.

The oil pump is gear type. There's a pressure limiting valve installed on the oil pump to control the oil pressure.

The oil filter is Model JXZ0810 on which a pressure adjusting valve is installed to adjust the oil pressure. There's also a bypass valve in the oil filter. When the oil filter or viscosity of the oil is too high, the bypass valve will open, and the oil will enters into the main oil passage without being filtered through oil cooler or filter to ensure the engine running safely. Customer shall not dismantle and adjust the bypass valve without authorization.

Turbocharged diesel engine has a model J0506 oil filter to filter the oil lubricating the turbocharger.

The oil filter wick should be maintained regularly.

8. Cooling System

The engine adopts close (or open) type forced circulation water cooling system, which consists of the radiator (or cooling pool), water pump, fan thermostat, cowling, water inlet and outlet hose etc.

The diesel engine adopts centrifugal water pump which is installed at the front of

the engine block and driven by the crankshaft belt wheel through the V belt. If find the water-relief hole dripping water seriously, you should change the water seal. The diesel engine adopts closed type integral radiator, which element is consist of radiation tube or flake in staggered pattern. Aluminum alloy plate-fin type water&oil radiator can also be adopted. Radiator of more than 14m² shall be met, if customers use their own.

9. Electric System

The electric system of the 495, 4100,4102 series diesel engine has two types: 12V and 24V, both of which are single wire system with negative pole grounded. The rated voltage of the motor and other electrical equipment must meet the voltage requirement of the electric system.

The battery for starting is a power device of the diesel engine, its performance influence the start of the diesel engine directly, suitable capacity battery should be chosen according to the starting motor's specific property. The battery should be installed near the starting motor so as to shorten the length of the cable between the battery and the starting motor to avoid the voltage drop too hard when the engine starting, the section area 36mm² low voltage connecting cable should be adopted.

When the staring current is highest, for 12V and 24V starting motor, the voltage drop should be less than 0.5V and 1V respectively.

The battery with the diesel engine hasn't been charged before delivery, it should be first charged as the battery's requirement before used. When the diesel engine is working, the amount of the charging current should often be noticed. When the needle of the ammeter is reaching to zero, or shows that the battery has been fully charged and the charging circuit can be switched off.

The diesel engine adopts the JF series silicon rectified charging alternator which has the characteristics of small volume, simple structure, good low-speed charging performance etc. It' s fitted with two units(3nos of each unit) of silicon rectifier element.AC current from 3P windings is converted to DC through full-wave bridge rectifier,and output via “+” terminal. During maintenance, it' s not allowed to check generation by earthing spark,or else rectifier will get burned.

The use of voltage regulator is to keep the voltage at the range of 13.5–14.5V or

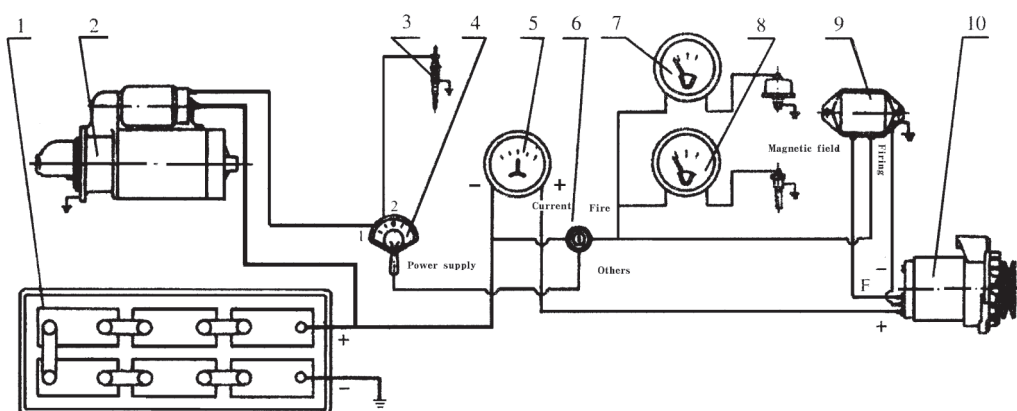
27–29V respectively when the speed of the 14V or 28V generators adopt FT111 or FT211 voltage regulator respectively. If the charging indicator is needed, the generators should adopt FT126 or FT226 voltage regulator. When the FT111 type and FT211 type regulators are used, the key switch should be turned off as soon as the engine stops in case the battery discharge to the magnetic coil and make the battery insufficient, this will influence the next starting.

The starting motor is full closed direct current series excitation motor. The working current of the starting motor is very large, it can only works within a short time, and every starting time can't exceeds 5s. if it's necessary to continuously start, the break shouldn't less than 2 minutes and shouldn't exceed 10 times in case the starting motor and the battery be damaged.

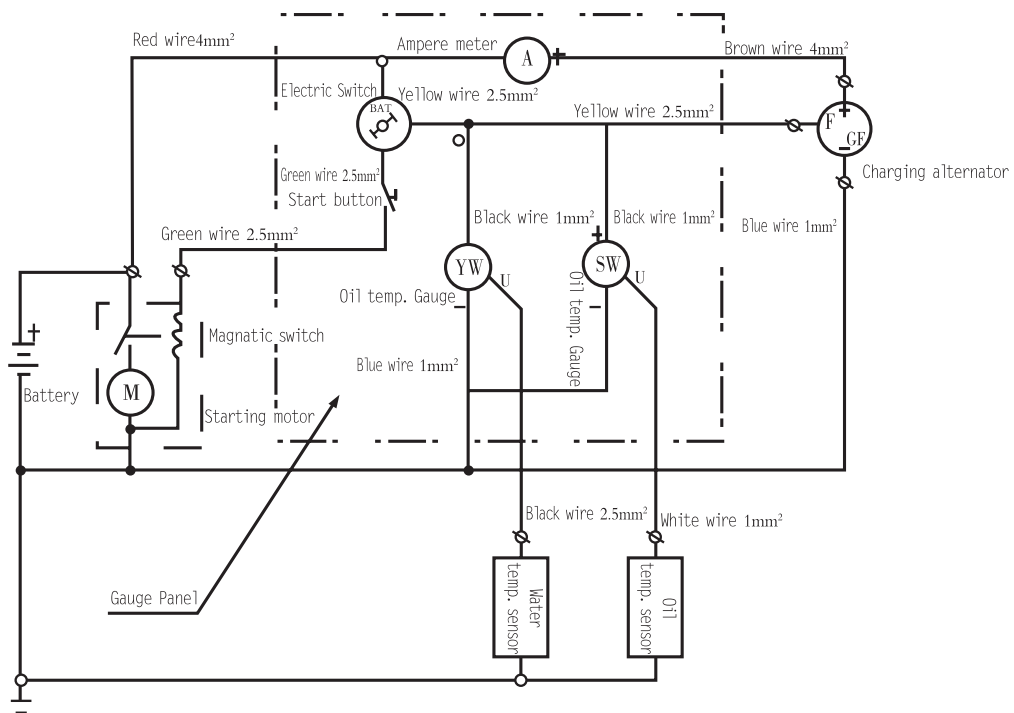
IMPORTANT

Some engine models are fitted with pre-heater, after power on with 30 seconds, the temperature inside swirl chamber will get upto 800–900oC, then engine can start. After engine starting, pre-heater power shall be cut off, or else it will get burned.

The key switch has three working positions, at the center position, the whole circuit will be turned off, turning the key clockwise, the preheating–starting switch, Voltage regulator and other electric equipment will all be switched on and the diesel engine will start. After the engine starts, the switch should be turned anticlockwise to the end to turn off the preheating–starting switch and in case of any trouble.



- 1. Battery
- 2. Starting motor
- 3. Electric plunger
- 4. Preheating–starting switch
- 5. Ammeter
- 6. Key switch
- 7. Pressure gauge
- 8. Temperature gauge
- 9. Voltage regulator
- 10. Silicon rectified generator



4102D Electrical diagram

10. Transmission System

The transmission system includes the common V belt transmission and the gear transmission in the gear housing. (Fig 8)

The crankshaft belt pulley drives the water pump belt pulley and the alternator belt pulley through the "B" type V belt. There are three different specification of belt length: B1168, B1143 and B1080 according to the different positions of the water pump and the alternator. Some engine models adopt AV17 or V belts for vehicles. The belt is tightened by the alternator adjusting frame. When we press the middle part of the V belt using the finger, 10–15mm should be pressed down.

The transmission gears are all slanted gears in which the crankshaft timing gear, camshaft timing gear, fuel pump gear and idling gear have timing mark. We should align the mark when installing, otherwise, it will affect the normal operation seriously for the incorrectness of fuel advance angle, and even can't start the engine.

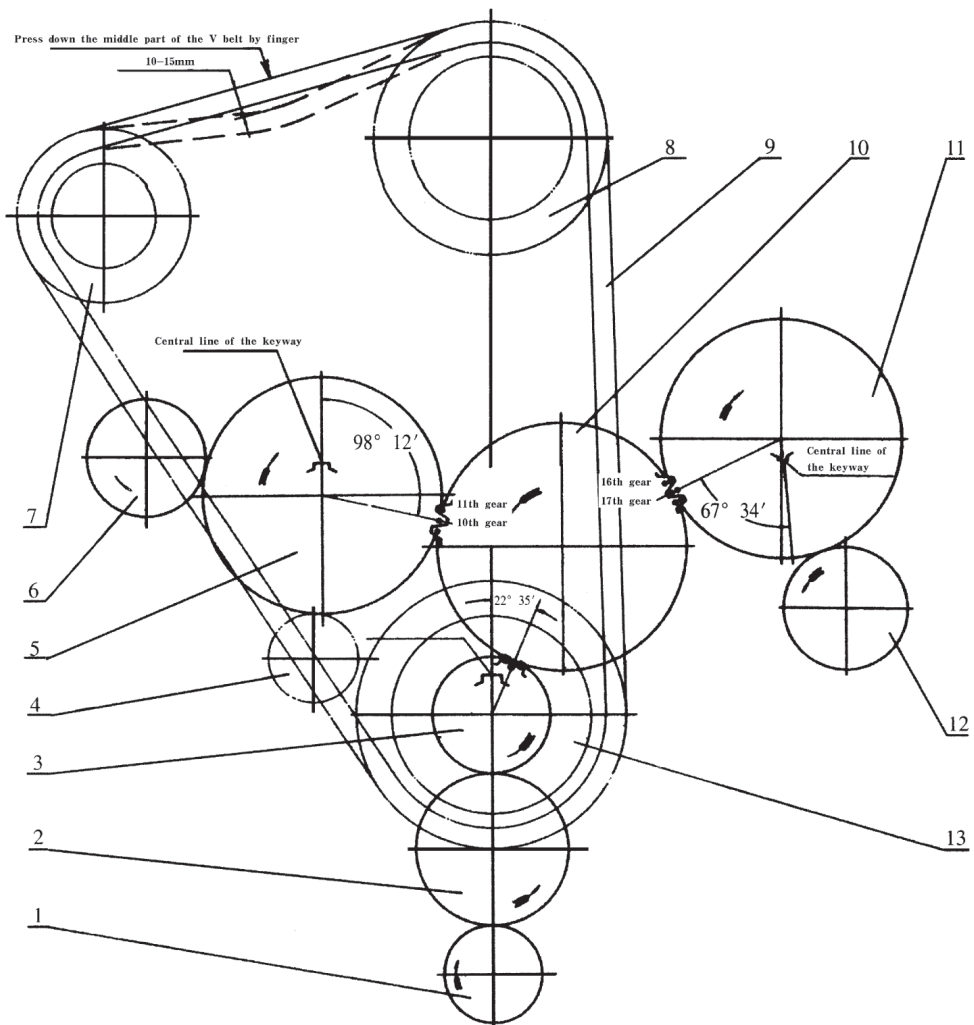


Fig. 8 Transmission system

1. Oil pump transmission gear ($Z=17$) 2. Oil pump middle gear ($Z=25$) 3. Crankshaft timing gear ($Z=20$) 4. Oil pump gear ($Z=16$) 5. Camshaft timing gear ($Z=40$) 6. Hydraulic pump gear ($Z=20$) 7. Alternator belt pulley 8. Water pump belt pulley 9. Common V belt 10. Idling gear 11. Fuel pump gear 12. Timing gear 13. Crankshaft belt pulley

11. Power Take Off Equipment

The diesel engine takes off power through the flywheel and clutch or flexible coupler. We can't adopt the rigid connection of belt pulley and flywheel in case the crankshaft subject to additional pressure to get broken.

495, K4100 adopt the dry, single piece and normal closed type clutch, which is shown in Fig. 9.

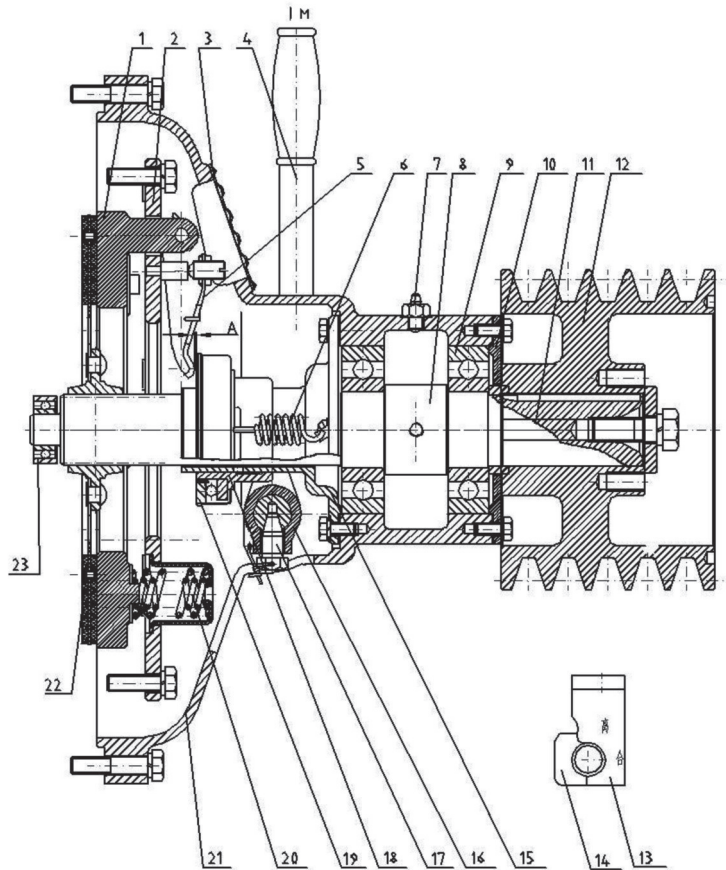


Fig. 9 Clutch assembly

1. Pressure disc
2. Supporting disc
3. Adjusting hole cover
4. Control lever
5. Release lever & adjusting bolt
6. Return spring
7. Adding oil lever
8. Bushing
9. Rotating shaft
10. Rear shaft cover
11. Take-out shaft
12. Belt pulley
13. Clutch board
14. Adaptor
15. Front shaft cover
16. Release yoke
17. Tightening bolt
18. Release shaft seat
19. Release bearing
20. Pressure big spring & pressure small spring
21. Clutch housing
22. Driven plate subassembly
23. Rotating shaft

A. The clearance between the release lever and the release shaft should be 3mm.

The diesel engine takes out power through flywheel, supporting disc, pressure disc

and driven plate putout shaft. A flat belt pulley, V-belt pulley or a coupler can be installed at the output shaft end.

The front end of the clutch output shaft is supported on the flywheel bearing, the rear end is supported on the two bearings inside the clutch housing. The release bearing and the seat are installed on the front bearing cover. There are three pulling ears on the pressure disc stretched out of the supporting disc, on which installed three release lever. When the control lever is moved forward, the release yoke pushes the release bearing move forward, the release bearing contacts the release lever, and press the lever to overcome the pressure of the spring and leave the driven plate, finally cut the power.

Operation of clutch:

1) Clutch shall be put “engaged” only when engine running less than 1500rpm. The action shall be slow, or else,engine will get heavy smoke for sudden load and even shutdown.The action of “disengaged” shall be quick,in order to avoid earlier damage of disk for slipping.

2) During engine running,its not allowed to let clutch “disengaged” for more than 15 seconds,in order to avoid earlier damage of release bearing.In winter during engine warming period,the stationary equipment shall be separated from engine,but the clutch shall be in “engaged” position.

3) During dismantling of clutch, friction disk,flywheel and compression disk shall not be stick with oil pollution.During assembling of clutch, spline shaft and flywheel center shall be concentrated, by positioning with centering shaft(accessory).Tighten the supporting plate to flywheel after friction disk being compressed.Take off the centering shaft and then assemble the clutch housing.

4) When adjusting clearance “A” between the release lever and release shaft, first open cover of adjusting hole, then unloose the screw,and adjust the position when the control lever at “engaged” .Clearance ” A” shall be 3mm,and the difference of 3 levers of “A” shall be within 0.2mm.

12. The Main Changed Parts of K4100 Diesel Engine

K4100 diesel engine is developed on the basis of 495 through cylinder expansion. The cylinder block, cylinder liner, water seal ring, cylinder cover gasket, piston and piston ring are newly designed. They can be in common use with 495 diesel engine.

13. The Main Changed Parts of ZH4100 Diesel Engine

ZH4100 diesel engine is developed on the basis of K4100 by the changing of direct injection. The main changed parts are cylinder head, fuel pump, injector, high

pressure pipe, inlet pipe, piston and piston ring etc.

14. The Main Changed Parts of K4102 Diesel Engine

K4102 diesel engine is developed on the basis of K4100 through cylinder expansion. The cylinder block, cylinder liner, water seal ring, piston and piston ring are newly designed. They can be in common use with K4100 diesel engine.

15. The Main Changed Parts of ZH4102 Diesel Engine

ZH4102 diesel engine is developed on the basis of K4102 by the changing of direct injection. The main changed parts are cylinder head, fuel pump, injector, high pressure pipe, inlet pipe, piston and piston ring etc.

CHAPTER III OPERATION OF THE DIESEL ENGINE

1. Transportation & installation

When the diesel engine is transported, the front and rear lifting hook should be used to lift the engine and close attention should be paid to protect the appearance, accessories and oil pipes of the diesel engine from being damaged.

If the diesel engine will be transported for a long distance, the air filter and silencer should be dismantled, use plugs and plastics to seal the air intake and exhaust hole, water pump inlet and outlet hole, fuel inlet and outlet hole. If necessary, use plastic cover and wooden case to pack the diesel engine.

If the diesel engine is used for stationary application, the foundation must be firm, the mounting surface must be kept horizontal, the driving equipment should conform to the requirement of stipulation, the working place should be spacious, well ventilated, clean and rain-proof.

2. Fuel, lubricating oil and cooling water

2.1 Fuel

The diesel engine should adopt different brand of light diesel oil according to the atmospheric temperature

Atmospheric temperature(°C):	>4	4~-5	-6~-14	-15~30
Brand of diesel fuel:	0	-10	-20	-35

The fuel oil must be kept very clean, before filling it into the fuel tank, you should clear the fuel oil for over 3 days so as to make the dust and water inside the oil precipitated to the bottom, then pick up the top clean fuel oil. The fuel oil must be strictly filtered when filled to the fuel tank.

2.2 Lubricating oil

The diesel engine should adopt different brand CF diesel engine lubricating oil according to different area and atmospheric temperature.

No	Quality Class	Viscosity Brand	Amb.Temp. (°C)
1	CF and above	30	5-30
2	CF and above	40	25 and above
3	CF and above	10W/30	-25~20
4	CF and above	15W/40	-20 and above
5	CF and above	20W/40	-15 and above

The lubricating oil must be filtered before it is filled into diesel engine, other brand lubricating oil is forbidden to be used for engine so as to protect the parts such as bearing and piston ring from being damaged.

IMPORTANT

It is not allowed to check oil level when engine is running.

Different brand of oil is not allowed for mixed use.

2.3 Cooling Water

The diesel engine should adopt clear soft water such as tap water, rain water and river water ,etc..If hard water is adopted such as well water and spring water which contains much more minerals, the hard water should be softened, otherwise there will be scale on the water passage of the engine and block the water, weaken the cooling effect and result in the engine too hot.

One of below methods can be used to soften water:

(1) boiled, precipitated and filtered before used.

(2) Fill 20g Na₃PO₃ on each 10kg water, precipitated and piston ring from being damaged.

When the temperature is below 0 °C , antifreeze mixture can be used for cooling medium.

When compound and fill the antifreeze mixture, pay attention to:

(1) The antifreeze mixture is poisonous, never drink it.

(2) test the volume of the antifreeze mixture each 25–30hrs, compensate it if not enough.

(3) The volume of antifreeze mixture should be 6% less than the water, because the antifreeze mixture preventive liquid will expand at high temperature.

IMPORTANT

When ambient temperature is lower than 5°C, cooling water shall be drained out after engine stopped.

If adopting anti-freeze mixture, check the concentration of the mixture timely, when temperature lower than 0°C.

3. Preparation for starting

3.1 Check and replenish the oil sump to keep the oil surface between the top and bottom carved line,

3.2 Check cooling system and fill up cooling water

3.3 Check fuel level in tank.

3.4 Open the switch of the fuel tank, check the fuel system for leakage and eliminate it if there is any.

3.5 Check the battery be sufficient or not, connect the battery to the circuit and see whether it is electrified.

4. Starting

The diesel engine shouldn't be started until the preparation is completed and meets the requirement. When starting, the clutch should be apart, operate as following steps:

4.1 Set the control handle of the fuel valve to the position where the fuel will be delivered rather more.

4.2 Turn the pressure releasing lever to starting pressure release position (In summer or longtime no stop, it's also ok no releasing). Direct injection engine is not applicable.

4.3 Turn the circuit switch clockwise and close the circuit.

4.4 Turn the starting switch to the "starting position", after the crankshaft is speeded up by the starting motor, switch back the pressure release lever, the engine is started then.

4.5 When ambient temperature is very low, engine with pre-heater can be used for pre-heating start.

- 1) Operate as step of 4.1, 4.2, 4.3
- 2) Turn key to “Pre-heat” , keep 40–50seconds for heating.
- 3) Operate as step of 4.4

4.6 For the protection of the starting motor and battery,the starting time shouldn't exceed 5s. If need to start continuously, the interval time should be more than 2min.If can't start for continuous 3 times, then don't start until the trouble is found out and eliminated.

4.7 As soon as the engine starts. Set the control handle of the fuel valve to the idel speed position,turn the circuit key switch counterclockwise to the charging position.

4.8 Check the oil pressure after the engine starts, the oil pressure in ilde speed never be lower than 0.05mpa. After the engine starts for 5min, stop it and wait for 15 min, check the surface of the oil when the oil flows back to the oil sump, if necessary, add oil to the required level.

5. Running

5.1 After being started, the engine shouldn't operator at full load immediately. It should be warmed up at low speed without load, only after the temperature of the cooling water reaches to 60°C , it can be speeded up to the highest speed and operates at full load.

5.2 When operating, the engine's speed and load should be increased and decreased gradually. In general, shouldn't increase or decrease rapidly.

5.3 When the engine is working, should often pay attention to oil pressure, oil temperature, cooling water temperature, charging current, should also observe the color of the exhaust smoke, listen attentively to the voice inside. If any trouble such as overheating, black smoking, knock and others, should stop the engine to check and remedy immediately. It is forbidden to let the engine operatewith trouble so as to prevent the engine parts from being damaged.

5.4 When the engine working, often pay attention to the oil passage, water passage and union joint, if any leakage, should remedy it at once so as to avoid waste and pollution to the environment.

5.5 For new or just overhauled engine,it is permitted to run af full olad only after it has worked for over 60h.

5.6 It is forbidden to let the engine running at idle speed for a long time.

5.7 The injection pump has been adjusted rightly before leaving factory, it is forbidden for users to change it at will. If necessary, it should be adjusted at the

injection pump equipment.

6. Stopping

6.1 Before stopping the engine, unload first, decrease the engine to the idling speed gradually, when the water temperature falls down below 70°C, turn the stopping lever to stop. After the engine stops, take out the switch key and close the fuel tank valve.

6.2 It is forbidden to stop the engine suddenly at high water temperature.

6.3 It is not permitted to stop the engine by shutting off the valve of the fuel tank so as to preventing the air from entering into the oil passage.

6.4 When it is below 5°C, if the antifreeze mixture is not used, should drain off the cooling water so as to avoid the cylinder block and water pump being frost crack.

6.5 The found trouble should be remedied after every stopping, and should often check the engine.

6.6 In case

7. Safe and technical operating instruction

7.1 It's forbidden to let the person who don't know the operating technique to operate the engine.

7.2 The engine can be started only after all the starting preparation has been completed.

7.3 Pay close attention to prevent fire, it's forbidden to let the naked flame near the working engine. If the engine is working beside inflammable substance, a fire extinguisher system should be installed on the exhaust manifold.

7.4 When the engine is working, never to dismantle or adjust, the operator don't leave the working site.

7.5 It's forbidden to let the engine working under no oil pressure, low oil pressure or with abnormal noise inside. If you meet with these cases, the engine should be stopped urgently.

7.6 If the engine happens to be over-speed, you should turn the stopping handle to stop it to have a check. If the stopping handle malfunctions, you can stop the engine with the method of plugging up the air inlet hole.

CHAPTER IV Technique maintenance of the diesel engine

Periodic technique maintenance is an important content of using engine normally, in order to remain the engine in good technique state and to prolong its service life, the technique maintenance system must be seriously performed as standard.

The maintenance of the engine is classified as follows:

- 1) Working day maintenance(per 8–10h)
- 2) First grade technique maintenance (accumulative working hours:50h;or for the cargo vehicle,traveling distance over 2500km)
- 3) Second grade technique maintenance (accumulative working hours: 250h; or for the cargo vehicle, traveling distance over 12500km)
- 4) Third grade technique maintenance (accumulative working hours: 1000h; or for the cargo vehicle, traveling distance over 50000km)
- 5) Technique maintenance on winter use.

1.Working day maintenance

1.1 Check the oil surface in the oil sump, oil bath type air filter and the power output gear box, if the oil surface is higher, find out the trouble and eliminate it; if the oil is insufficient, the refill it to the required amount.

1.2 Check the cooling water surface in the water tank ,if insufficient, fill it up .If the air temperature will be under +5°C ,then drain off the cooling water after stopping.

1.3 Check and fasten the shown bolt and nut, eliminate the leak of oil, water and air.

1.4 During working at the dusty place, use the compressed air to clean the air filter element. And if necessary, replace the filter accordingly

1.5 Clean the mud, dust and oil dirt on the appearance of the engine.

1.6 When the engine is working, listen to the voice, observe the smoke color and eliminate the trouble and abnormal appearance.

2. First grade technique maintenance

2.1 Perform the items on the “working day maintenance”

2.2 Clean the dust on the air filter element and inside the dust deposit set.Replace the oil inside the oilbath type air filter.

2.3 Check and adjust the tension of the fan belt.

- 2.4 Fill the lubricating grease into the weater pump bearing.
- 2.5 Check all parts of the engine,to do the necessary adjustment if need.
- 2.6 when the maintenance is finished,start the engine and test it's working appearance,eliminate the trouble and abnormal appearance.

3.Second grade technique maintenance.

- 3.1 Perform the items on the “first grade technique maintenance”
- 3.2 Replace the oil,clean the oil sump and the oil strainer, replace the filter cartridge.
- 3.3 Replace the oil in the fuel injection pump.
- 3.4 Clean the fuel tank,oil delivery pump screen and pipe. Replace the fuel filter cartridge every two maintenance period.
- 3.5 If the engine is turbocharged type, then clean the cave and propeller impeller of the turbocharger air pump, and also check the moving and fasten parts.
- 3.6 Blow off the dust inside the charging alternator with compressed air. Check all parts, eliminate and abnormal parts.
- 3.7 Check and adjust the valve gap and lift of pressure releasing shaft.
- 3.8 Check the injecting open pressure and it's spray quality of the injector, if needed, adjust it.
- 3.9 Fill the lubricating grease to the filling boles of the clutch, check the gap between the releasing lever and the releasing bearing and adjust accordingly.

4. Third grade technique maintenance

- 4.1 Perform the full items on the “second grade technique maintenance” .
- 4.2 Clean the cooling system,wipe off the scale.
- 4.3 Clean the oil cooler.
- 4.4 Replace the air filter element.
- 4.5 Dismantle and check the cylinder head.Test the valve seal,wipe off the carbon deposit, lap the valve according the conditions.
- 4.6 Check the fasten situation of the cylinder head bolt,main bearing bolt, connecting rod bolt. For the bolts which tightening torque is insufficient,then tighten it to the set point value.
- 4.7 Check the water pump, replace the lubricating grease,if necessary,replace the water seal.
- 4.8 Check the charging alternator, starting motor, clean, repair and fill new lubrication grease.
- 4.9 Check the injection pump, adjust the fuel advance angle, and adjust the injection

pump according to the conditions.

4.10 Check the clutch, clean the inside dust deposit, oil dirt, and replace the lubricating grease.

4.11 Check the turbocharger, wipe off the carbon deposit, and test the rotor slipping allowance.

4.12 Check the air compressor, lap the valve according to the situation, and clean the carbon deposit.

5. Technique maintenance on winter using

If the temperature may be lower than 5°C , the engine must be maintained specially.

5.1 Must use the winter used oil and fuel, note the damp in the fuel so as to protect the fuel passage from being jammed.

5.2 It's better to fill the antifreeze fluid to the cooling system, or must drain off the cooling water after its temperature is lower than $40-50^{\circ}\text{C}$.

5.3 On the cold season or area, it's better to prevent the diesel engine (or vehicle) from being deposit in the open air, or when starting, it's need to heat the cooling water to preheat the engine body.

CHAPTER V Troubleshooting

1. Start failures

Trouble cause and its feature

1.1 Troubles in fuel system

- (1) Jammed in the fuels
- (2) Air trapped in the fuel system
- (3) Delivery pump fails in delivering fuel or delivers brokenly
- (4) Injector sprays abnormally
- (5) Fuel timing is wrong

Remedy

- (1) Dismantle and clean
- (2) Vent the air from the system with the fuel delivery pump, check whether there is leakage of fuel and air in the fuel pipes
- (3) Check and repair
- (4) Check and adjust or replace the needle valve mate
- (5) Check and adjust

1.2 insufficient compress pressure

- (1) Piston ring and cylinder liner wear
- (2) Piston ring carbon deposition
- (3) Valve leaks
- (4) Temperature is low after end of compression

1.2

- (1) Check and replace worn parts
- (2) Clear off carbon deposition
- (3) Valve spring broken or elasticity weakens, valve lash is incorrect, valve seal is not good, eliminate the fault.
- (4) Environmental temperature is low, use preheat starting method

1.3 Trouble in electric devices

- (1) Battery is insufficient
- (2) Connecting of electric devices is not good
- (3) Starting motor no rotation or rotates insufficiently
- (4) Gear of starting motor cant engage the flywheel gear-rim

1.3

- (1) Recharging the battery to the specified point
- (2) Check the tighten of the connection
- (3) Check the starting motor
- (4) Find out the fault and eliminate it

2. Unsteady running of the engine

Trouble cause and its feature

- (1) Fault in fuel system
- (2) Too much water in fuel
- (3) Leakage in fuel passage

Remedy

- (1) Handle according to the (1),(2)(3),(4) in the 1.1
- (2) check the dampness in the fuel
- (3) Check and eliminate the fault

- (4) Governor works abnormally
- (5) Cylinder blows by
- (6) Uneven fuel delivery to each cylinder
- ① Uneven fuel delivery to each cylinder in injection pump
- ② Injector sprays not well or the mate be choked
- ③ The plunger of the injection pump worn out or the spring broken

- (4) Check and adjust the governor
- (5) Check the tightening torque of the cylinder head bolt and the seal of the cylinder head gasket
- ① Check and adjust
- ② Check the spray quality of the injector, replace the mate if necessary
- ③ Check and replace

3. Output is insufficient or drops suddenly

Trouble cause and its feature

- (1) Air filter choked
- (2) Valve spring or push rod broken
- (3) Valve lash is incorrect
- (4) Compress pressure is insufficient
- (5) Fuel delivery advance angle is incorrect
- (6) Air trapped in the fuel system or the system is choked
- (7) Fuel delivery is insufficient
- (8) Injector spray not well
- (9) Governotr works abnormally
- (10) Engine overbeated
- (11) Too much carbon deposited inside the engine
- (12) Exhaust manifold not expedite

Remedy

- (1) Clean or replace filter element
- (2) Check and replace
- (3) Check and adjust
- (4) Handle according to 1.2
- (5) Check and adjust
- (6) Handle a ccoyding to (1),(2),(3) in 1.1
- (7) Check the plunger of the injection pump and fuel outlet valve
- (8) Check, clean and adjust the pressure
- (9) Test and repair the governor
- (10) Test and repair thd cooling system, wipe off the scale
- (11) Clean off the carbon deposit
- (12) Find out the fault and eliminate it.

4. Abnormal noise during engine operation

Trouble cause and its feature

- (1) Injecting time is too early to cause the rhythmic and clear metallic pounding noise be heard inside the

Remedy

- (1) Adjust the fuel delivery advance

cylinder.

(2) Injecting time is too late to cause the grave and unclear noise is heard inside the cylinder.

(3) Pounding noise can be heard inside the cylinder after the engine starts because of too large gap between the piston and cylinder liner, this noise gets lower along with the warming of the engine.

(4) Too large clearance between the piston pin and pinhole, clear and sharp sound, especially when idling.

(5) Too large clearance between the main bearing and the con-rod bearing, parts pounding sound is heard when the engine speed drops suddenly, grave and strong sound when at low speed.

(6) The axle gap of the crankshaft is too large, pounding noise when idling.

(7) Valve spring broken, push rod bent, valve clearance too large and so on, disorderly sound or light and rhythmic pounding sound be heard inside the cylinder head cover.

(8) Piston touches valve, metallic pounding sound can be heard beside the cylinder head

(9) Too large gear clearance, pounding sound is heard at the gear case when the speed

(2) Adjust the fuel delivery advance angle

(3) Check the cylinder clearance, replace the piston or cylinder liner

(4) Replace the parts, assure the stipulated gap

(5) Replace the parts, assure the stipulated gap

(6) Replace the thrust plate, assure stipulated gap

(7) Replace the parts, adjust valve gap

(8) Check valve clearance and transmitting gear mark

(9) Test the gear back lash, replace gear according to the situation

5. Abnormal exhaust smoke

When the engine works normally, the smoke color is light grey, when the load is higher at low time, its color is only dark grey, when the exhaust smoke is blue, white or black, then the smoke color is abnormal. Blue means burning oil; white means fuel

fog no burns thoroughly inside the cylinder or water trapped inside the cylinder;black means injecting fuel too much to burns thoroughly. Trouble cause and its feature.

5.1 Blue smoke

- (1) Lubricating oil flees,piston ring installed inversely,choked or worn out to badly
- (2) Clearance between valve and pipe hole too large

Remedy

- (1) Check piston ring and eliminate the fault
- (2) Replace the parts and assure the stipulated lash

5.2 White smoke

- (1) Fuel spray be atomized not well, fuel drips
- (2) too much water trapped in the fuel
- (3)Water trapped in the cylinder

Remedy

- (1) Check the injection pressure and the seal of the mate,adjust and clean or replace
- (2) Test the fuel quality
Inspect seal of the cylinder
- (3)gasket,check the water leakage of the cylinder head and cylinder liner,repair or replace

5.3 Black smoke

- (1) Engine is ouer-loaded
- (2) Fuel sprays too much
- (3) Injecting time is too late,late burning is heavy
- (4) Valve lash is incorrect or valve seal is not good
- (5) Air filter choked

Remedy

- (1) Adjust to the stipulated load
- (2) Adjust the fuel delivery amount of the fuel injection pump
- (3) Adjust the fuel delivery advance angle
- (4) Adjust the valve lash and seal,eliminate the fault
- (5) Clean the filter element

6.Insufficient oil pressure

Trouble cause and its feature

- (1) Oil pressure gauge is in trouble or the connecting pipe choked
- (2) Too little oil in the sump
- (3) Too thin oil
- (4) Oil pump driving and driven gear

Remedy

- (1) Replace the pressure gauge or dredge the passage
- (2) Fill oil to the stipulated level
- (3) Inspect oil grade,check whether the oil be thinned out with fuel or oil temperature too high,eliminate it

worn out
 (5) Strainer screen and oil filter element blocked
 (6) Pressure limiting valve and pressure regulating valve spring broken
 (7) Oil passage choked or oil leaks
 (8) Lash between the bearings too large

(4) Replace driveing and driven gear
 (5) Clean or replace
 (6) Inspect and replace
 (7) Check and eliminate
 (8) Test the matching lash

7. Oil temperature too high
 Trouble cause and its feature
 (1) Engine is over-loaded
 (2) oil is insufficient or overmuch
 (3) Piston ring leaks heavily
 (4) Oil cooler choked inside, dirt deposited outside, influence the heat radiating efficiency

Remedy
 (1) Adjust the load
 (2) Add or reduce the oil according the stipulation
 (3) Replace piston ring or cylinder liner
 (4) Check and clean

8. The temperature of used cooling water too high
 Trouble cause and its feature
 (1) Water temperature gauge or inductor be in trouble
 (2) Cooling water is not enough
 (3) Flow of cooling water is too small
 ① Flow of water pump is too small
 ② Too much scale deposit inside the engine
 (4) The efficiency of radiator is not well
 (5) Engine is over-loadedp

Remedy
 (1) Inspect and replace
 (2) Fill cooling water and get rid of the air from the water passage
 (3) ① Check the lash of the water impellers, adjust the tension of the fan belt
 ②)Wipe off the scale deposit
 (4) Clean off the dirt and ecale deposit
 (5) Adjust to the stipulated load

9. Trouble in the injection pump
 Trouble cause and its features
 (1) No fuel delivery
 ① Fuel delivery pump is out of order
 ② Fuel filter or fuel passage is choked

Remedy
 (1)
 ① Process according to 10
 ② Clean or replace
 ③ Clear of air

- ③ Air trapped in fuel passage
- ④ Fuel outlet Valve Spring broken
- (2) Fuel delivery uneven
- ① Air trapped in fuel passage
- ② Fuel outlet valve spring broken
- ③ Seal face and outer face worn out
- ④ Plunger mate worn out or spring
- ⑤ Plunger choked with impurity
- ⑥ Pressure of inlet fuel is uneven
- (3) Insufficient fuel delivery
- ① Fuel cock leaks
- ② Connector of fuel pipe leaks
- ③ Plunger worn out

- ④ Replace spring
- (2)
- ① Wipe off air
- ② Replace spring
- ③ Repair or replace
- ④ Replace parts
- ⑤ Clean
- ⑥ Inspect fuel delivery pump and filter
- (3)
- ① Replace parts
- ② Tighten the connector
- ③ Replace parts

10. Insufficient fuel supply of the fuel delivery pump

- (1) Non–return spring broken or seal of the valve seat is not good
- (2) Piston worn out
- (3) Fuel inlet pipe leaks or choked

Remedy

- (1) Replace spring or repair no–return valve
- (2) Replace piston
- (3) Check the seal of the pipes, tighten the screw, dredge the pipes

11. Injector malfunction

Trouble cause and its feature

- (1) Spray less or no spray
- ① Air trapped in the fuel passage
- ② Needle is blocked
- ③ Loose combination of the needle valve with valve body
- ④ Heavy leakage in fuel system
- ⑤ Abnormal fuel supply of the injection pump
- (2) Injecting pressure is low
- ① Pressure adjusting spring get aging
- ② Spring broken
- (3) Too high injecting pressure

Remedy

- (1)
- ① Blow off air
- ② Repairing or replace
- ③ Replace
- ④ Tighten connector or replace parts
- ⑤ Inspect fuel supply of the injection pump
- (2)
- ① Adjust or replace suitable spring
- ② Replace
- (3)

① Needle valve blocked	① Clean or replace
② Injecting hole choked	② Clean
③ Pressure adjusting spring is improper	③ Adjust
(4) Too much of fuel leakage	(4)
① Pressure adjusting spring is broken	① Replace
② Needle valve seal is improper	② Repair or replace
③ Needle valve blocked	③ Clean or replace
④ Pressing cap is loose or distorted	④ Tighten,replace parts
⑤ Fuel inlet and outlet connector screw is loose	⑤ Tighten,replace parts
(5)Fuel atomized not well	(5)
① Needle valve is distorted or worn out	① Replace
② Bad seal of the needle valve	② Repair or replace
③ Spray hole blocked	③ Clean
④ Needle valve blocked	④ Clean or replace

12. Governor malfunction	Remedy
Trouble cause and its feature	(1)
(1)Unsteady speed	① check fuel pump
① Cylinders fuel supply uneven	② check injector
② Injector blocked or bad spray	③ check and repair
③ tooth rod get stuck	(2)
(2) Too high idling speed	① Inspect and adjust
① Operating handle lever no reaches its position	② Readjust or repair
② Tooth rod get stuck	(3)
(3) Speed hunting	① Replace the speed adjusted spring
① Speed adjusted spring distorted	② Check and tighten
② Fly hammer assembly loosen	③ Repair and eliminate
③ Too large friction resistance inside the governor	④ Readjust
④ Too Large axile lash of the injection pump camshaft	(4)
(4) Overrunning of the engine	① check and repair
① Adjusting arm loose or get stuck	② Check and replace
② Lubricated not well, shaft & sleeve burned	③ adjust the stroke
③ Short stroke of tooth rod	④ check and tighten
④ Fly hammer assembly loosen	

13. Engine stops suddenly

Trouble cause and its features

(1) Crankshaft can't be rotated after the engine stops

① Crankshaft seized with bushing

② Piston seized with cylinder liner

(2) Crankshaft can be rotated easily

① Air trapped in fuel system

② Fuel system choked

③ Air filter choked

Remedy

(1)

① Inspect,replace parts

② Inspect,replace parts

(2)

① Blow out air

② Clean

③ Maintenance the air filter

14. Charged charging alternator out of order

Trouble cause and its feature

(1) Can't be charged at all

① Open circuit or short circuit,,circuit connecting wrong

② Charging alternator claw loosened,rotor circuit opened,brush contacted badly

③ Charging alternator silicon parts out of order

(2) Insufficient charging or charging unsteadily

① Brush contacts badly,insufficient spring pressure,oil dirt on slip ring

② Transmitting V-belt loosened

③ Some silicon parts open circuited[

(3) Abnormal sound when working

① Charging alternator bearing worn out

② Installed improperly

③ Short circuit inside the stator coil or parts short circuited

Remedy

(1)

① Check the circuit connecting

② Repair or check

③ Replace

(2)

① Check and repair

② Adjust the tension of V-belt

③ Replace

(3)

① Replace

② Adjust

③ Repair

15. Starting motor malfunction

Trouble cause and its feature

(1) Starting motor no works

① Connecting electric wire contacts badly

② Insufficient charging of the battery

③ Brush contacts badly

④ Open circuited inside the starting motor itself

(2) Starting motor rotates weakly

① Bearing bush worn out

② Brush contacted badly

③ Connecting electric wire contacted badly

④ Switch contacted badly

⑤ Insufficient charging of the battery or its capacity is too small

⑥ Clutch clips

(3) Gear returns hardly

① Switch contacting slice burning out and cemented

Remedy

(1)

① Clean and tighten the contacting point

② Recharging

③ Clean the contacting surface of the commutator

④ Repair

(2)

① Replace bearing bush

② Clean the contacting surface of the commutator

③ Clean and tighten the contacting point

④ Inspect switch

⑤ Recharging or replace large capacity battery

⑥ Repair clutch

(3)

① Repair switch

16. Governor in trouble

Trouble cause and its feature

(1) No generating electricity at all

① Too low of regulating voltage

② Connecting wrong

③ Relay coil worn out, contacting point contacted badly

(2) Charging insufficiently or unsteadily

① Too low of adjusting voltage

② Too dirty of contacting point

(3) Overcharge

① Adjusting voltage too high or unadjusted, uncontrolled

Remedy

(1)

① Inspect and adjust

② Inspect the connecting

③ Repair

(2)

① Inspect and adjust

② Clean

(3)

① Inspect and adjust

17. Turbocharger in trouble

Trouble cause and its feature

Remedy

(1) Engine output drops

(1)

① Passage of air filter or air pump dirty

① Clean

② Leakage at the connector of the air pump body

② tighten

③ Leakage at the air inlet connector

③ Tighten

④ Air inlet passage of the turbine be choked or dirty

④ Clean

⑤ Floating bearing worn out

⑤ Replace

(2) Black or blue smoke

(2)

① Passage of air filter or air pump dirty

① Clean

② Altitude or temperature too high

② Adjust output

③ Fuel return pipe of the turbocharger choked

③ Wipe out

(3) Abnormal noise inside the turbocharger

(3)

① Pounding sound

① Check and repair

② Foreign matter enters into impeller or impeller be worn out

② Dismantle,inspect and repair

③ Seal ring burned out

③ Replace

(4) Rotor rotates not flexibly

(4)

① Leakage of turbocharger causes carbon deposited

① Clean

② Floating bearing worn out

② Replace

③ Over-heating causes parts be transmuted

③ Replace

④ Precision of running balance too low

④ Replace

18. Air compressor in trouble

Trouble cause and its feature

Remedy

(1) Efficiency gets worse because of carbon deposited on exhaust valve, valve spring broken or cylinder liner worn out

(1) Clean off carbon deposit,replace parts

(2) Oil mixes because of piston ring broken,cylinder liner worn out or oil

(2) Clean and repair,replace parts

return pipe choked

(3) Abnormal sound can be heard when working because of shaft and bearing worn out or piston touches cylinder head

(3) Check and repair, clean off carbon deposit, replace parts.

19. Clutch in trouble

Trouble cause and its feature

(1) Clutch slips

- ① Oil dirt on friction disc
- ② Compress spring get aging or broken
- ③ Small clearance between releasing lever and releasing bearing
- ④ Driven plate distorted or uneven wearing or over wearing

(2) Clutch disconnects not completely

- ① Control lever working stroke too short
- ② Driven plate distorted or uneven wearing or over wearing
- ③ Three releasing lever are not in the same plane
- ④ Friction disk worn out

(3) Vibration noise are inside the clutch

- ① Compressing spring worn out
- ② Releasing bearing worn out
- ③ Driven plate spline hole or clutch output spline shaft worn out
- ④ Clutch output shaft bearing worn out

Remedy

(1)

- ① Clean off oil dirt on the friction disc with gasoline oil
- ② Replace
- ③ Adjust as per regulation
- ④ Correct or replace the driven plate

(2)

- ① Adjust as per regulation
- ② Correct or replace the driven plate
- ③ Adjust as per regulation
- ④ Replace

(3)

- ① Replace
- ② Replace
- ③ Replace driven plate or clutch output shaft
- ④ Replace bearing

APPENDIX:

The wearing in of the diesel engine

The time of wearing in should not less than 60 hours. The load and time of wearing in is as follows:

Load	Operation time	
Idling speed	10 minutes	
25%	2 h	
50%	15 h	Check the pressure of lubricating oil and whether there is abnormal noise etc.
75%	30 h	
100%	15 h	

During the period of wearing in, the throttle should be fully opened. The load numeral value can be gained according to the load estimation of the matched belt, however, we must obey the principle of increasing load gradually from low load.

Due to the different fitting machines, such as tractors, vehicles, construction machines, generating sets and harvesters etc., the wearing in should meet the different requirements for the usage.

Attached:Table (1)

Engine shall be specially designed and matched for equipment if it working in areas with special environment conditions ,like altitude higher than 1000m, or ambient temperature higher than 45°C ; Engine shall not be directly bought and used. In common area, along with variation of altitude and ambient temperature, engine power will get affected to some extent. Details refer to attached table as following.

Table-Power Correction Factor

Correction Factor of Natural Aspirated Engine with RH 30%

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

Correction Factor of Natural Aspirated Engine with RH 100%

Altitude m	Amb.Pressure		Amb.Temp. °C									
	kPa	mmHg	0	5	10	15	20	25	30	35	40	45
100	100.0	750	—	—	—	—	1.00	0.97	0.95	0.92	0.89	0.85
200	98.9	742	—	—	—	—	0.99	0.96	0.94	0.91	0.87	0.84
400	96.7	725	—	—	1.00	0.98	0.96	0.94	0.91	0.88	0.85	0.81
600	94.4	708	—	0.99	0.97	0.95	0.93	0.91	0.88	0.85	0.82	0.79
800	92.1	691	0.99	0.97	0.95	0.93	0.91	0.88	0.86	0.83	0.80	0.76
1000	89.9	674	0.96	0.94	0.92	0.90	0.88	0.86	0.83	0.80	0.77	0.74
1200	87.7	658	0.93	0.91	0.89	0.87	0.85	0.83	0.81	0.78	0.75	0.71
1400	85.6	642	0.90	0.89	0.87	0.85	0.83	0.81	0.78	0.76	0.72	0.69
1600	83.5	626	0.88	0.96	0.84	0.82	0.80	0.78	0.76	0.73	0.70	0.67
1800	81.5	611	0.85	0.84	0.82	0.80	0.78	0.76	0.74	0.71	0.68	0.64
2000	79.5	596	0.83	0.81	0.79	0.78	0.76	0.74	0.71	0.69	0.66	0.62
2200	77.6	582	0.80	0.79	0.77	0.75	0.73	0.71	0.69	0.66	0.64	0.60
2400	75.6	567	0.78	0.76	0.75	0.73	0.71	0.69	0.67	0.64	0.61	0.58
2600	73.7	553	0.76	0.74	0.72	0.71	0.69	0.67	0.65	0.62	0.59	0.56
2800	71.9	539	0.73	0.72	0.70	0.69	0.67	0.65	0.63	0.60	0.57	0.54
3000	70.1	526	0.71	0.70	0.68	0.66	0.65	0.63	0.61	0.58	0.55	0.52
3400	66.7	500	0.67	0.65	0.64	0.63	0.61	0.59	0.57	0.54	0.51	0.48
4000	61.5	462	0.60	0.59	0.58	0.56	0.55	0.53	0.51	0.48	0.45	0.42

Correction Factor of Turbocharged Engine

Altitude m	Amb.Pressure		Amb.Temp. °C									
	kPa	mmHg	0	5	10	15	20	25	30	35	40	45
0	101.3	760	1.20	1.16	1.12	1.08	1.04	1.01	0.98	0.95	0.92	0.89
200	98.9	742	1.18	1.14	1.10	1.06	1.03	0.99	0.96	0.93	0.90	0.87
400	96.7	725	1.16	1.12	1.08	1.05	1.01	0.98	0.95	0.92	0.89	0.86
600	94.4	708	1.14	1.10	1.06	1.03	0.99	0.96	0.93	0.90	0.87	0.84
800	92.1	691	1.13	1.09	1.05	1.01	0.98	0.94	0.91	0.88	0.86	0.83
1000	89.9	674	1.11	1.07	1.03	0.99	0.96	0.93	0.88	0.87	0.84	0.82
1500	84.5	634	1.06	1.02	0.99	0.95	0.92	0.89	0.86	0.83	0.81	0.78
2000	79.5	596	1.01	0.98	0.94	0.91	0.88	0.85	0.82	0.80	0.77	0.75
2500	74.6	560	0.97	0.94	0.90	0.87	0.84	0.82	0.79	0.76	0.74	0.72
3000	70.1	526	0.93	0.90	0.87	0.84	0.81	0.78	0.75	0.73	0.71	0.69
3500	65.7	493	0.89	0.86	0.83	0.80	0.77	0.75	0.72	0.70	0.64	0.66
4000	61.5	462	0.85	0.82	0.79	0.76	0.74	0.72	0.69	0.67	0.65	0.63