Operation Manual of Diesel Engine for Generators

BS-20KVA(4DW91-29D)
BS-30KVA(4DW92-39D)
BS-50KVA(4DX22-65D)

Safety Precautions

Please read this operation manual carefully, which is closely related to your personal safety. This manual contains basic safety measures that must be adopted when maintaining your engines. Make sure that manuals are matched with your engine model before reading.

◆ Daily inspection items

Develop a good habit to inspect your engine and engine room with your eyes before turning on and after shutting down the engine, which will help you to promptly discover leakages of fuel, lubricating oil or coolant and any other abnormality that has occurred or will occur.

◆ Refueling

There are dangers of fire risks or explosions for refueling. Smoking is forbidden and do shut down the engine. Don’t overfill the fuel tank. Make sure that the cap of fuel tank is securely tightened. Only the fuel recommended in this manual is allowed to use. Fuel in poor quality may easily result in abnormal operation or shutdown of engine. Engine operating with poor fuel will lead to blockage of fuel pump and will cause engine racing. Even worse, engine maybe destroyed and personal injuries maybe caused.

◆ Engine operation

Don’t operate the engine in a place where there are explosive substances or gases because not all the electrical and mechanical components are properly protected to prevent sparks. It is dangerous to get close to the engine under operation. Loose cloth, hair, fingers or falling tools may be caught up in rotating parts, giving rise to serious personal injuries. In case that protective devices are not provided at the time of engine delivery, you must equip all the rotating parts and hot surfaces with protective devices to ensure personal safety.

◆ Carbon monoxide poisoning

It is only allowed to operate the engine in a well-ventilated environment. If engine is running in an enclosed space, proper ventilation must be ensured to discharge exhaust gas outdoors from engine emission and crankcase. Lock the starting switch (Without starting switch lock for the instrument box, the engine room must be locked or a lockable main switch must be used) to prevent that engine is turned on by people without permission.

◆ Maintenance and service

This manual includes instructions regarding how to perform general maintenance and services safely

and correctly. Please read this manual carefully before you start with any work. You can obtain more detailed information in this respect from your distributor. Do not proceed with any work you are not certain about. Please contact with your distributors and ask them to extend help.

◆ Fire and explosion

(1) Fuel and lubricating oil

All the types of fuel, most types of lubricating oil and many chemical products are flammable. Please read and observe instructions marked on the packages. All the operations related to the fuel system must be performed after the engine is cooled because fuel splashed on hot surfaces or electrical parts may cause fire. All the rags immersed in fuel and lubricating oil as well as other flammable materials must be safely stored in a fire-proofing place. Under certain conditions, rags immersed in the lubricating oil may be ignited spontaneously. Smoking is strictly forbidden while filling fuel or lubricating oil, or near the fuel station and inside the engine room.

(2) Spraying liquid for engine start

Don’t start the engine equipped with air preheat device (glow plug/starting heater) using spraying liquids or equivalents. Otherwise explosion may occur inside the air intake manifold threatening personal safety.

◆ Hot surface and high-temperature liquid

There are dangers of scalding for people operating with high-temperature engines. Pay special attention to hot surfaces, such as exhaust pipe, turbocharger, oil pan, supercharged air pipe, starting heater, high-temperature cooling liquids, and high-temperature lubricating oil inside tubes.

◆ Chemical products

Most types of chemical products, such as anti-freezing liquids, anti-rust agents, oil seal greases and degreaser agents are harmful for people’s health. Please read and observe instructions marked on the packages. Some chemical products, for example, oil seal greases are flammable and harmful for human body once these substances are inhaled by people. Place chemical products and other hazardous substances out of reach of children. Please dispose used and residual chemical products in accordance with regulations for the benefits of environment protection.

◆ Cooling system

Don’t open the cap of cooling liquid for high-temperature engines to avoid any scalding as a result of spraying of steam or high-temperature cooling liquids. If you inevitably open the filling cap or switch of cooling liquid or you must remove the cooling liquid tubes, please unscrew the cap slowly and carefully to discharge the pressure before fully opening the filling cap. Pay attention that high-temperature

cooling liquids may easily give rise to scalding.

◆ Lubricating system

Don’t touch high-temperature lubricating oil with your skin to prevent any scalding. Make sure that pressure has been discharged from the system before you start to work with the lubricating system. Don’t start or operate the engine when the filling cap of lubricating oil is not closed to avoid the danger of lubricating oil ejection.

◆ Electric welding

Firstly, remove the battery positive and negative cable. Then, disconnect all the cables connecting to the charging generator. The electric welding clamp must be fixed to the components to be welded while approaching to the welding point as close as possible. Don’t fix the electric welding clamp on the engine or have current go through any bearing. Once the welding task is completed, be sure to securely connect the cables for charging generator and control module before connections of battery cables.

Preface

BS-30KVA/BS-50KVA Series diesel engines are evolved and developed on the basis of BS-30KVA/BS-50KVA Series vehicle diesel engines according to the requirements for electricity-application diesel engines, including models of naturally aspirated types, supercharged types and supercharged inter-cooling types. The power for this series of diesel engines is defined in accordance with the ISO standard power specified in section 5.1.2 of GB/T 2820.2-2009 “Reciprocating internal combustion engine driven alternating current generating sets-Part2: Engines”.This manual introduces various technical specifications, operation instructions and maintenance methods for BS-30KVA/BS-50KVA Series diesel engines applicable for generator sets.

Correct operation and maintenance are crucial for safety operation and long service life of diesel engines. Please read this manual carefully before any operation. Operate and maintain diesel engines in consistent with the requirements. Refer to part list and service manual for the adjustment, service and spare part replacement of diesel engines.

Diesel engines you purchase may slightly differ with what has been listed in this manual due to constant product improvement. For accurate information, please inform the factory of model, delivery number (purchase order) and serial number marked on the nameplate whenever you want to purchase the parts.

Content

Chapter 1. Diesel Engine Data

1. Major technical parameters of diesel engine (1500rpm)

Engine Model	4DW81-23D	4DW91-29D	4DW92-35D	4DW92-39D	4DW93-42D
Type	In-line, four-cylinder, four-stroke				
Aspiration	Naturally aspirated	Naturally aspirated	Supercharged	Supercharged	Supercharged and inter-cooling
Cooling mode	Water-cooling				
Bore × Stroke (mm×mm)	85×95	90×100	90×100	90×100	90×100
Compression ratio	18:1	18:1	17.5:1	17.5:1	17.5:1
Displacement (L)	2.156	2.545	2.545	2.545	2.545
Dry weight (basic configuration)(kg)	220	220	240	240	240
Prime power (without fan)(kW)	17	21	26	29	31
Max. Standby power (kW)	18.7	23	29	32	34
Applicable power station (kW)	12	16	20	22	24
Fuel system	Mechanical/ electronic governor	Mechanical/ electronic governor	Mechanical/ electronic governor	Mechanical/ electronic governor	Mechanical/ electronic governor
Speed regulation rate in steady state	5%/3%	5%/3%	5%/3%	3%	5%/3%
Emission	Stage Ⅱ	Stage Ⅱ	Stage Ⅱ	Stage Ⅱ	Stage Ⅱ
Average effective pressure (MPa)	0.63	0.66	0.82	0.91	0.97
Fuel supply advance angle	17°CA±1°CA	17°CA±1°CA	17°CA±1°CA	17°CA±1°CA	17°CA±1°CA
Valve clearance in cold state (mm)	0.3±0.03	0.3±0.03	0.3±0.03	0.3±0.03	0.3±0.03
Lubricating oil capacity (with filter) (L)	7.8	8	8	8	8
Lubricating oil consumption (L/h)	0.04	0.05	0.05	0.05	0.05
Fuel consumption of prime power (g/kW.h)	4.08	4.94	5.98	6.67	6.98
Fuel consumption ratio of prime power (g/kW.h)	240	235	230	230	225
Air consumption (m^3/min)	1.6	1.9	2.2	2.5	2.7
Permissible max. air intake resistance (kPa)	3.7	3.7	3.7	3.7	3.7
Amount of exhaust emission (m^3/min)	4.7	5.5	6.4	7.1	7.8
Exhaust temperature after turbine (℃)	470	500	450	460	420
Heat dissipation of exhaust gas(kW)	16.0	20.2	21.0	23.9	23.9
Max. permissible back pressure of exhaust pipe(kPa)	6.7	6.7	6.7	6.7	6.7

Heat dissipation of engine (kW)	1.3	1.6	2.3	2.6	2.7
Heat dissipation of coolant (kW)	13.1	16.1	18.9	20.8	22.1
Heat dissipation of inter-cooler (kW)	-	-	-	-	4.1
Speed ratio of fan	170/113	170/113	200/113	200/113	200/113
Water pump flow rate-lift (L/s-mH2o)	2257rpm 60-≥4.5m		2655rpm 71-≥6.3m		
Diameter of fan(mm)	400	400	430	-	430
Power of fan(kW)	1	1	1.5	1.5	2
Engine	12V 3.5kW	12V 3.5kW	12V 3.5kW	12V 3.5kW	12V 3.5kW
Generator	14V 750W	14V 750W	14V 750W	14V 750W	14V 750W
Air heater parameter	12V 430W	12V 430W	12V 430W	-	12V 400W
Recommended battery capacity(Ah)	100×1	100×1	100×1	100×1	100×1
Flywheel teeth number	109	109	109	109	109
Oil pressure sensor parameter (MPa)	$0.08^{0}_{-0.01}$MPa	$0.08^{0}_{-0.01}$MPa	$0.08^{0}_{-0.01}$MPa	-	$0.08^{0}_{-0.01}$MPa
Water temperature sensor parameter	97℃±2℃	97℃±2℃	97℃±2℃	-	97℃±2℃

Major technical parameters of diesel engine (1500rpm)

Engine Model	4DX21-45D	4DX21-53D	4DX22-50D	4DX22-65D	4DX23-65D	4DX23-78D
Type	In-line, four-cylinder, four-stroke					
Aspiration	Naturally aspirated	Naturally aspirated	Supercharged	Supercharged	Supercharged and inter-cooling	Supercharged
Cooling mode	Water-cooling					
Bore × Stroke (mm×mm)	102×118	102×118	102×118	102×118	102×118	102×118
Compression ratio	17.5:1	17.5:1	17.5:1	17.5:1	17.5:1	17.5:1
Displacement (L)	3.86	3.86	3.86	3.86	3.86	3.86
Dry weight (basic configuration)(kg)	350	350	380	380	380	380
Prime power (without fan)(kW)	33	39	37	48	48	57
Max. Standby power (kW)	36	43	41	53	53	64
Applicable power station (kW)	24	32	30	38	38	46
Fuel system	Mechanical/ electronic governor	Electronic governor	Mechanical/ electronic governor	Electronic governor	Mechanical/ electronic governor	Electronic governor
Speed regulation rate in steady state	5%/3%	3%	5%/3%	3%	5%/3%	3%
Emission	Stage Ⅱ	Stage Ⅱ	Stage Ⅱ	Stage Ⅱ	Stage Ⅱ	Stage Ⅱ
Average effective pressure (MPa)	0.68	0.81	0.77	0.99	0.99	1.18
Fuel supply advance angle	14°±1°CA	14°±1°CA	12°±1°CA	12°±1°CA	12°±1°CA	12°±1°CA
Valve clearance in cold state (mm)	0.4±0.05	0.4±0.05	0.4±0.05	0.4±0.05	0.4±0.05	0.4±0.05
Lubricating oil capacity (with filter) (L)	12.5	12.5	13	13	13	13
Lubricating oil consumption (L/h)	0.06	0.06	0.05	0.05	0.05	0.05
Fuel consumption of prime power (g/kW.h)	7.43	8.78	8.14	10.56	10.08	11.97
Fuel consumption ratio of prime power (g/kW.h)	225	225	220	220	210	210
Air consumption (m^3/min)	2.9	3.1	3.0	3.9	4.0	4.8
Permissible max. air intake resistance (kPa)	3.7					
Amount of exhaust emission (m^3/min)	8.3	9.3	8.7	11.3	11.6	13.8
Exhaust temperature after turbine (℃)	500	550	450	460	430	440
Heat dissipation of exhaust gas(kW)	30.4	31.6	28.5	37.9	36.1	44.0
Max. permissible back pressure of exhaust pipe(kPa)	6.7					

Heat dissipation of engine (kW)	2.5	3.3	3.3	4.2	4.2	5.1
Heat dissipation of coolant (kW)	25.2	26.1	26.7	34.5	34.5	41.6
Heat dissipation of inter-cooler (kW)	-	-	-	-	6.0	7.1
Speed ratio of fan	185/110		185/110		185/110	
Water pump flow rate-lift (L/s-mH2o)	2523r/min 162≥5.4		2000r/min 152-≥5.4		2000r/min 152-≥5.4	
Diameter of fan(mm)	420		450	-	520	-
Power of fan(kW)	1.3	1.3	2	2	3	3
Engine	24V 4.5kW		24V 4.5kW		24V 4.5kW	
Generator	1000W 28V 6000r/min		1000W 28V 6000r/min		1000W 28V 6000r/min	
Air heater parameter	24V 600W		24V 600W	-	24V 600W	-
Recommended battery capacity(Ah)	120×2					
Flywheel teeth number	128		128		128	
Oil pressure sensor parameter (MPa)	$0.08^{+0.01}_{-0.01}$MPa	-	$0.08^{+0.01}_{-0.01}$MPa	-	$0.08^{+0.01}_{-0.01}$MPa	-
Water temperature sensor parameter	97℃±2℃	-	97℃±2℃	-	97℃±2℃	-

Major technical parameters of diesel engine (1800rpm)

Engine Model	4DW81-28D	4DW91-38D	4DW92-42D	4DW92-45D	4DW93-50D
Type	In-line, four-cylinder, four-stroke				
Aspiration	Naturally aspirated	Naturally aspirated	Supercharged	Supercharged	Supercharged and inter-cooling
Cooling mode	Water-cooling				
Bore × Stroke (mm×mm)	85×95	90×100	90×100	90×100	90×100
Compression ratio	18:01	18:01	17.5:1	17.5:1	17.5:1
Displacement (L)	2.156	2.545	2.545	2.545	2.545
Dry weight (basic configuration)(kg)	220	240	240	240	240
Prime power (without fan)(kW)	20	28	31	33	37
Max. Standby power (kW)	22	31	34	36	41
Applicable power station (kW)	15	22	25	26	30
Fuel system	Mechanical/ electronic governor	Mechanical/ electronic governor	Mechanical/ electronic governor	Electronic governor	Mechanical/ electronic governor
Speed regulation rate in steady state	5%/3%	5%/3%	5%/3%	3%	5%/3%
Emission	Stage Ⅱ	Stage Ⅱ	Stage Ⅱ	Stage Ⅱ	Stage Ⅱ
Average effective pressure (MPa)	0.62	0.73	0.81	0.86	0.97
Fuel supply advance angle	17°CA±1°CA	17°CA±1°CA	17°CA±1°CA	17°CA±1°CA	17°CA±1°CA
Valve clearance in cold state (mm)	0.3±0.03	0.3±0.03	0.3±0.03	0.3±0.03	0.3±0.03
Lubricating oil capacity (with filter) (L)	7.8	8	8	8	8
Lubricating oil consumption (L/h)	0.04	0.05	0.05	0.05	0.05
Fuel consumption of prime power (g/kW.h)	4.80	6.44	7.13	7.59	8.14
Fuel consumption ratio of prime power (g/kW.h)	240	230	230	230	220
Air consumption (m^3/min)	1.9	2.3	2.6	2.8	3.2
Permissible max. air intake resistance (kPa)	3.7	3.7	3.7	3.7	3.7
Amount of exhaust emission (m^3/min)	5.6	6.6	7.6	8.1	9.4
Exhaust temperature after turbine (℃)	450	500	450	450	450
Heat dissipation of exhaust gas(kW)	19.1	24.1	25.0	27.2	28.5
Max. permissible back pressure of exhaust pipe(kPa)	6.7	6.7	6.7	6.7	6.7

Heat dissipation of engine (kW)	1.5	2.2	2.7	2.9	3.3
Heat dissipation of coolant (kW)	15.4	21.7	22.1	23.4	26.7
Heat dissipation of inter-cooler (kW)	-	-	-	-	4.8
Speed ratio of fan	170/113	170/113	200/113	200/113	200/113
Water pump flow rate-lift (L/s-mH2o)	2708rpm 73-≥6.5m		3186rpm 86-≥9.0m		
Diameter of fan(mm)	400	400	430	-	430
Power of fan(kW)	1.3	1.3	1.8	1.8	2.2
Engine	12V 3.5kW	12V 3.5kW	12V 3.5kW	12V 3.5kW	12V 3.5kW
Generator	14V 750W	14V 750W	14V 750W	14V 750W	14V 750W
Air heater parameter	12V 430W	12V 430W	12V 430W	-	12V 400W
Recommended battery capacity(Ah)	100×2	100×2	100×2	100×2	100×2
Flywheel teeth number	109	109	109	109	109
Oil pressure sensor parameter (MPa)	$0.08^{0}_{-0.01}$MPa	$0.08^{0}_{-0.01}$MPa	$0.08^{0}_{-0.01}$MPa	-	$0.08^{0}_{-0.01}$MPa
Water temperature sensor parameter	97℃±2℃	97℃±2℃	97℃±2℃	-	97℃±2℃

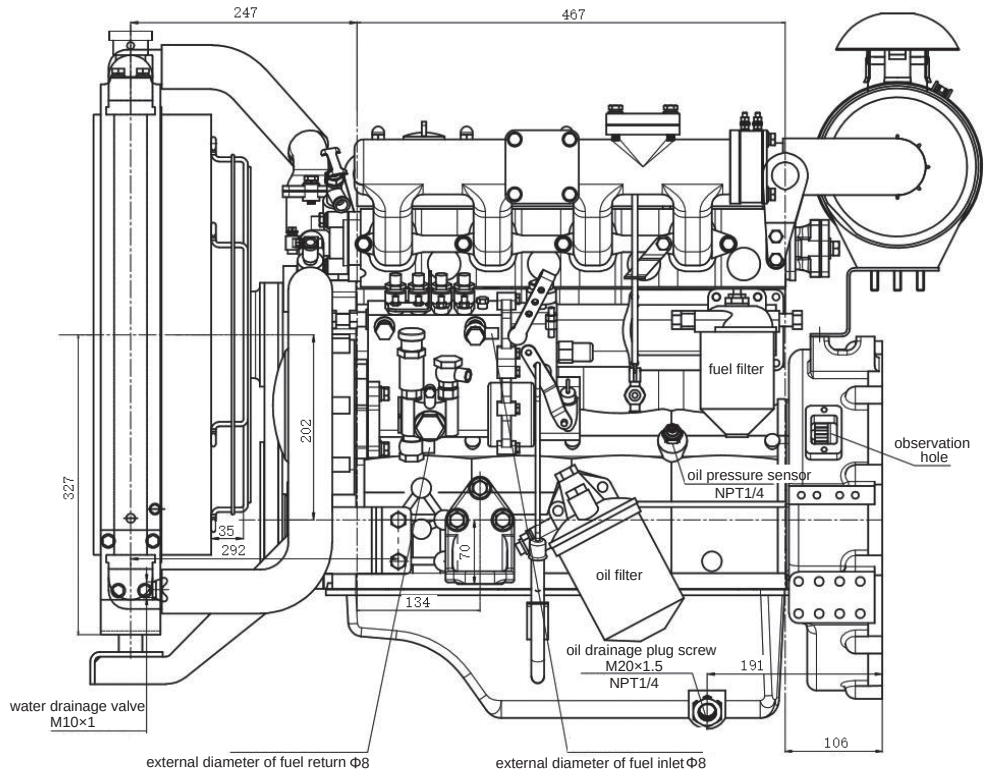
Major technical parameters of diesel engine (1800rpm)

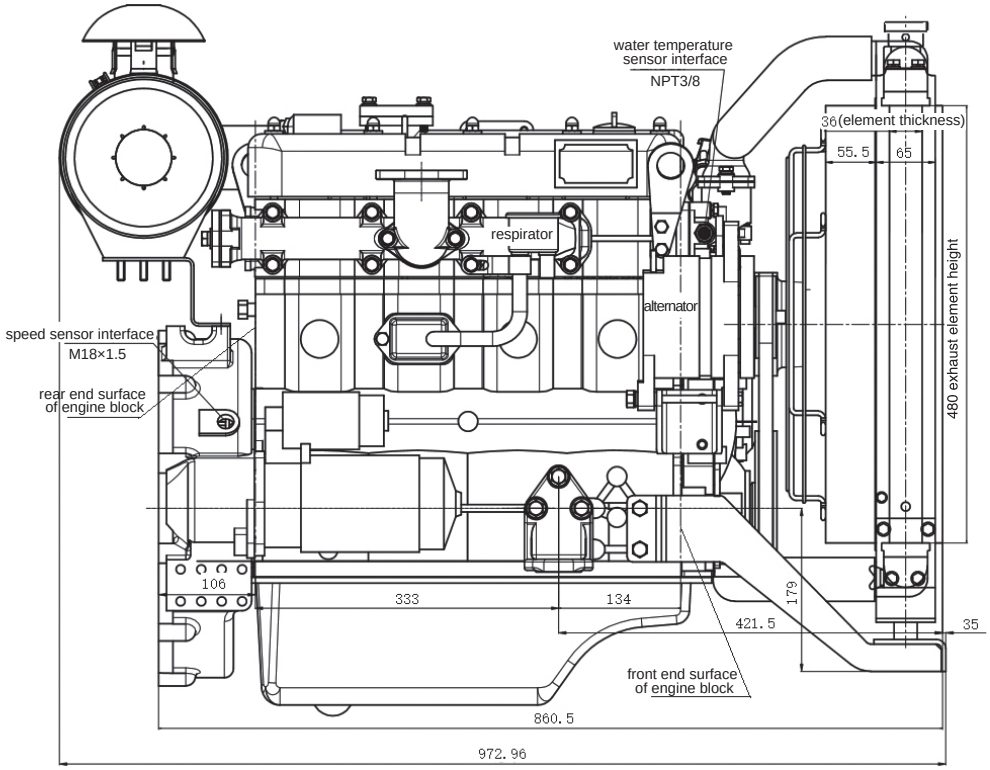
Engine Model	4DX21-53D	4DX21-61D	4DX22-60D	4DX22-75D	4DX23-82D	4DX23-90D
Type	In-line, four-cylinder, four-stroke					
Aspiration	Naturally aspirated	Naturally aspirated	Supercharged	Supercharged	Supercharged and inter-cooling	Supercharged and inter-cooling
Cooling mode	Water-cooling					
Bore × Stroke (mm×mm)	102×118	102×118	102×118	102×118	102×118	102×118
Compression ratio	17.5:1	17.5:1	17.5:1	17.5:1	17.5:1	17.5:1
Displacement (L)	3.86	3.86	3.86	3.86	3.86	3.86
Dry weight (basic configuration)(kg)	350	350	380	380	380	380
Prime power (without fan)(kW)	39	45	45	55	60	66
Max. Standby power (kW)	43	50	50	60	66	72
Applicable power station (kW)	30	35	35	44	48	56
Fuel system	Mechanical/ electronic governor	Electronic governor	Mechanical/ electronic governor	Electronic governor	Mechanical/ electronic governor	Electronic governor
Speed regulation rate in steady state	5%/3%	3%	5%/3%	3%	5%/3%	3%
Emission	Stage Ⅱ	Stage Ⅱ	Stage Ⅱ	Stage Ⅱ	Stage Ⅱ	Stage Ⅱ
Average effective pressure (MPa)	0.67	0.79	0.78	0.95	1.04	1.14
Fuel supply advance angle	14°±1°CA	14°±1°CA	12°±1°CA	12°±1°CA	12°±1°CA	12°±1°CA
Valve clearance in cold state (mm)	0.4±0.05	0.4±0.05	0.4±0.05	0.4±0.05	0.4±0.05	0.4±0.05
Lubricating oil capacity (with filter) (L)	12.5	12.5	13	13	13	13
Lubricating oil consumption (L/h)	0.06	0.06	0.05	0.05	0.05	0.05
Fuel consumption of prime power (g/kW.h)	8.78	10.13	9.90	12.10	12.60	14.19
Fuel consumption ratio of prime power (g/kW.h)	225	225	220	220	210	215
Air consumption (m^3/min)	3.5	3.9	3.7	4.5	5.0	5.7
Permissible max. air intake resistance (kPa)	3.7	3.7	3.7	3.7	3.7	3.7
Amount of exhaust emission (m^3/min)	10.1	11.8	10.6	13.0	14.5	16.3
Exhaust temperature after turbine (℃)	500	620	450	480	450	500
Heat dissipation of exhaust gas(kW)	37.7	43.9	34.7	45.4	46.3	54.7
Max. permissible back pressure of exhaust pipe(kPa)	6.7	6.7	6.7	6.7	6.7	6.7

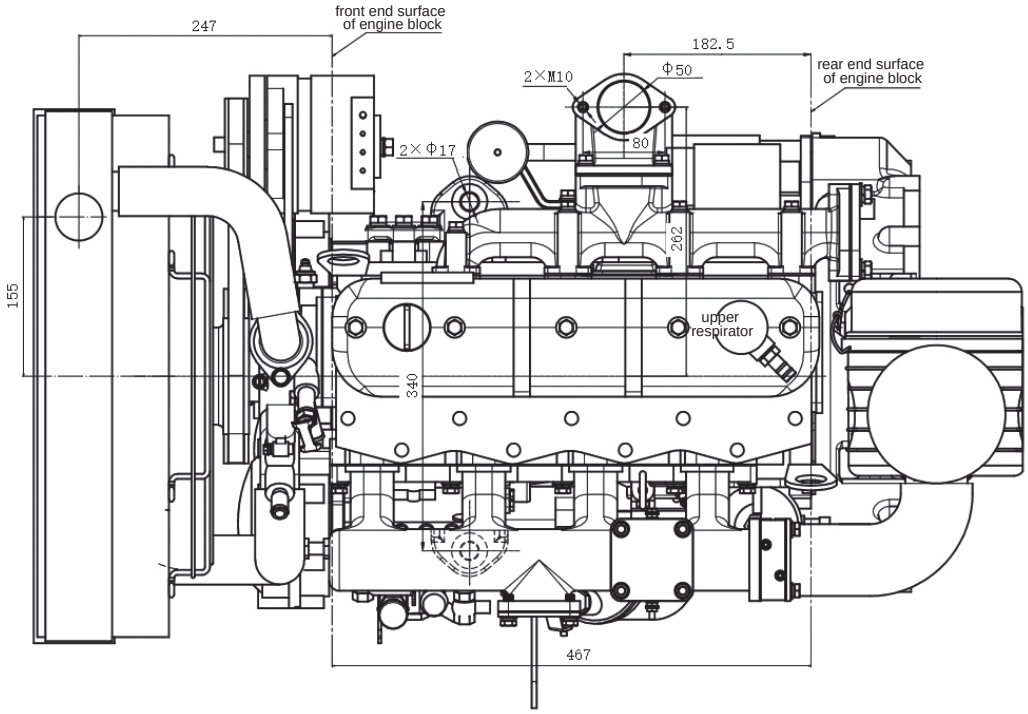
Heat dissipation of engine (kW)	3.0	3.4	4.0	4.8	5.3	5.8
Heat dissipation of coolant (kW)	27.3	31	29.3	35.8	39.0	42.9
Heat dissipation of inter-cooler (kW)	-	-	-	-	7.5	8.4
Speed ratio of fan	185/110		185/110		185/110	
Water pump flow rate-lift (L/s-mH2o)	3027r/min 165-≥8.9		3027r/min 165-≥8.9		3027r/min 165-≥8.9	
Diameter of fan(mm)	420	420	450	-	520	-
Power of fan(kW)	2.2	2.2	2.6	2.6	3.6	3.6
Engine	24V 4.5kW	24V 4.5kW	24V 4.5kW	24V 4.5kW	24V 4.5kW	24V 4.5kW
Generator	1000W 28V 6000r/min		1000W 28V 6000r/min		1000W 28V 6000r/min	
Air heater parameter	24V 600W	24V 600W	24V 600W	-	24V 600W	-
Recommended battery capacity(Ah)	120×2	120×2	120×2	120×2	120×2	120×2
Flywheel teeth number	128	128	128	128	128	128
Oil pressure sensor parameter (MPa)	$0.08^{+0.01}_{-0.01}$MPa	-	$0.08^{+0.01}_{-0.01}$MPa	-	$0.08^{+0.01}_{-0.01}$MPa	-
Water temperature sensor parameter	97℃±2℃	-	97℃±2℃	-	97℃±2℃	-

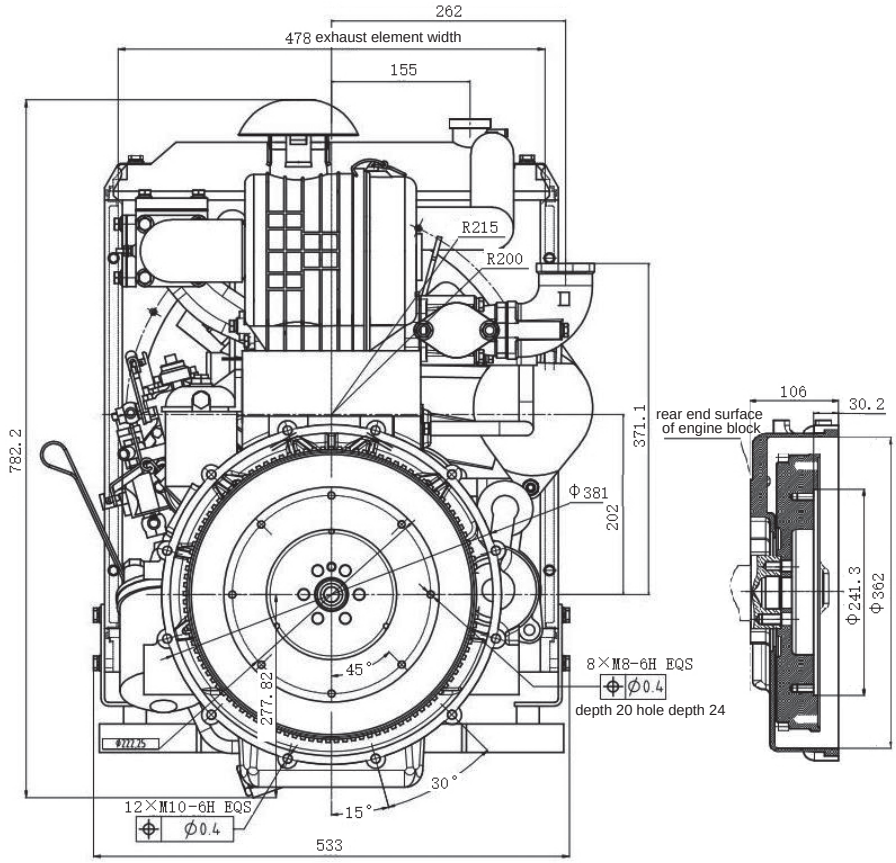
2、Outline Drawing of Diesel Engine

2.1 Outline drawings of 4DW81-23D, 4DW81-28D, 4DW91-29D and 4DW91-38D

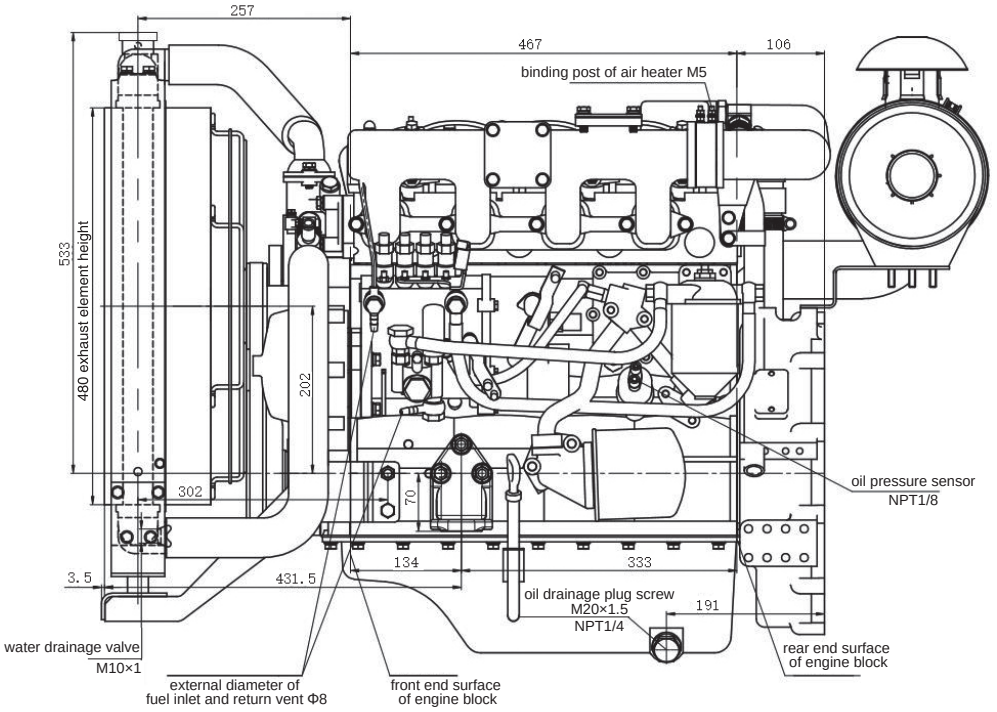


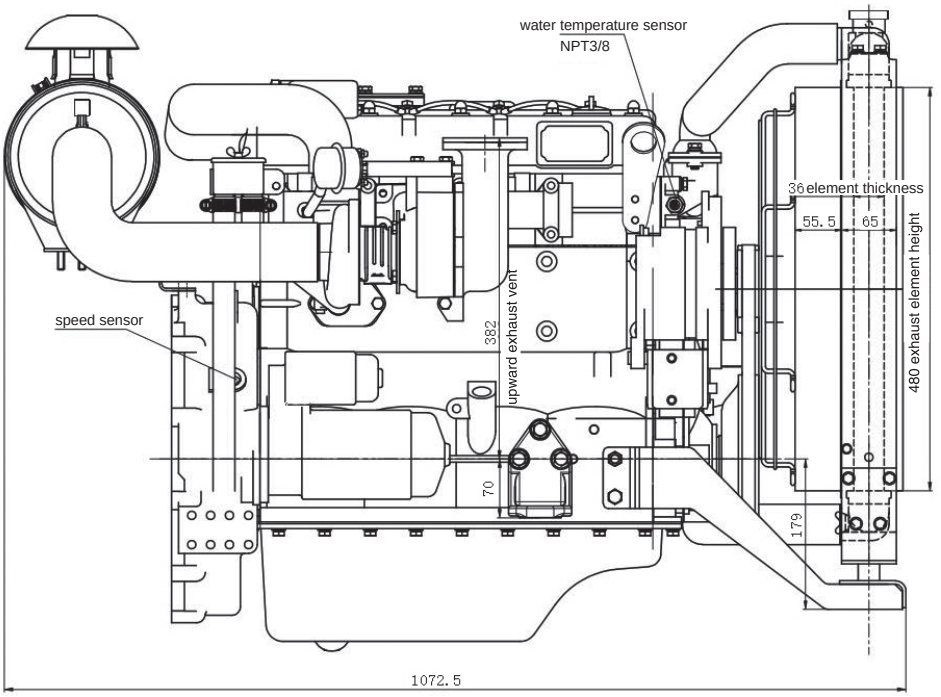


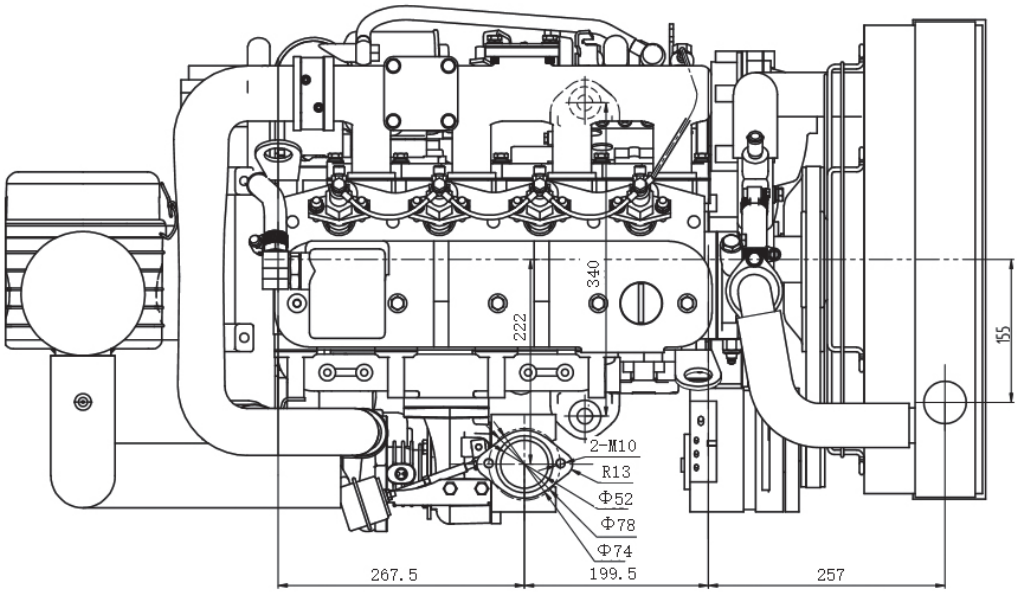


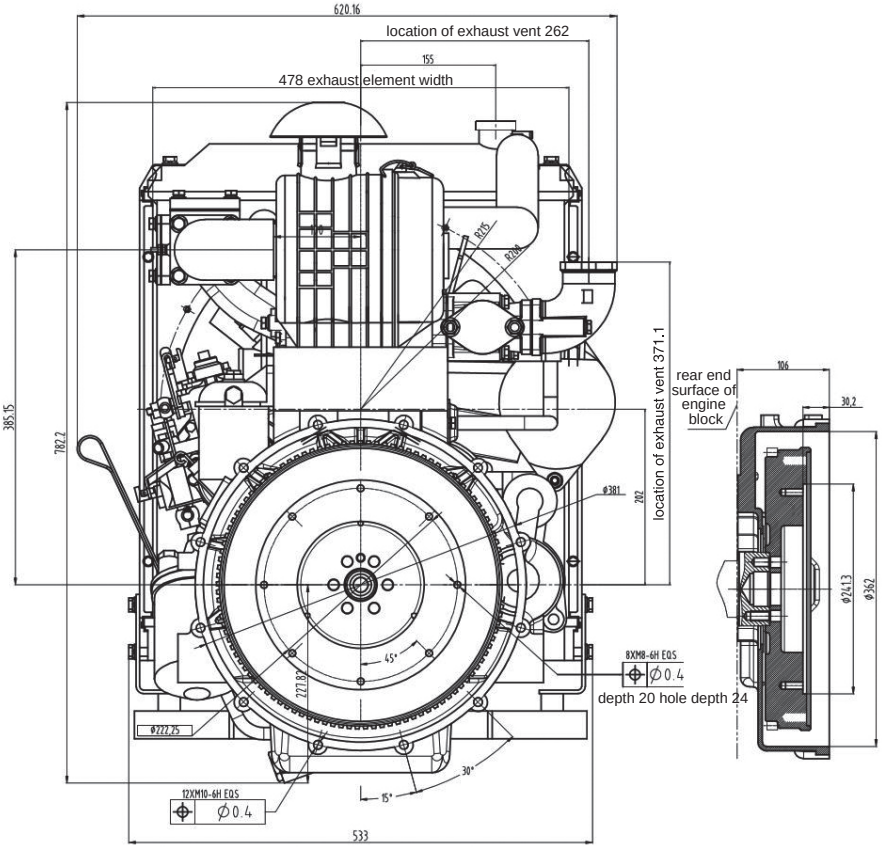


2.2 Outline drawings of 4DW92-35D and 4DW92-42D

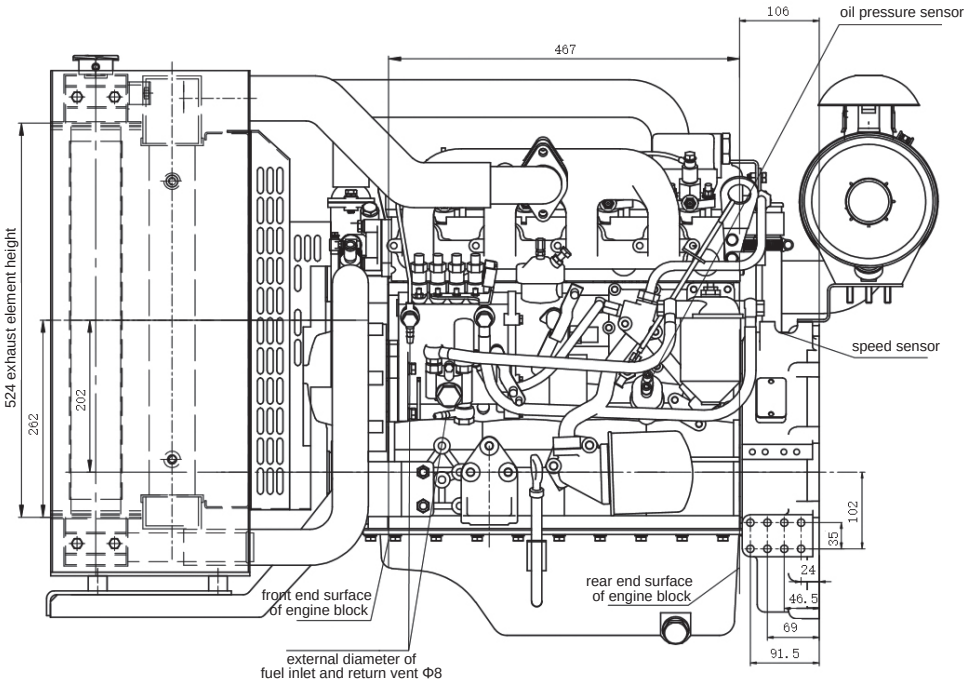


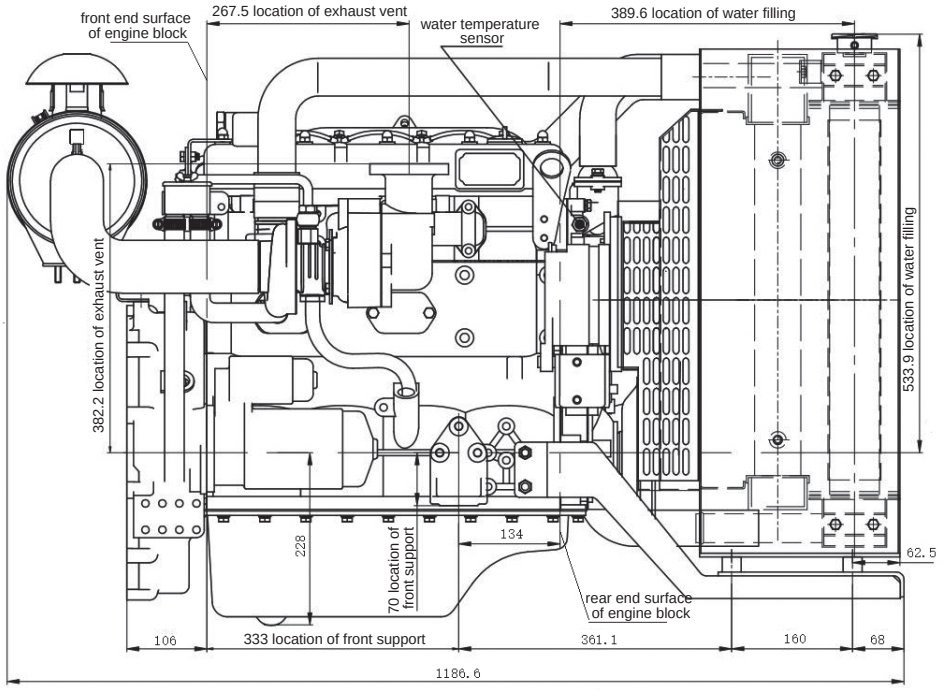


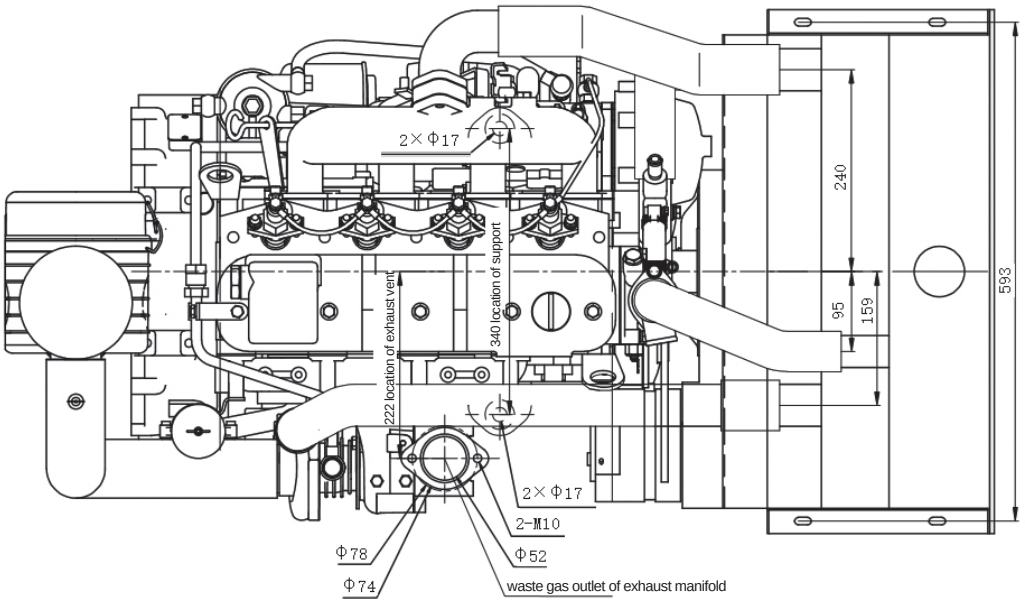


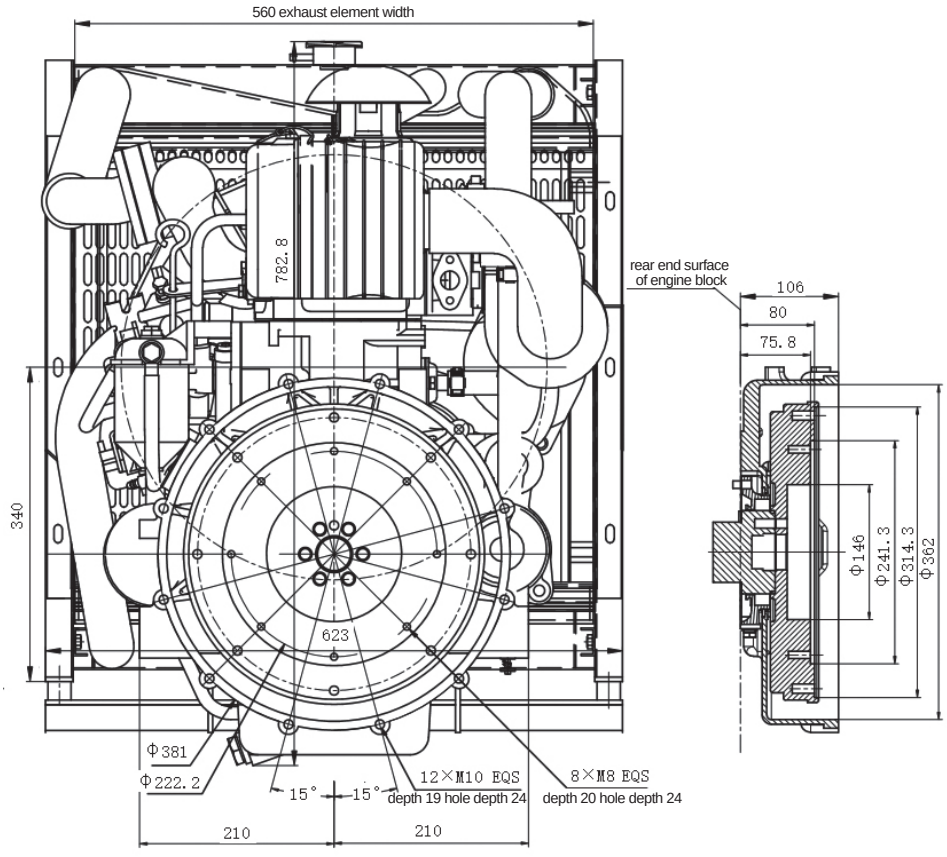


2.3 Outline drawings of 4DW93-42D and 4DW93-50D

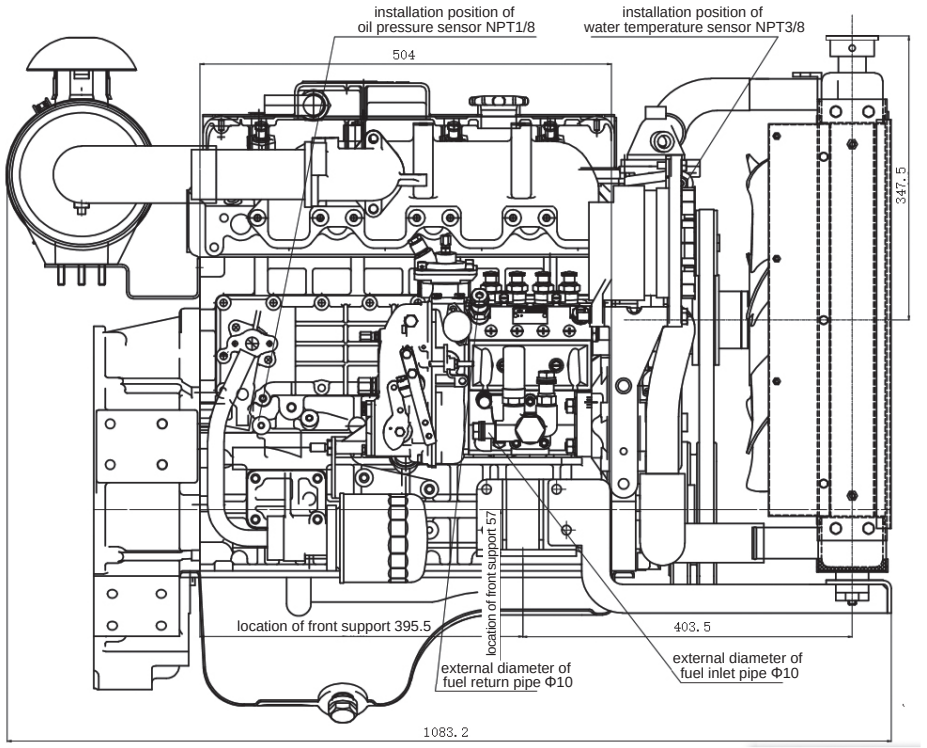


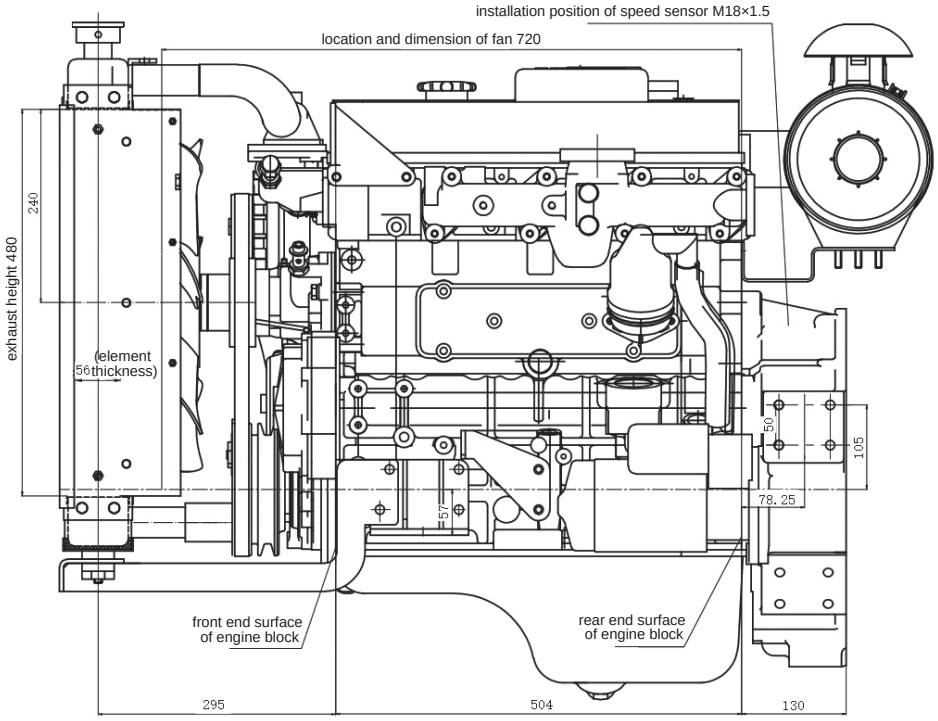


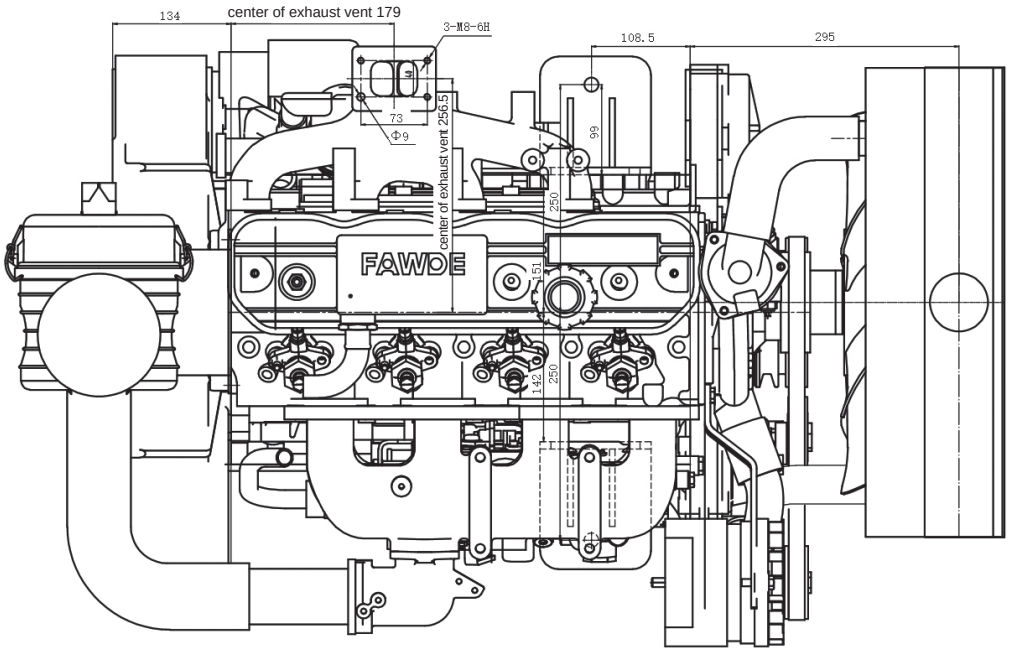


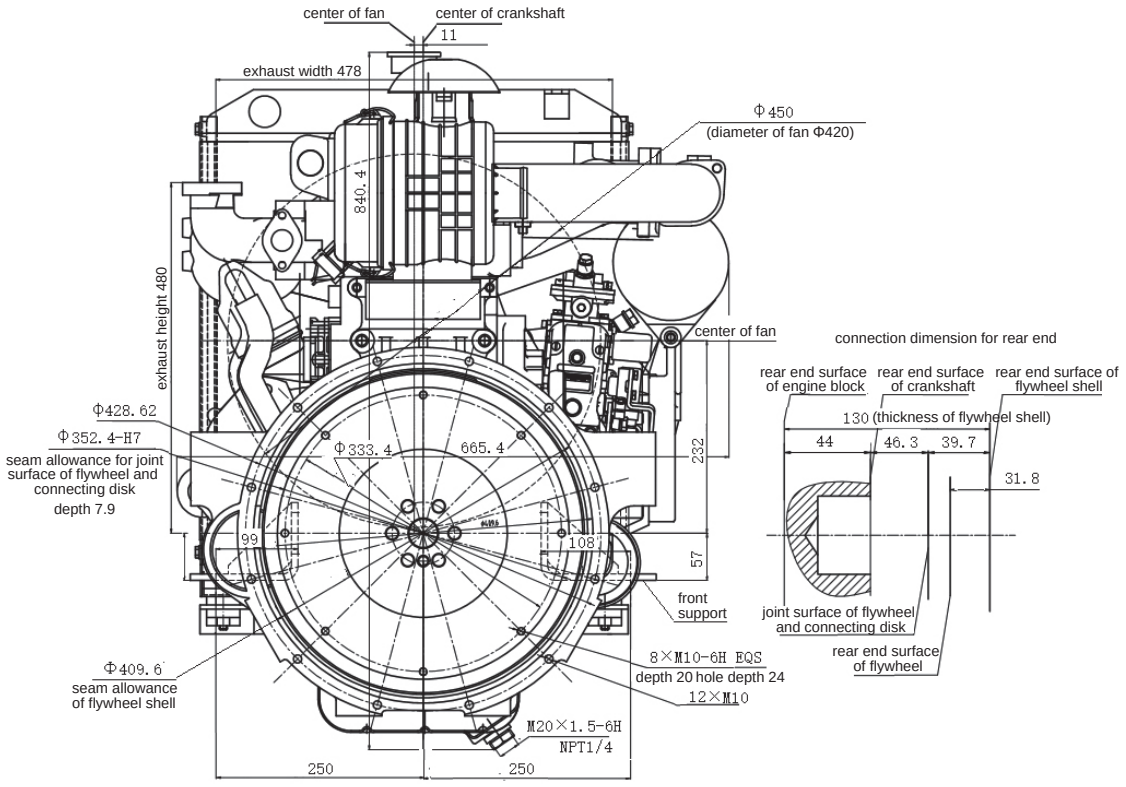


2.4 Outline drawings of 4DX21-45D and 4DX21-53D

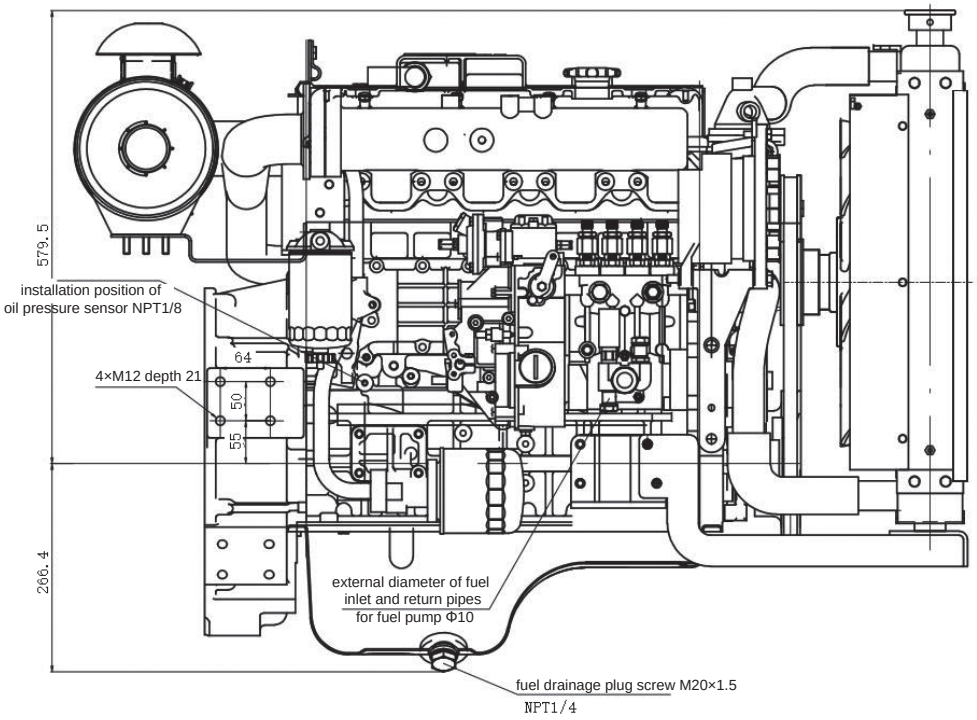


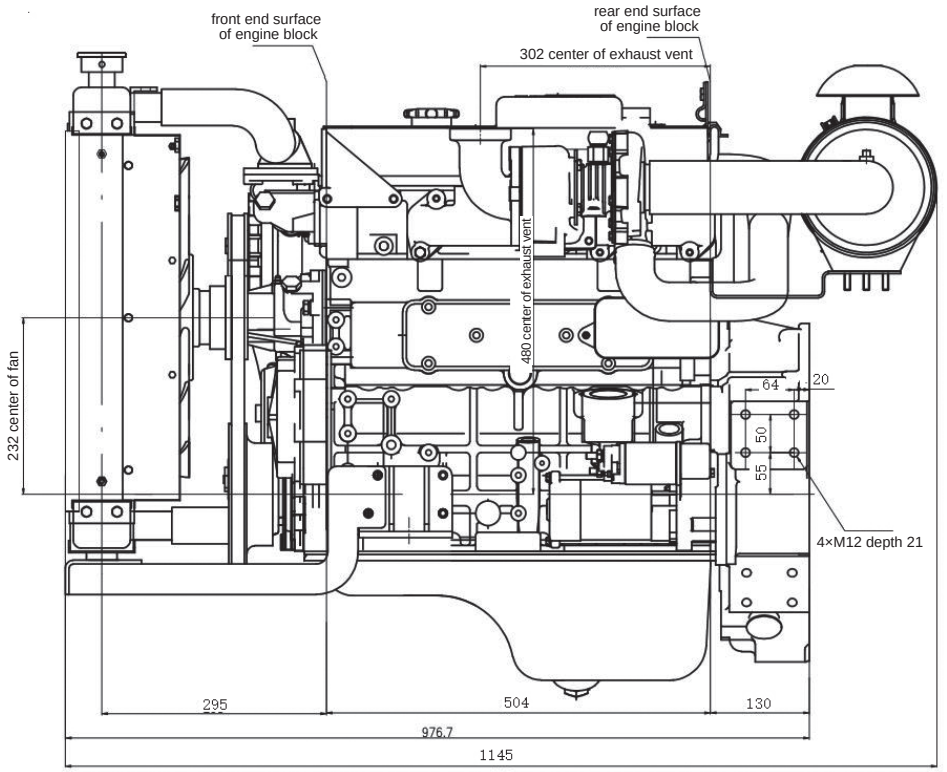


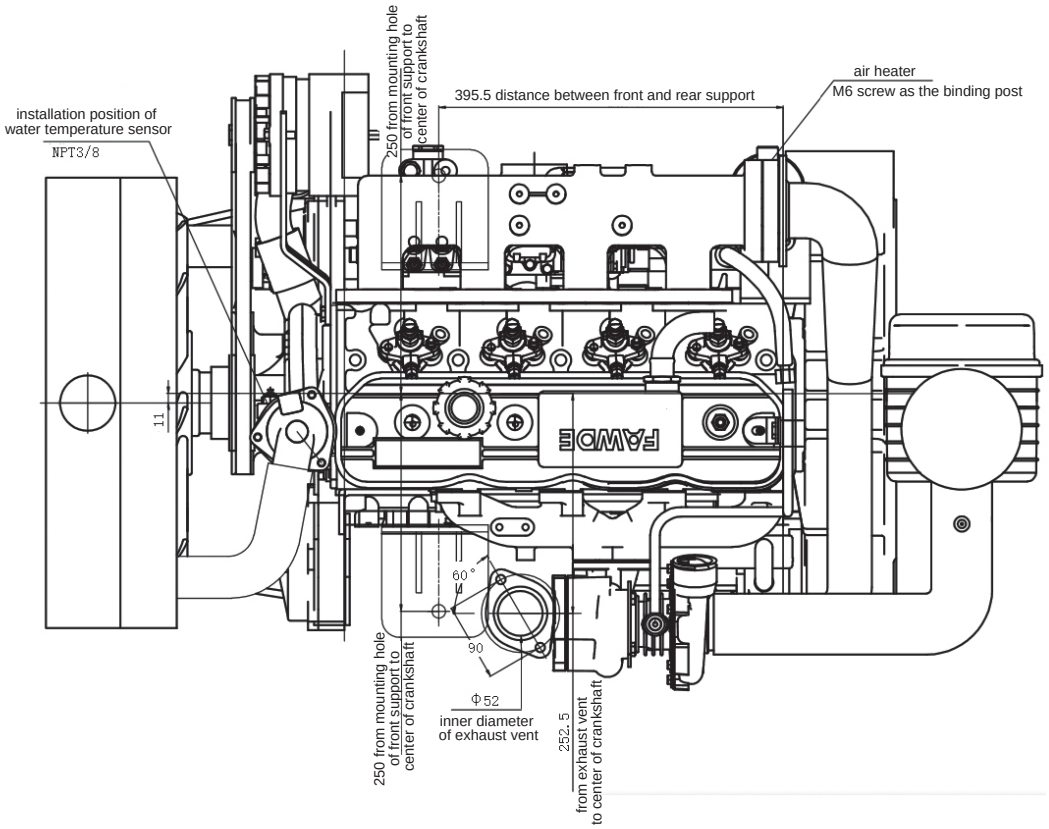


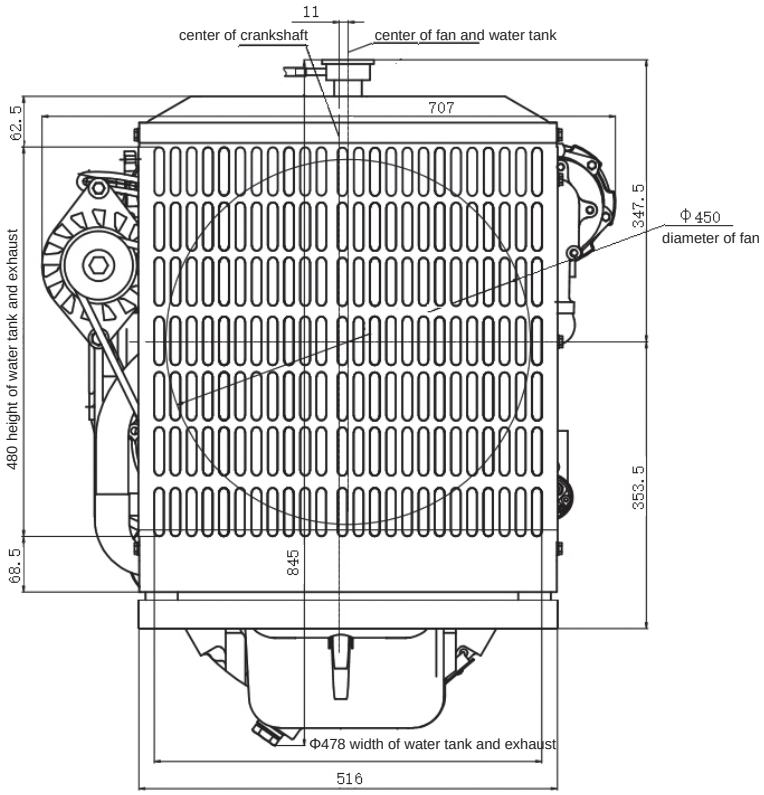


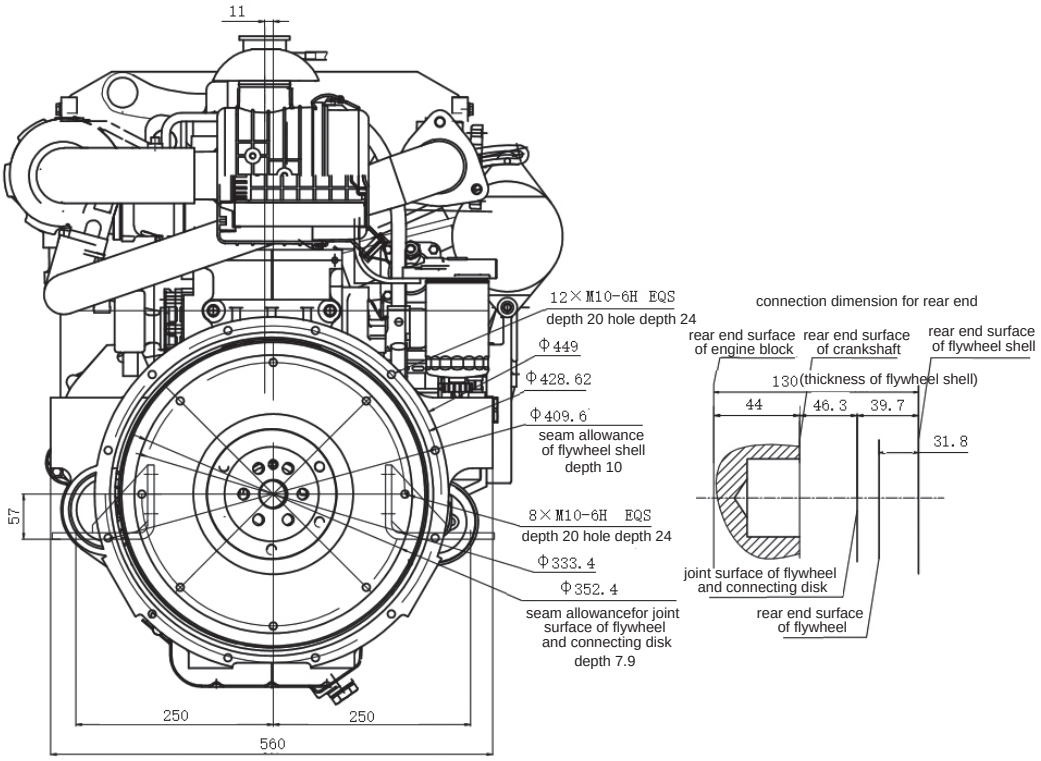
2.5 Outline drawings of 4DX22-50D and 4DX22-60D



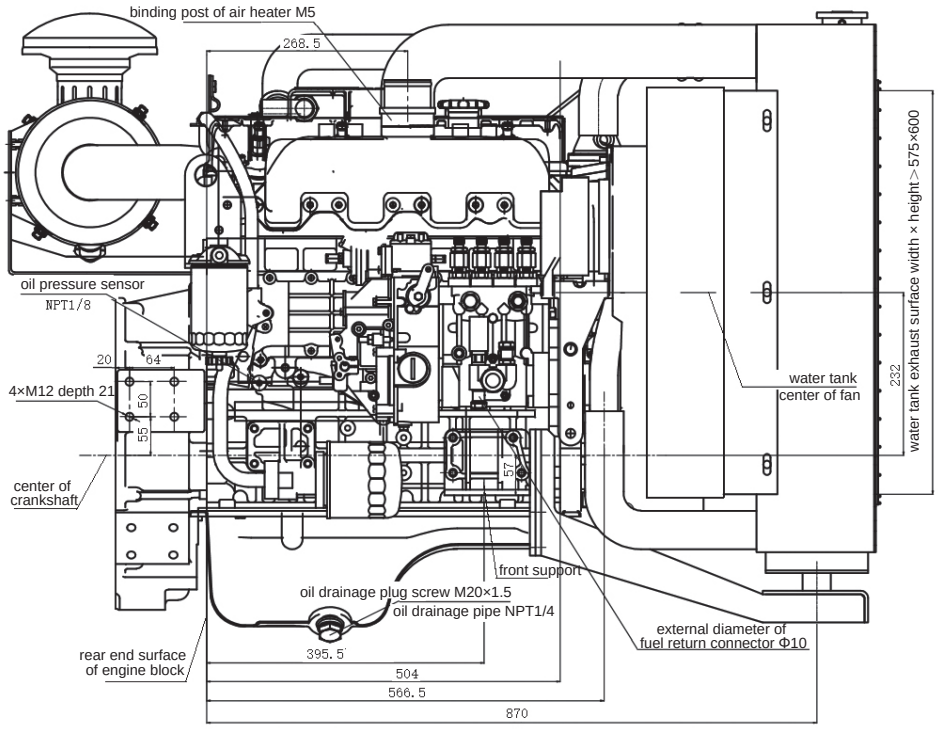


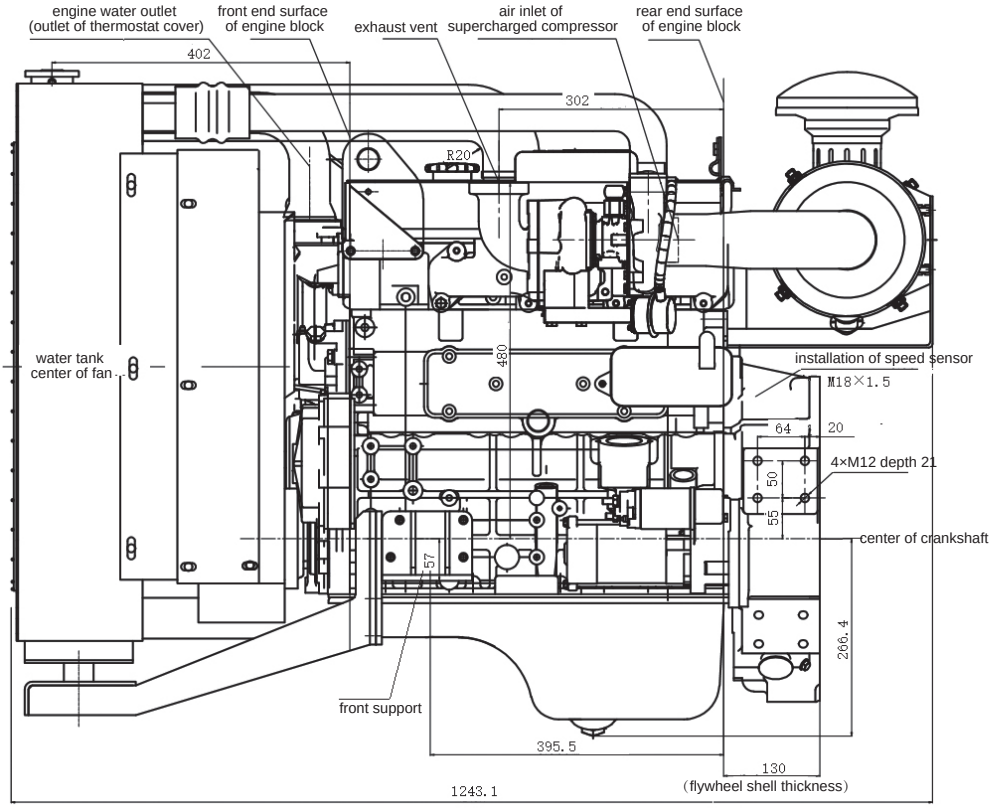


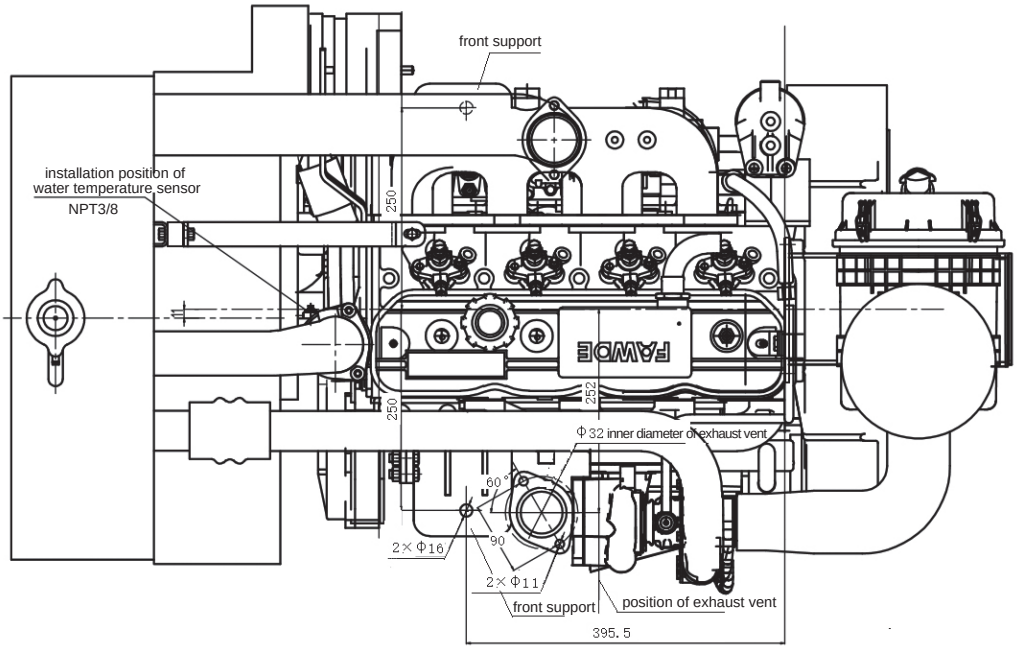


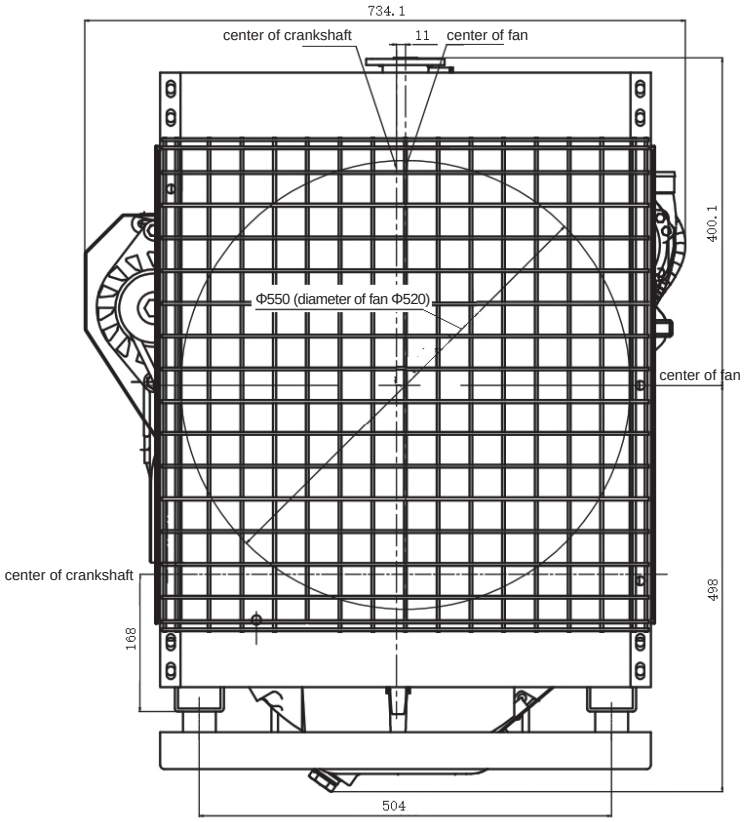


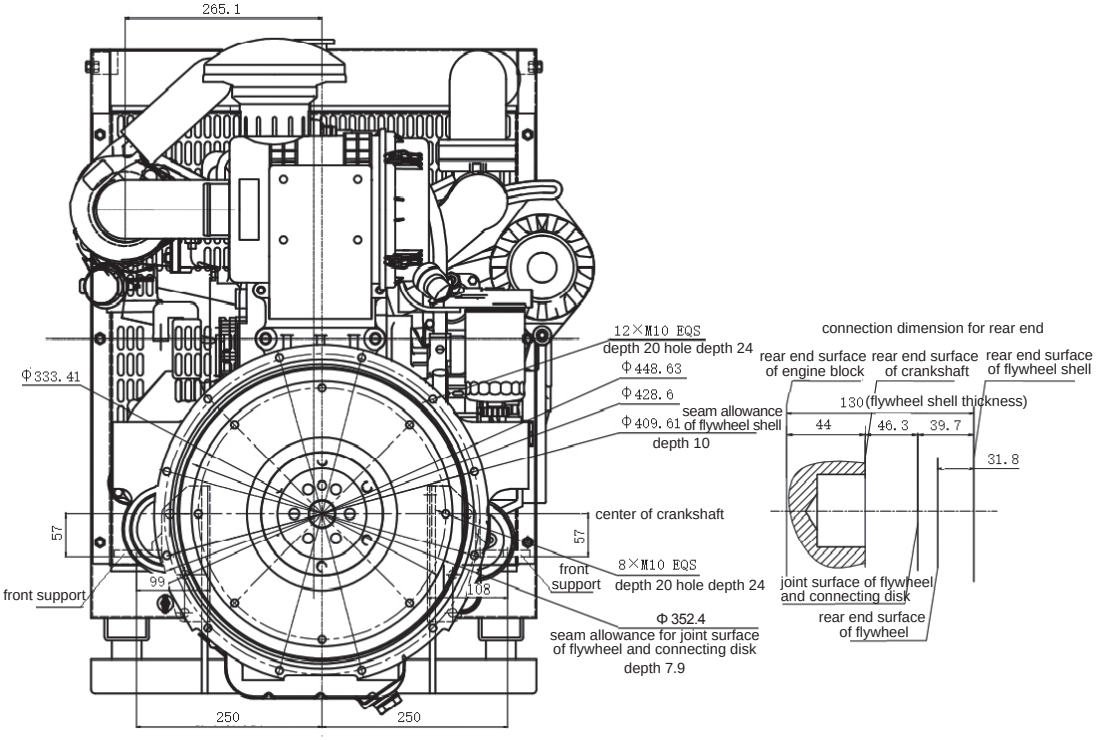
2.6 Outline drawing of 4DX23-65D





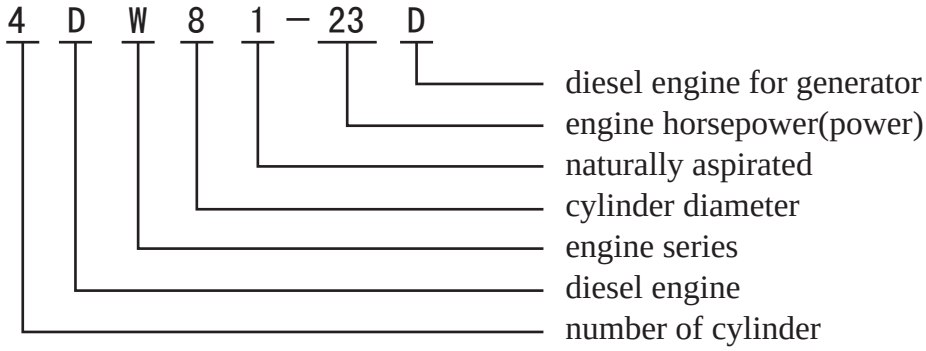






3. Engine model and its definitions

Definitions of each character constituting the engine model



Note:

① W represents the engine series. BS-30KVA/BS-50KVA Series has two engine models: 4DW and 4DX

② 8 represents that the diameter of cylinder is 85. The cylinder diameters of Kangwei engines are as follows:

Code of cylinder diameter	8	9	2
Cylinder diameter	85	90	102

③ 1 represents the naturally aspirated air inlet. Other types of air inlet are as follows

Code of air inlet	1	2	3
Type of air inlet	Naturally aspirated	Supercharged	Supercharged and inter-cooling

4. Rated power

The power of engine is defined in accordance with the ISO standard power specified in section 5.1.2 of GB/T 2820.2-2009 (equal to ISO8528-2) “Reciprocating internal combustion engine driven alternating current generating sets-Part2: Engines”.

The standard situation is specified as:

Barometric pressure: 100kPa

Air temperature: 298K(25℃)

Relative humidity: 30%

Temperature of supercharged and inter-cooling media:298K(25℃)

Note: with air temperature of 298K(25℃), 30% relative humidity and 1kPa partial pressure of vapour, the relative dry air pressure is 99kPa.

Test of engine power is performed in accordance with GB/T 6072.1-2008 standard (equal to ISO3046-1).

The inlet air density may change according to the altitude and region where the engine is operating due to the change of the air inlet amount. Accordingly, the output power of diesel engine is also changed.

Appendix 1 illustrates the changes of air density as the variations of altitude and ambient temperature. For diesel engines operating in the environment deviated from the standard criteria, the power should be modified according to the ambient environment or to the mutual agreement.

① Naturally-aspirated diesel engine (with mechanical governor or electronic governor)

For naturally-aspirated diesel engine, it is allowed not to reduce the service power if the altitude is lower than 200M and the ambient temperature is less than 40℃. With altitude higher than 200M, apply the service power specified in Appendix 1. Meanwhile, modify and reduce the service power according to Appendix 2 while taking into consideration of percentage between air density and standard density.

② Supercharged diesel engine (with mechanical governor or electronic governor)

For supercharged diesel engine, it is allowed not to reduce the service power if the altitude is lower than 1000M and the ambient temperature is less than 40℃. In the event of altitude higher than 1000M, the service power must be reduced according to the below table.

Altitude lower than 3000M	Power reduction %/M	-4 per 500M
Altitude higher than 3000M	Power reduction %/M	-6 per 500M
Ambient temperature	Power reduction %/M	-3 per 5℃

5. The operating environment of diesel engine

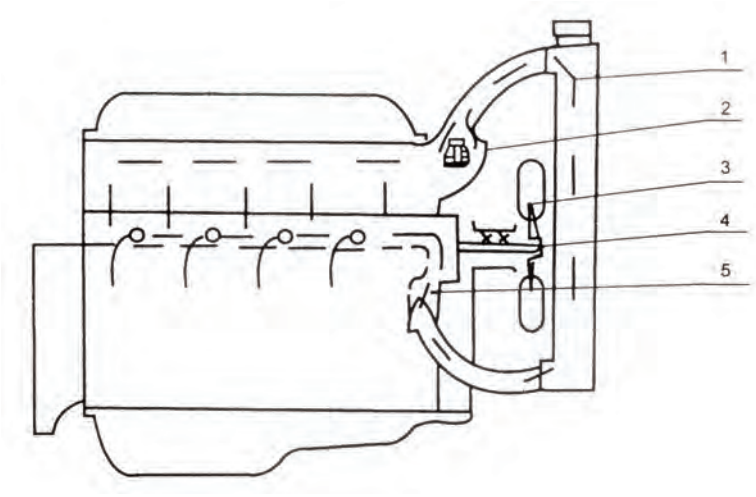
BS-30KVA/BS-50KVA series diesel engine for generators are all equipped with air inlet heating device. With ambient temperature higher than -15℃ and below 40℃ at an altitude lower than 1000M, diesel engine can properly operate.

Ensure good ventilation for engine operation with a working temperature below 50℃. For an engine operating in an environment at a temperature greatly higher than the ambient temperature, connect the engine inlet to a lower temperature location. Meanwhile, choose correct inlet pipeline to prevent large air inlet resistance.

Users must inform the manufacturer if they have special requirements for the operating environment when placing an order.

Chapter 2. Installation Precautions of Diesel Engine

6. The cooling system of diesel engine for generators



1-Radiator 2-Thermostat 3-Fan 4-Water pump 5-Water inlet pipe

(1) Cooling performance and layout of the cooling system

The design of cooling system is very essential for the proper operation of diesel engines. Lack of cooling capability of the cooling system may easily cause the overheat of engine. The cooling liquids of the cooling system can help take away extra heat produced during the engine operation, aiming at bringing down the temperature of the system to ensure that the whole system and each hot spare part can operate within optimal working temperature range.

To prevent overheat of the engine, diesel engine owned by power station is generally equipped with exhaust fan. The inter-cooler is often placed at the location close to the fan. The cooling air can first cool down the inter-cooler before it goes through the coolant tank.

(2) Engine ATB

ATB is a common indicator to measure the performance of the cooling system, representing the permitted ambient temperature for the normal operation of diesel engines at the power station. For diesel engine equipped with suction fan, ATB is equivalent to the permitted ambient temperature for engine operation. For diesel engine equipped with exhaust fan, the inter-cooler and air in the water tank are heated by the engine and its surface temperature. As a result, the air inlet temperature can represent the cooling system performance instead of ATB.

ATB (suction fan) =Tbp-TW+Ta

Air inlet temperature (exhaust fan) = Tbp -TW+Tia

Tbp: The boiling point of the cooling liquid. In standard environment, the boiling point of water is 100℃ and the boiling point of anti-freezing liquid is classified by its composition.

Tw: The cooling liquid temperature at the engine outlet.

Ta: The ambient temperature.

Tia: The cooling air temperature before getting into the inter-cooler and water tank.

Tia=Ta+Δt Δt: Temperature rise of cooling air before getting into the engine and generator. Generally, Δt equals to 4-7℃.

Herein, ATB=air inlet temperature -Δt; Under standard environment, ATB of diesel engines at power station is no less than 50℃.

(3) The pressure cap of water tank and expansion water tank

The pressure cap can increase the boiling temperature of cooling liquid, which is especially important for operation in high-temperature and high-altitude regions. The impact of the pressure of the pressure cap on the boiling point of cooling liquid is illustrated in the table below.

Altitude-m	Barometric pressure-kPa	Boiling point of water-℃	Boiling point of 50kPa pressure cap-℃	Boiling point of 70kPa pressure cap-℃
0	101	100	112	115
500	95	98	110	114
1000	89	96	109	113
2000	79	93	107	111
3000	69	90	105	109
4000	61	86	103	107

The expansion water tank can increase the expansion volume of cooling liquid for the cooling system, separate air from the cooling liquid, maintain a static pressure at the water inlet of the coolant pump and prevent cavitation erosion for water pump. The expansion water tank can be isolated from the diesel engine or installed in the upper water chamber of radiator tank.

(4) Design of the cooling system

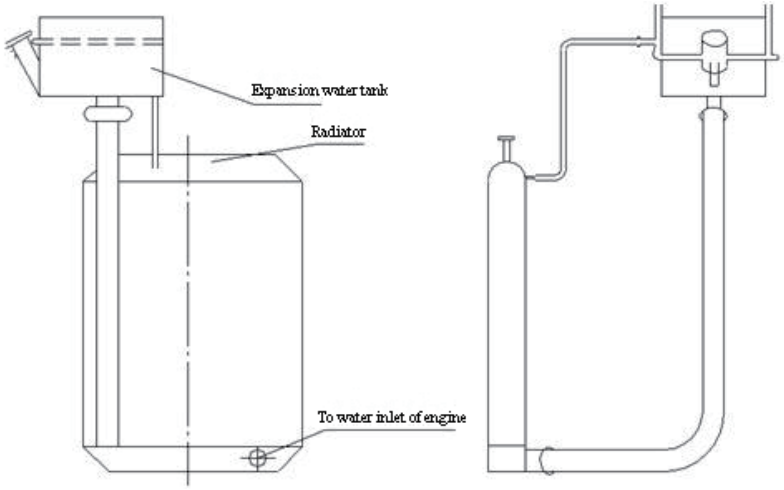
To improve the cooling efficiency and performance, the design of the cooling system should be carried out in accordance with the following principles:

① At rated speed, there should be a static pressure at the inlet of the engine water pump. In the case that a cooler is required in front of the water pump inlet, the negative pressure of the inlet should not exceed 2kPa.

② Ensure that the diameter of the fan is equal to the width or height of the water tank so that the fan can cover the area of the water tank as much as possible. There needs to be an appropriate distance between the fan and the water tank, which should not be less than 50mm. The clearance between these two parts must be within 15-25mm (as small as possible). Excessively large clearance may give rise to backflow of hot air and reduce the cooling performance.

③ Generally, the ideal temperature difference between the inlet and outlet of the water tank is within 6-10℃. The wind velocity is 6-10m/s. The speed of fan blade rim must not exceed 90m/s. The effective cooling air volume required by the diesel engines at power station is 1.1-1.4 m3/min•kW. And the area of the water tank facing the wind is 0.35-0.40/m2/100Kw.

The specific radiation area of water tank is 0.35-0.50m2/Kw.



7.Air inlet and exhaust system of diesel engine

Selection of air inlet and exhaust system is one of the most important factor affecting the engine power and its service life.

(1) Air filter. Choose correct air filter according to the working environment of the diesel engine. For engines operating indoors or in regions with less dust, paper air filter without centrifugal rough filter can be used. It is recommended to use dry air filter with centrifugal rough filter in dusty area.

The flow rate of air filter and the diameter of the connecting air pipe should be selected according to the air inlet flow rate specified in the specification data of diesel engine. At rated power, the air inlet resistance of the new air filter must be less than 2.5kPa.

The rated flow rate of air filter used in each engine model is listed in the table below.

Model	Rated flow rate of air filter(m^3/h)	Original resistance (kPa)
4DW81	≥240	≤2.5
4DW91	≥240	≤2.5
4DW92	≥240	≤2.5
4DW93	≥240	≤2.5
4DX21	≥240	≤2.5
4DX22	≥350	≤2.5
4DX23	≥350	≤2.5

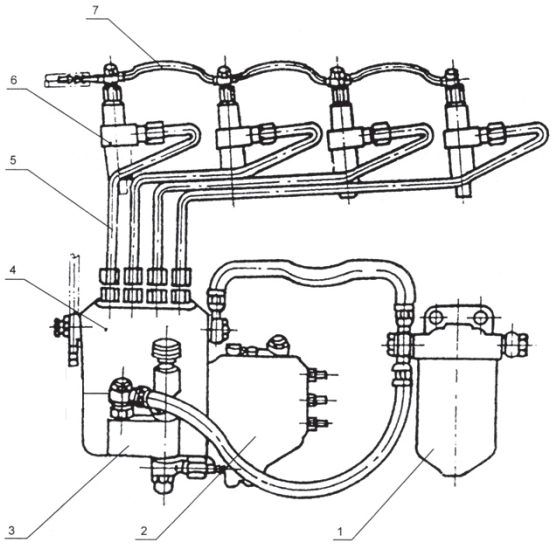
(2) Supercharged inter-cooler. Select the supercharged inter-cooler in accordance with the air inlet flow rate and heat taken away by the supercharged air. Under standard environment, the air temperature getting into the diesel engine through the inter-cooler should be within 45-50℃, which is specified in the emission requirements. The pressure drop produced by the inter-cooler must not exceed 10kPa.

(3) Exhaust pipe and muffler. The exhaust pipe diameter must be selected in line with the flow rate of the exhaust air and with the flow rate of the muffler.

8. The fuel supply system of diesel engine

The fuel and speed regulating systems, consisting of fuel supply pump, fuel filter, fuel injection pump, high and low pressure fuel pipe and fuel injector, are important parts for a diesel engine.

After fuel is pumped into the fuel filter from the fuel tank by the fuel supply pump, it will get into the fuel injection pump, where a high pressure is produced. Then the fuel will go through the high-pressure pipe and be sprayed into the combustion chamber by the fuel injector.



1-Fuel filter 2-governor 3-Fuel supply pump 4-Fuel injection pump
5-High pressure fuel pipe 6-Fuel injector 7-Fuel returning pipe

Figure 9.1 The fuel system

9. The speed governing system of diesel engine

According to the speed regulating performance, series diesel engine can offer mechanical governor and electronic governor to customers.

(1) Mechanical governor

Mechanical centrifugal-type governor is constituted by driving parts, sliding disk, sliding sleeve, governing spring and speed governing control shaft.

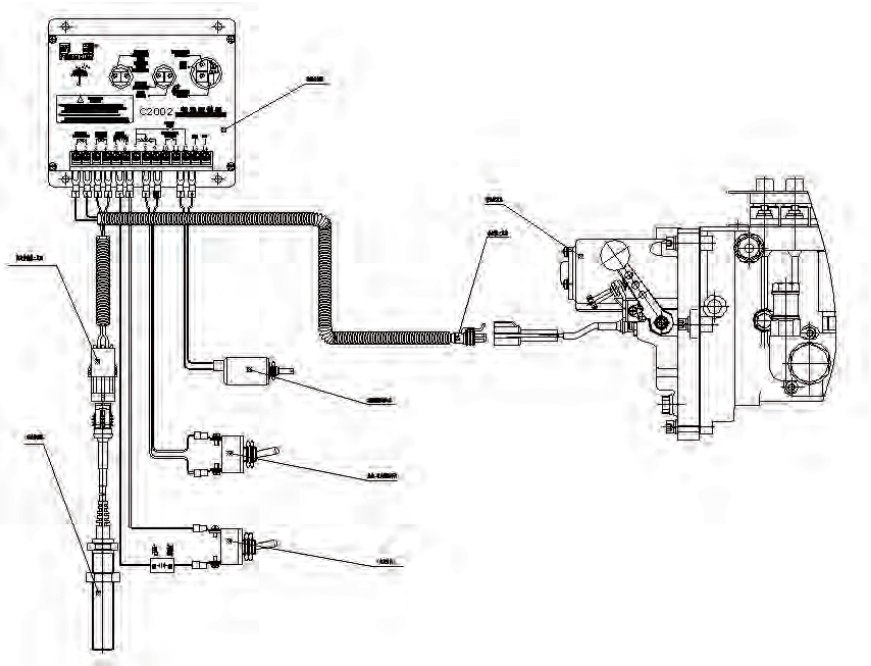
The operating speed governing lever can control the engine operation. When the lever is at the position of the idle speed limit screw, the engine is operation at idle speed. When the lever is at the position of maximum fuel supply, the engine is running at the maximum idle speed(the maximum speed rate without load). The engine speed will be reduced with the increase of load. When the engine is operating with rated power, its speed is reaching the rated speed. The location of the limit screw has been well adjusted before delivery. Don't modify it during operation.

Shut-down lever is fitted on the governor shell. Pull the lever to shut down the engine.

Respirator is installed on top of the governor cover and fuel drainage plug is fixed at the bottom. Because the governor seat is connected with the fuel pump, when the fuel indicating window of fuel injection pump shows the fuel level, the oil level of governor can also be enough for lubricating.

(2) Electronic governor

Diesel engine equipped with electronic governor can control the fuel injection by connecting the electro-mechanical actuator to the fuel injection pump. The electronic governor can obtain the speed signal by magneto-electrical sensor (typically installed near the flywheel gear ring for testing). Comparing the tested speed with the rated speed, the electronic governor can make relevant adjustment. Once the engine speed reaches the rated value, the electronic governor can promptly respond to the change of load and instantly get back to a stable status. The electronic governor can also provide users with strategy of smoke intensity reduction for engine start, overload protection and fuel limit function.



Wiring diagram of governor

Governor adjustment after engine start

① During engine start, adjust the potentiometer of engine start fuel level to regulate the fuel supply for actuator. Sufficient fuel supply can ensure complete engine start while limiting the black smoke produced by engine.

② After engine start, use controller to run the engine at idle speed. Idle speed potentiometer is used to set the engine speed for starting. If the external speed switch is turned off, engine will operate at rated speed instead of idle speed. Rated speed potentiometer is applied to adjust the rated engine speed. Precise adjustment can be realized by using rated speed potentiometer or external trimmer potentiometer. Rotate the rated speed setting knob in clockwise direction will increase the frequency.

③ For any unstable operation after engine start, adjust the gain or stability potentiometer to ensure stable engine operation.

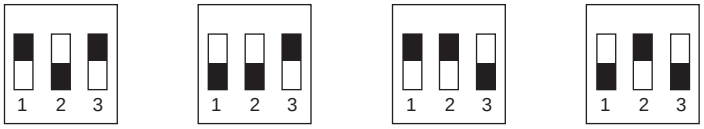
④ After engine start, make the following adjustment when the engine is running without load:
Rotate the gain potentiometer in clockwise direction until the operation is unstable. Then, rotate the gain potentiometer in anticlockwise direction until the operation is stable. Further adjust the potentiometer in anticlockwise direction to ensure stable operation.

Rotate the stability potentiometer in clockwise direction until the operation is unstable. Then, rotate the stability potentiometer in anticlockwise direction until the operation is stable. Further adjust the potentiometer in anticlockwise direction to ensure stable operation.

After the above adjustment for the gain and stability potentiometer, adjust the trimmer potentiometer to ensure a proper rated speed.

If idle operation is required, switch on the high/low speed switch and then adjust the idle potentiometer to ensure a proper engine speed. Rotation in clockwise direction can increase the frequency (normally 50% of the rated engine speed).

If engine still fails to operate in a stable status by the above procedures, there needs to be some adjustment for the dial switch. Refer to the four circumstances of dial switch adjustment illustrated in the below four figures before regulating the gain and stability potentiometer until the engine is running stably.



10. Engine Operation

10.1 Preparation before engine start

(1) Selection of diesel

Sulphur content of the diesel will directly determine the emission of engine. Please use diesel compliance with the sulfur content requirements of emission.

Users should choose proper grade of diesel according to the ambient temperature. At low temperature in winter, diesel with low freezing point is recommended to use. The selection is opposite for summer. Users can refer to Table 10.1 below for appropriate diesel. For instance, at the temperature of -27℃, users should choose to use -35# diesel.

Table 10.1 Relationship between Grade of Diesel and the Applicable Lowest Temperature

Grade of diesel fuel	10#	0#	-10#	-20#	-35#
Cetane number	50	50	50	45	43
Freezing point(℃)	+10	0	-10	-20	-35
Applicable Lowest Temperature (Ambient temperature)(℃)	+18	+8	-2	-12	-27

Make sure to keep diesel clean, without being polluted by dust and impurities. Put the diesel where it was for more than 72 hours before filling it to the fuel tank. Select diesel at the upper part of the container, which is of great essential to prevent earlier abrasion of fuel injection pump plunger.

(2) Selection of lubricating oil

To ensure proper operation of diesel engine and increase its service life, please select lubricating oil in line with the operation load of engine. For naturally aspirated diesel engine, lubricating oil of CD grade or above is recommended. For supercharged diesel engine, please select lubricating oil above CH grade.

Choose lubricating oil of various viscosity according to ambient temperature. Users can refer to below table for correct lubricating oil.

Applicable region	Chilly winter	Whole year for common area	Summer in south area
Lubricating oil grade	5W/30	30 or 15W/30	30 or 40
Applicable temperature range for API lubricating oil			
API viscosity grade	Ambient temperature		
	Lowest	Highest	
SAE 0W20	-40℃	10℃	
SAE 0W40	-40℃	40℃	
SAE 5W40	-30℃	40℃	
SAE 10W30	-20℃	40℃	
SAE 15W40	-10℃	40℃	
SAE 20W50	0℃	50℃	

In addition, lubricating oil must be kept clean to avoid confusion of lubricating oil of different grades.

(3) Selection of cooling liquids

Like fuel and lubricating oil, cooling liquid is also crucial for diesel engine. Correct selection of cooling liquids and proper maintenance of cooling system can prevent many failures concerned with the cooling system, such as overheat of diesel engine, leakage of coolant pump, blockage of radiator and cavitation erosion of cylinder liner.

Cooling liquid is generally constituted by three ingredients: water (distilled water or deionized water), additive and glycol.

Either ethylene glycol or propylene glycol can be selected as glycol. Glycol is used as cooling liquid/coolant for diesel engines providing services for routine and burdensome works. Where glycol and water are mixed with the same proportion, ethylene glycol and propylene glycol are similar in performances of boiling and freeze resistance. Performances of cooling liquids are listed below.

Table 10.3 Performances of Cooling Liquids

Ethylene glycol		
Concentration	Freezing point	Boiling point
50%	-36℃	106℃
60%	-51℃	111℃
Propylene glycol		
Concentration	Freezing point	Boiling point
50%	-29℃	106℃

The mixture concentration of propylene glycol must not exceed 50%. In case of extra boiling and freeze resistance, ethylene glycol is recommended.

Cooling liquids can effectively protect the metal surface of the cooling system. Cooling liquids listed above can protect diesel engines from freezing and boiling within the temperature range of -45℃ and 106℃ for the whole year.

Cooling liquids must be replaced at least every two years.

10.2 Getting prepared before starting the engine.

(1) Check the oil level of oil pan and keep it between the upper and lower marks of oil gauge;

(2) Check the remaining fuel in fuel tank;

(3) Turn on the switch of fuel tank so that fuel can flow to fuel injection pump;

(4) Discharge air from the fuel system of new engine;

(5) Check the cooling system and refill enough cooling liquids;

(6) In the event of chill and freezing temperature, diesel engine must be put in a warm place resisting cold and freeze. When engine is operating in the open air, warm up the oil pan and heat the cooling liquid before starting the engine.

10.3 Starting the engine

(1) Don't start the engine until all the preparation works are completed complying with the requirements. Start the engine as the following procedures:

Pull the locking-type switch to start the engine. To protect the starter and battery, each start cannot exceed 15 seconds. For each failure of start, wait at least 120 seconds before another attempt. In the event of three consecutive start failures, please find out the reasons and troubleshoot the failure before another start.

When engine is started at a temperature lower than -5℃, please switch on the air inlet electrical heater for 30 seconds before starting the diesel engine (The heater can be turned on during the engine start, but it's better not to run it for more than 45 seconds in total).

Please release the start button immediately after the engine is started and put the locking-type switch back to where it originally was.

(2) Check the oil pressure after the engine is started.

When engine is running at idle speed, make sure that oil pressure for BS-30KVA diesel engine and BS-50KVA diesel engine must be respectively no less than 78KPa and 98KPa. For newly-assembled diesel engine, please check the oil level for oil pan and add the oil if necessary to ensure that the oil level is between the upper and lower mark of oil gauge.

10.4 Engine operation

(1) Run the engine at idle speed for 3 to 5 minutes and check the sealing performance for its joints of fuel and water pipelines. Please repair it if any leakage is discovered. Make the engine run at the rated speed with less than 30% load. Pay attention to the oil pressure (oil pressure for 4DW diesel engine and 4DX diesel engine must be no less than 280KPa and 350KPa) and temperature of cooling liquids. In the event that the cooling liquid temperature is higher than 60 degree, run the engine with more load.

(2) For new engine or engine experiencing overhaul, don't run it with full load before 40 hours of low-load operation.

(3) Don't operate the diesel engine at idle speed for long term, especially for supercharged diesel engine. Excessively low oil pressure will increase the abrasion of its supercharger bearing.

10.5 Engine shut-down

(1) Remove the load and operate the engine at low or idle speed for 5 minutes before shut-down. For supercharged diesel engine, a certain period of operation without load before engine shut-down can protect the supercharger from damage due to hot load.

(2) If anti-freezing agent is not used at a temperature lower than 5℃, drain coolant promptly after engine is shut down to prevent damage of engine block.

(3) Every time after engine shut-down, please troubleshoot any failure discovered during the operation.

(4) If diesel engine is not used for a long period, please clean it and make proper oil seal to resist against rust.

11. Maintenance of diesel engine

Correct service and maintenance are crucial for good performance and long service-life of diesel engines. With proper service and maintenance, diesel engines can operate reliably for a long term and ensure good economical efficiency. Users must perform daily maintenance on their units strictly in accordance with instructions specified in this manual.

Please maintain and service your engines according to the instructions listed below and fill your maintenance records in the appendix “List of Maintenance and Service”. If engine is frequently operating at a temperature higher than 40 ℃, the time interval for maintenance must be reduced. If engine is working in an environment full of dust or under a situation where frequent shut-down is inevitable, its maintenance periods should also be reduced.

List - Maintenance Period and Contents of Diesel Engine

Time Interval of Maintenance	Ref	Maintenance Contents
After breaking-in (40 hours)	1	Drain the lubrication oil from the oil pan and clean the oil pan; replace with new lubricating oil.
	2	Clean the filter mesh for the lubricating oil collector
	3	Check the tightening torque for the fastening bolts of exhaust pipe
	4	Check and adjust the valve clearance
	5	Replace the fuel filter and lubricating oil filter; clean the dust on the air filter element
	6	Check the installation angle of fuel injection pump
	7	Check the driving belt tension
	8	Check for any cracks on suspension cushion and any loose for nuts

Daily maintenance	9	Check the lubricating oil level
	10	Check the cooling liquid level
	11	Check the tightness for joints of fuel, water and air pipelines; troubleshoot any defect.
Every three months or 300 hours	9~11	The same as the contents for daily maintenance
	12	Check the air intake system
	13	Check the air filter
	14	Replace lubricating oil
	15	Replace the full-type lubricating oil filter assembly and the bypass lubricating oil filter assembly
Every six months or 600 hours	9~15	The same as the maintenance required by that for three months
	16	Replace the fuel filter
	17	Check and adjust the valve clearance
	18	Check the tension of belt
	19	Check the bolts for exhaust manifold
Every two years or 2400 hours	9~19	The same as the maintenance required by that for six months
	20	Replace cooling liquids

Attention!

Air filter, fuel filter and lubricating oil filter are essential for long service-life of engines.

Please use genuine filter elements manufactured by the original supplier to ensure good quality.

Please replace the lubricating oil when engine is still hot.

Please adjust the valve clearance after engine is cooled down.

12.Troubleshooting of common failures

Reason of failure	Troubleshooting
1. Diesel engine cannot be started properly	
1. Low starting engine speed	
(1) Low battery capacity or loose connector.	(1) Charging: tighten the connector securely; repair the binding post if necessary.
(2) Poor contact between carbon brush of starter and rectifier.	(2) Repair or replace carbon brush.
(3) Starter teeth cannot be inserted into the flywheel gear ring.	(3) Move the flywheel disk; check the installation of starter if necessary to ensure that starter is parallel to the axis line of gear ring.
2. Abnormal fuel system	
(1) Empty fuel tank or valve of fuel tank is closed.	(1) Refill: open the valve.
(2) Air in fuel system or water mixed in fuel or fuel leakage for the connectors.	(2) Discharge the air; change the diesel fuel; tighten the connector securely.
(3) Fuel circuit blockage.	(3) Clean the pipelines; replace the element of fuel filter; clean the fuel inlet pipe of fuel supply pump.
(4) Fuel supply pump is not properly working.	(4) Check for any leakage of fuel inlet pipe of fuel supply pump; check the fuel supply pump.
(5) Fuel injector is not working or giving a poor performance with low torque and bad atomization; broken pressure adjustment spring of fuel injector; blockage of injection hole.	(5) Remove and check the fuel injector with the tester; inspect the starting of fuel injection pump.
(6) Leakage of fuel outlet valve for fuel injection pump; broken spring; abrasive plunger and barrel assembly.	(6) Grinding: repair or replace spare parts.
3. Poor compression pressure	
(1) Excessively large valve clearance.	(1) Make adjustment as specified.
(2) Air leakage of valves.	(2) Grinding valve.
(3) Air leakage of cylinder head liner.	(3) Replace cylinder head liner and screw the bolt of cylinder head tightly as specified.
(4) Piston ring is abrasive, gumming or repeated in the opening.	(4) Replacement, cleaning and adjustment.
4. Other reasons	
(1) Excessively low air temperature or large oil viscosity.	(1) Fill the cooling system with hot water; preheat starting technology is recommended; Use the designated oil grade.
(2) Water mixed in the combustion chamber or cylinders.	(2) Inspection, repair, replacement.

Reason of failure	Troubleshooting
2. Abnormal oil pressure	
1. Oil pressure is zero or too low	
(1) Excessively low oil level, giving rise to poor or thin oil quality.	(1) Oil filling; replace with new oil.
(2) Broken oil pipe;oil leakage due to loose pipe joint; damaged oil pressure gauge.	(2) Welding; tighten it securely; replacement.
(3) Deformation or breakage of pressure adjustment spring of oil pump.	(3) Replacement.
(4) Excessively large clearance of oil pump.	(4) Contact with factory to repair it; replacement.
(5) Broken oil pump gasket.	(5) Replacement.
(6) Excessively large clearance between each bearing.	(6) Inspection, adjustment or replacement.
(7) Plug screw of oil passage is loose and leaked.	(7) Check for blockage.
2. Oil pressure is too high	
(1) Relief valve of oil pump is not working properly, leading to poor oil returning.	(1) Inspection and adjustment.
(2) Large oil viscosity due to low temperature.	(2) Use the designated oil grade and the oil viscosity will be naturally dropped after warming.
3. No oil reaching rocker arm shaft	
(1) Blockage of oil holes for oil passage of upper cylinder head and at the bottom of seat for rocker arm shaft.	(1) Clean and dredge.

Reason of failure	Troubleshooting
3.Smoke in exhaust gas	
1. Black smoke	
(1) Fuel injector is blocked by carbon deposit and needle valve is getting stuck.	(1) Inspection, repair and replacement.
(2) Overload.	(2) Adjust load to ensure it is within the specified range.
(3) Delay of fuel injection and some fuel is burning during the process of emission.	(3) Adjust the fuel supply advanced angle of fuel injection pump.
(4) Incorrect valve clearance and poor tightness of valve.	(4) Check air valve clearance, contact of air valve sealing surface, performance of air valve spring to eliminate any defect.
(5) Uneven fuel supply of each cylinder for fuel injection pump.	(5) Adjust fuel supply of each cylinder.
(6) Blockage of air intake pipe and air filter.	(6) Remove and clean air filter.
2. White smoke	
(1) Low fuel injection pressure; poor atomization with fuel drip.	(1) Inspect, adjust, repair or replace fuel injector nozzle parts.
(2) Low coolant temperature.	(2) Increase coolant temperature.
(3) Water getting into the cylinder.	(3) Check cylinder head liner.
3. Blue smoke	
(1) Excessive abrasion of piston ring or oil getting into the combustion chamber due to bad elasticity as a result of carbon deposit.	(1) Clean or replace piston ring.
(2) Oil level is too high.	(2) Discharge extra oil.
(3) Conical air rings are installed upside down.	(3) Face the air ring marked with “upper” upwards.

Reason of failure	Troubleshooting
4. Insufficient power	
1. Blockage of fuel filter or filter of fuel inlet pipe connector for fuel supply pump.	1. Clean or replacement.
2. Incorrect pressure or poor atomization of fuel injector.	2. Inspect fuel injector or replace fuel injection nozzle parts.
3. Excessively abrasion of precise parts for fuel injection pump.	3. Adjust fuel supply; check plunger parts and fuel outlet valve part.
4. Deformation and loose of governor spring, disabling the engine to reach the rated speed.	4. Adjust high-speed limit screw or replace speed regulating spring.
5. Air mixed in the fuel system.	5. Discharge air from the fuel system.
6. Incorrect fuel supply advanced angle.	6. Adjust it as specified.
7. Uneven fuel supply for each cylinder.	7. Adjust fuel supply for each cylinder.
8. Blockage of air filter.	8. Clean or replace filter element.
9. Air valve leakage.	9. Check valve clearance, valve spring performance, abrasion of valve tube, sealing of valve and replace spare parts or inspect valves if necessary.
10. Lack of compression pressure.	10. Refer to section 1 and 3 of this chapter.
11. Wrong valve timing.	11. Excessive abrasion of camshaft and you may replace the camshaft.
12. Leakage of fuel injector hole.	12. Replace copper washer; clean the surface of holes; tighten the nuts of pressing plate evenly.
13. Loose cylinder head bolt.	13. Tighten the bolts according to the specified torque.

Reason of failure	Troubleshooting
5. Abnormal noise	
1. The fuel supply advanced angle is too large and there are noises inside the cylinder sound like knock on the metal.	1. Adjust the fuel supply advanced angle.
2. The fuel injection nozzle is dripping oil and meshed with the needle valve, causing noises sound like “da,da,da”.	2. Clean, repair or replace needle valve parts.
3. Too large valve clearance will cause clear and uniform knocking noise.	3. Adjust the valve clearance.
4. The collision between piston and valve will cause strong and uniform knocking noise (You will feel vibration of piston if putting your hands slightly on the nuts of cylinder head).	4. Increase the valve clearance properly;correct the clearance for connecting rod bearing or replace the connecting rod bearing shell.
5. Strong knocking noises can be head if piston is hitting the bottom of cylinder head.	5. Replace the cylinder head liner.
6. There will be slight knocking noises for the valve mechanism when valve spring is broken, valve pushing rod is bent or valve tappet is abrasive.	6. Replace spring, push rod or tappet and adjust the valve clearance.
7. Noises because of the large clearance between piston and cylinder liner will be relieved after the diesel engine is warming up.	7. Replace the cylinder liner and piston in line with the abrasion.
8. In case of great clearance between connecting rod bearing, strong knocking noise can be heard when the speed is abruptly dropped.	8. Replace the connecting rod bearing.
9. Large clearance between connecting rod liner and piston pin will result in slight and sharp noise that can be especially heard at idle speed.	9. Replace the connecting rod liner.
10. If the thrust plate of crankshaft is greatly worn with large clearance, the noise caused by the knock of crankshaft at idle speed can be heard.	10. Replace the thrust plate of crankshaft.

Reason of failure	Troubleshooting
6. Severe vibration	
1. Uneven fuel supply for each cylinder; some fuel injection nozzles have bad atomization, severe gas leakage and compression ratios of cylinders differ greatly with each other. 2. Water and gas mixed in the diesel fuel. 3. The alignment is not proper for engine installation and supporting bolts are not tightly fixed. 4. Knocking noises heard from diesel engine during operation.	1. Inspect and adjust fuel supply of fuel injection pump; repair fuel injection nozzle; eliminate leakage and check the compression pressure for each cylinder. 2. Discharge the air and make the diesel fuel precipitate. 3. Check the alignment and tighten the bolt securely. 4. Check the fuel supply advanced angle and apply the load after the diesel engine is warmed up.
7. Engine overheat	
1. Fuel is getting into the crankcase; oil is diluted with water; oil is insufficient or excessive; the flow rate of oil is too small with low pressure; the bearing clearance is too small. 2. Water pump impeller is damaged or cracked; fan belt is slippery; radiator and fan are not installed in proper positions; failure of thermostat; blockage of cooling system; incrustation is greatly built up in water jacket; insufficient displacement of water pump; lack of water; fuel gas is getting into the water channel because of the broken cylinder head liner.	1. Inspect and replace piston ring; replace the oil; check the oil level; check the abrasion of outer rotor inside the oil pump; check the clearance between the bearings. 2. Check and replace water pump impeller; Check the tension of fan belt or replace the belt; check the installation position of radiator; check the performance of thermostat; clean the cooling system and water jacket; check the clearance of water pump impeller; refill the water; replace cylinder head liner.
8. Excessively large oil consumption	
1. Use wrong oil grade with low oil viscosity. 2. Great abrasion between piston and cylinder liner; blockage of oil returning hole for piston ring groove. 3. Piston ring is glued; F-side of air ring is installed inversely with much abrasion. 4. Oil leakage discovered for the front and rear oil seal of crankshaft, connecting surface of oil pan and side cover seals. 5. The oil temperature and pressure is too high.	1. Change to the designated oil grade. 2. Replace and clean the oil returning hole. 3. Clean or replace. 4. Check or replace relevant spare parts. 5. Reduce the temperature(Refer to the last section); check and adjust the relief valve of oil pump.

Reason of failure	Troubleshooting
9. Sharply increase of engine speed	
1. Governor is failed; pull rod is getting stuck at the position of high fuel level.	1. Repair governor and its pull rod.
2. Sliding disk sleeve of governor is getting stuck.	2. Repair it.
3. Adjusting arm is removed from fork.	3. Repair it.
10. Shut-down by itself	
1. Air mixed in fuel pipeline; failure of fuel supply pump; blockage of fuel filter.	1. Discharge air and repair the fuel supply pump; clean the diesel filter.
2. Piston seizing; shaft neck is completely seized by bearing bush.	2. Since the clearance is not correct, repair and replace it.
3. Fuel outlet valve of fuel injection pump is getting stuck; broken of plunger spring; Sliding disk sleeve of governor is getting stuck.	3. Repair or replace it.
11. Engine speed fluctuated within a certain range	
1. Uneven fuel supply for each cylinder; fuel drip of fuel injector; fork screws of pull rod are loose.	1. Make the adjustment and ensure the even fuel supply for each cylinder; repair or replace the needle valve parts for fuel injection nozzle; fix the fork screw.
2. Clearance between fork and adjusting arm is too large; sink mark appears as the result of abrasion between steel ball and sliding plate.	2. Replace spare parts.
3. The axial movement of fuel injection pump and camshaft is too large.	3. Adjust with copper washer.
4. Sliding disk sleeve is getting stuck.	4. Clean, repair or replace the sleeve.

Appendix 1 Altitude and Air Density

Altitude (M)	Barometric Pressure (mmHg)	Barometric Pressure (kPa)	Air Density (kg/m^3)									
			0℃	5℃	10℃	15℃	20℃	25℃	30℃	35℃	40℃	45℃
0	760	101.30	1.29	1.27	1.25	1.23	1.21	1.18	1.17	1.15	1.13	1.11
	750	99.97	1.28	1.25	1.23	1.21	1.19	1.17	1.15	1.13	1.11	1.10
300	736	98.10	1.25	1.23	1.21	1.19	1.17	1.15	1.13	1.11	1.09	1.08
500	717	95.50	1.22	1.20	1.18	1.16	1.14	1.12	1.10	1.08	1.06	1.05
1000	675	89.90	1.15	1.13	1.11	1.09	1.07	1.05	1.03	1.02	1.00	0.99
2000	596	79.44	1.01	1.00	0.98	0.96	0.95	0.93	0.91	0.90	0.88	0.87
3000	526	70.11	0.90	0.88	0.86	0.85	0.83	0.82	0.81	0.79	0.78	0.77
4000	462	61.58	0.79	0.77	0.76	0.75	0.73	0.72	0.71	0.70	0.69	0.68
5000	405	53.98	0.69	0.68	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59

Appendix 2 Power Modified Ratio of Diesel Engine

Altitude (M)	Barometric Pressure (mmHg)	Barometric Pressure (kPa)	Air Density / Density of State for Standard Environment									
			0℃	5℃	10℃	15℃	20℃	25℃	30℃	35℃	40℃	45℃
0	760.0	101.30	1.11	1.09	1.07	1.05	1.03	1.01	1.00	0.98	0.96	0.95
	750.0	99.97	1.09	1.07	1.05	1.03	1.02	1.00	0.98	0.97	0.95	0.94
300	736.0	98.10	1.07	1.05	1.03	1.02	1.00	0.98	0.97	0.95	0.93	0.92
500	716.5	95.50	1.04	1.02	1.01	0.99	0.97	0.96	0.94	0.92	0.91	0.90
1000	674.5	89.90	0.98	0.96	0.95	0.93	0.91	0.90	0.88	0.87	0.86	0.84
2000	596.0	79.44	0.87	0.85	0.84	0.82	0.81	0.79	0.78	0.77	0.76	0.74
3000	526.0	70.11	0.77	0.75	0.74	0.73	0.71	0.70	0.69	0.68	0.67	0.66
4000	462.0	61.58	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58
5000	405.0	53.98	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.51