Table S1. Fuel elements and characteristics statistical results.

Ingredient	Unit	Valve	Standard
Carbon	%, m/m	85.15~86.99	GB/T 476-2008; NB/SH/T 0656-2017
Hydrogen	%, m/m	12.61~14.62	GB/T 476-2008; NB/SH/T 0656-2017
Oxygen	%, m/m	0.06~0.81	Differential subtraction
Nitrogen	%, m/m	0.00~0.04	GB/T 19227-2008; SH/T 0657-2007
Sulfur	%, m/m	0.00~0.09	ISO 8754-2003; SH/T 0689-2000
Gross calorific value	MJ/kg	44.49~46.30	ASTM D240-2019; GB/T 384-1981
Net calorific value	MJ/kg	42.01~43.12	ASTM D240-2019; GB/T 384-1981
Viscosity(20℃)	mm^2/s	3.85~5.05	ISO 3104-1994; GB/T 265-1988
Density(20℃)	kg/m^3	820.7~845.0	GB/T1885-1998; GB/T 1884-2000
Water content	%, m/m	0.00~0.05	ISO 3733-1999; GB/T 260-2016

Table S2. Fuel-based emission factors-CHINA I emission standard. (kg/t-fuel)

Cycle	SV [1] (L)	SP [2] (kW)	n [3]	EF^f_{NOx} x±s [4]	EF^f_{CO} x±s	EF^f_{CO2} x±s	EF^f_{HC} x±s	EF^f_{NOx+HC} x±s
E3	A	-	-	-	-	-	-	-
	B	14~28	4	24.73±3.26	2.47±1.19	3087±13	1.07±0.37	25.80±3.25
	C	33~100	14	29.84±2.53	3.04±1.22	3130±52	1.26±0.80	31.10±2.31
	D	73~245	12	32.95±3.47	4.67±1.59	3078±32	2.49±1.44	35.44±3.77
	E	245	1	39.14	4.28	3077	2.43	41.57
	F	340~365	2	42.22±4.81	5.14±2.01	3083±10	2.65±0.25	44.87±4.56
	G	400	1	34.93	5.76	3121	1.45	36.38
E2	A	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
	C	92	1	28.33	3.65	3079	0.97	29.30
	D	100~245	9	28.10±2.62	3.84±1.78	3080±29	3.18±1.97	31.28±3.14
	E	221~294	3	29.03±4.09	3.16±1.17	3086±41	2.65±1.36	31.68±4.35
	F	330~365	2	37.41±1.56	3.91±1.58	3083±11	3.06±0.39	40.47±1.17
	G	400	1	31.41	7.78	3116	1.99	33.40
D2	A	-	-	-	-	-	-	-
	B	14~40	4	24.98±4.38	5.20±4.55	3081±44	2.36±1.70	27.34±3.18
	C	48~100	8	26.35±2.44	4.32±1.10	3102±39	1.62±1.01	27.96±1.59
	D	100~245	10	26.99±3.66	5.25±2.13	3056±33	4.14±3.13	31.13±3.06
	E	202~268	2	33.10±1.09	5.62±1.13	3058±37	2.65±1.61	35.75±2.71
	F	300	1	38.41	4.05	3079	3.66	42.07
	G	375	1	29.42	13.22	3103	2.60	32.02

[1] SV represents the single cylinder displacement; [2] SP represents the single cylinder power;
[3] n represents the number of samples. [4] x represents the mean, and s represents the standard deviation;

Table S3. Fuel-based emission factors-CHINA II emission standard. (kg/t-fuel)

Cycle	SV [1] (L)	SP [2] (kW)	n [3]	EF^f_{NOx} x±s [4]	EF^f_{CO} x±s	EF^f_{CO2} x±s	EF^f_{HC} x±s	EF^f_{NOx+HC} x±s
E3	A	19~30	2	21.13±1.30	1.64±0.36	3048±18	0.45±0.12	21.58±1.41
	B	-	-	-	-	-	-	-
	C	33~135	7	20.68±2.41	2.50±0.47	3117±45	1.05±0.70	21.73±2.41
	D	73~221	8	25.55±5.58	3.88±2.12	3096±47	1.10±0.58	26.64±5.92
	E	221~335	5	32.40±3.77	4.90±1.49	3087±52	2.51±0.80	34.91±3.92
	F	365	1	44.03	3.36	3087	2.32	46.35
	G	400~450	4	39.55±3.72	5.46±1.47	3104±42	1.17±0.39	40.72±3.47

	A	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
	C	135	1	22.50	1.85	3088	0.89	23.39
E2	D	73~213	5	24.10±0.90	3.70±1.82	3093±47	1.15±1.01	25.25±1.41
	E	239~325	4	28.95±3.65	3.38±0.61	3076±51	3.15±0.81	32.10±3.63
	F	-	-	-	-	-	-	-
	G	300~450	4	36.61±4.03	5.21±1.86	3104±41	1.75±0.76	38.36±3.48
	A	15	1	14.99	3.21	3048	1.48	16.47
	B	-	-	-	-	-	-	-
	C	58~135	4	22.21±1.55	4.87±2.34	3087±19	1.89±1.42	24.10±1.39
D2	D	73~213	6	22.13±2.35	5.62±2.95	3080±63	2.13±1.32	24.26±2.21
	E	202~325	5	27.54±3.43	4.70±0.78	3043±11	3.82±1.10	31.36±2.86
	F	-	-	-	-	-	-	-
	G	394	2	39.55±4.71	4.88±1.02	3059±3	2.00±1.20	41.55±3.51

[1] SV represents the single cylinder displacement; [2] SP represents the single cylinder power;
[3] n represents the number of samples. [4] x represents the mean, and s represents the standard deviation;

Table S4. Energy-based emission factors-CHINA I emission standard. (g/kW•h)

Cycle	SV [1] (L)	SP [2] (kW)	n [3]	EF^e_{NOx} x±s [4]	EF^e_{HC} x±s	EF^e_{CO2} x±s	EF^e_{NOx+HC} x±s	EF^e_{NOx+HC} margin [5] (%)	EF^e_{PM} x±s	EF^e_{PM} margin (%)	EF^e_{CO} x±s	EF^e_{CO} margin (%)
E3	A	-	-	-	-	-	-	-	-	-	-	-
	B	14~28	4	5.50±0.51	0.20±0.07	683±34	5.70±0.49	21	0.10±0.08	67	0.49±0.24	90
	C	33~10	14	5.91±0.48	0.25±0.16	642±20	6.16±0.42	14	0.08±0.03	60	0.56±0.23	89
	D	73~24	12	6.48±0.61	0.49±0.26	635±23	6.97±0.67	11	0.16±0.05	41	0.93±0.33	81
	E	245	1	8.04	0.50	645	8.54	2	0.18	64	0.62	88
	F	340~3	2	8.22±0.78	0.53±0.07	620±10	8.75±0.71	11	0.13±0.01	74	0.95±0.39	81
	G	400	1	6.99	0.29	627	7.28	34	0.10	80	0.93	81
E2	A	-	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-	-
	C	92	1	5.96	0.20	645	6.16	14	0.09	55	0.70	86
	D	100~2	9	6.03±0.52	0.61±0.34	654±22	6.63±0.54	15	0.15±0.05	44	0.77±0.32	85
	E	221~2	3	6.38±1.10	0.53±0.28	657±34	6.91±1.19	21	0.19±0.05	62	0.59±0.23	88
	F	330~3	2	7.71±0.34	0.57±0.07	629±5	8.28±0.26	16	0.13±0.01	74	0.79±0.39	84
	G	400	1	6.63	0.37	638	7.00	36	0.18	64	1.19	76
D2	A	-	-	-	-	-	-	-	-	-	-	-
	B	14~40	4	5.56±0.56	0.35±0.23	672±59	5.92±0.51	18	0.05±0.02	83	0.86±0.80	83
	C	48~10	8	5.75±0.53	0.34±0.23	678±46	6.09±0.41	15	0.12±0.04	40	0.87±0.52	83
	D	100~2	10	6.13±0.74	0.76±0.53	679±19	6.89±0.54	12	0.20±0.02	26	0.97±0.39	81
	E	202~2	2	7.52±0.31	0.51±0.30	658±12	8.03±0.61	8	0.36±0.08	28	0.94±0.20	81
	F	300	1	8.53	0.71	659	9.24	6	0.26	48	0.75	85
	G	375	1	6.56	0.43	660	6.99	36	0.34	32	2.30	54

[1] SV represents the single cylinder displacement; [2] SP represents the single cylinder power; [3] n represents the number of samples; [4] x represents the mean, and s represents the standard deviation; [5] margin=(Avg.-Limit)/Limit×100%, limit value seen in Table 2.

Table S5. Energy-based emission factors-CHINA II emission standard. (g/kW•h)

Cycle	SV [1] (L)	SP [2] (kW)	n [3]	EF^e_{NOx} x±s [4]	EF^e_{HC} x±s	EF^e_{CO2} x±s	EF^e_{NOx+HC} x±s	EF^e_{NOx+HC} margin [5] (%)	EF^e_{PM} x±s	EF^e_{PM} margin (%)	EF^e_{CO} x±s	EF^e_{CO} margin (%)
E3	A	19~30	2	4.67±0.07	0.09±0.02	680±28	4.76±0.08	18	0.05±0.03	83	0.37±0.12	93
	B	-	-	-	-	-	-	-	-	-	-	-
	C	33~135	7	4.55±0.69	0.21±0.14	699±43	4.76±0.65	18	0.06±0.02	50	0.53±0.16	89
	D	73~221	8	5.52±0.69	0.23±0.12	692±35	5.75±0.75	-	0.09±0.02	-	0.72±0.45	86

	E	221~335	5	6.53±0.74	0.50±0.16	633±29	7.03±0.80	-	0.16±0.07	-	0.72±0.24	86
	F	365	1	8.61	0.46	630	9.07	7	0.07	86	0.65	87
	G	400~450	4	7.54±0.47	0.21±0.08	612±13	7.76±0.45	30	0.08±0.01	84	0.96±0.25	81
	A	-	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-	-
	C	135	1	4.83	0.17	685	5.00	14	0.07	42	0.36	93
E2	D	73~213	5	5.44±0.21	0.23±0.20	690±11	5.67±0.29	-	0.10±0.01	-	0.75±0.39	85
	E	239~325	4	6.25±0.78	0.63±0.16	656±6	6.88±0.80	-	0.20±0.09	-	0.64±0.13	87
	F	-	-	-	-	-	-	-	-	-	-	-
	G	300~450	4	7.40±0.60	0.29±0.13	624±16	7.69±0.55	30	0.11±0.01	78	0.95±0.28	81
	A	15	1	3.48	0.22	682	3.70	36	0.08	73	0.55	89
	B	-	-	-	-	-	-	-	-	-	-	-
	C	58~135	4	4.90±0.16	0.30±0.20	692±20	5.20±0.14	10	0.07±0.02	42	0.74±0.34	85
D2	D	73~213	6	5.20±0.35	0.36±0.24	718±33	5.56±0.33	-	0.10±0.01	29	0.93±0.38	81
	E	202~325	5	6.28±0.70	0.77±0.24	674±45	6.06±0.70	-	0.25±0.10	-	0.87±0.15	83
	F	-	-	-	-	-	-	-	-	-	-	-
	G	394	2	8.15±1.09	0.31±0.18	619±25	8.46±0.91	23	0.14±0.01	72	0.99±0.11	80

[1] SV represents the single cylinder displacement; [2] SP represents the single cylinder power; [3] n represents the number of samples; [4] x represents the mean, and s represents the standard deviation; [5] margin=(Avg.-Limit)/Limit×100%, limit value seen in Table 3.

Table S6. Carbon balance calculation method.

<table>
<tr><th>No.</th><th>Formula and Symbol</th><th>Unit</th></tr>
<tr><td rowspan="5">1</td><td>$$q_{mew} = q_{mf} \times \left\{ \left[\frac{\omega_{BET} \times \omega_{BET} \times 1.4}{\left(\frac{1.4 \times \omega_{BET}}{f_c} + \omega_{ALF} \times 0.08936 - 1 \right) \times \frac{1}{1.293} + f_{fd}} \right] + \omega_{ALF} \times 0.08936 \right.$$ $$\left. - 1 \right] \times \left(1 + \frac{H_a}{1000} \right) + 1 \right\}$$</td><td></td></tr>
<tr><td>q_{mew}: Exhaust gas mass flow rate on wet basis</td><td>kg/h</td></tr>
<tr><td>q_{mf}: Fuel mass flow rate</td><td>kg/h</td></tr>
<tr><td>Symbols for fuel composition:
<table>
<tr><td>ω_{ALF}</td><td>H content of fuel</td></tr>
<tr><td>ω_{BET}</td><td>C content of fuel</td></tr>
<tr><td>ω_{GAM}</td><td>S content of fuel</td></tr>
<tr><td>ω_{DEL}</td><td>N content of fuel</td></tr>
<tr><td>ω_{EPS}</td><td>O content of fuel</td></tr>
</table></td><td>%m/m</td></tr>
<tr><td rowspan="5">2</td><td>Ha: Absolute humidity of the intake air (g water /kg dry air)</td><td></td></tr>
<tr><td>$Ha=\frac{6.22\times pa\times Ra}{ps}=\frac{6.22\times pa\times Ra}{pb-0.01\times pa\times Ra}$</td><td>g/kg</td></tr>
<tr><td>pa: Saturation vapour pressure of the engine intake air determined using a temperature value for the intake air measured at the same physical location as the measurements for pb and Ra.</td><td>kPa</td></tr>
<tr><td>Ra: Relative humidity of the intake air</td><td>%</td></tr>
<tr><td>ps: Dry atmospheric pressure calculated by the following formula:
ps = Pb - Ra• Pa / 100</td><td>kPa</td></tr>
<tr><td>pb: Total barometric pressure</td><td>kPa</td></tr>
<tr><td rowspan="5">3</td><td>f_c: Carbon factor</td><td></td></tr>
<tr><td>$fc=(C_{CO2d}-C_{CO2ad})\times 0.5441+\frac{C_{COd}}{18522}+\frac{C_{HC\omega}}{17355}$</td><td>1</td></tr>
<tr><td>C_{CO2} d: CO_2 concentration in exhaust gas, dry</td><td>%</td></tr>
<tr><td>C_{CO2} ad: CO_2 concentration in the atmosphere, dry</td><td>%</td></tr>
<tr><td>C_{CO} d: CO concentration in exhaust gas, dry</td><td>ppm</td></tr>
<tr><td>$C_{HC\omega}$ d: HC concentration in exhaust gas, wet</td><td>ppm</td></tr>
<tr><td rowspan="2">4</td><td>$$f_{fd} = -0.055593 \times \omega_{ALF} + 0.0080021 \times \omega_{DEL} + 0.0070046 \times \omega_{EPS}$$</td><td>1</td></tr>
<tr><td>f_{fd}: Fuel-specific factor for exhaust flow calculation on dry-basis</td><td>1</td></tr>
<tr><td rowspan="3">5</td><td>k_{wr2}: Dry to wet correction factor for the raw exhaust gas</td><td></td></tr>
<tr><td>$k_{wr2}=\frac{1}{1+\alpha\times 0.005\times[C_{CO2d}+C_{COd}]-0.01\times C_{H2d}+k_{W2}-\frac{pr}{pb}}$</td><td>1</td></tr>
<tr><td>$\alpha=11.9164\times\frac{\omega_{ALF}}{\omega_{BET}}$</td><td>1</td></tr>
</table>

<table>
<tr><td></td><td>$C_{H2d}=\frac{0.5\times\alpha\times C_{COd}\times(C_{CO2d}+C_{COd})}{C_{COd}+3\times C_{CO2d}}$</td><td>1</td></tr>
<tr><td></td><td>$k_{w2}=\frac{1.608\times Ha}{1000+1.608\times Ha}$</td><td>1</td></tr>
<tr><td rowspan="5">6</td><td>KH: Humidity correction factor for NO_x</td><td></td></tr>
<tr><td>$KH=\frac{1}{1+A\times(Ha-10.71)+B\times(Ta-298)}$</td><td>1</td></tr>
<tr><td>A: $A=0.309\times\frac{qmf}{qmad}-0.0266$</td><td>1</td></tr>
<tr><td>B: $B=-0.209\times\frac{q_{mf}}{q_{mad}}+0.00954$</td><td>1</td></tr>
<tr><td>q_{mf}: Fuel mass flow rate</td><td>kg/h</td></tr>
<tr><td></td><td>qmad: Intake air mass flow rate on dry basis</td><td>kg/h</td></tr>
<tr><td rowspan="5">7</td><td>Emission mass flow rate of individual gas</td><td></td></tr>
<tr><td>$q_{mgas}=u_{gas}\times c_{gas}\times q_{mew}\times KH$ (for NOx)</td><td>g/h</td></tr>
<tr><td>$q_{mgas}=u_{gas}\times c_{gas}\times q_{mew}$ (for other gases)</td><td>g/h</td></tr>
<tr><td>c_{gas}: concentration of the respective component in the raw exhaust gas, wet
$c_w=k_{wr2}\times c_d$</td><td>ppm</td></tr>
<tr><td>Coefficient u_{gas} and fuel-specific parameters for raw exhaust gas
<table>
<tr><td>Gas</td><td></td><td>NO_X</td><td>CO</td><td>HC</td><td>CO_2</td><td>O_2</td></tr>
<tr><td>ρ_{gas}</td><td>kg/m^3</td><td>2.053</td><td>1.250</td><td>*</td><td>1.9636</td><td>1.4277</td></tr>
<tr><td></td><td>ρ_e **</td><td colspan="5">Coefficient u_{gas} ***</td></tr>
<tr><td>Fuel oil</td><td>1.2943</td><td>0.001586</td><td>0.000966</td><td>0.000479</td><td>0.001517</td><td>0.001103</td></tr>
</table>
* depending on fuel
** ρ_e is the normal density of the exhaust gas
*** at λ=2, wet air, 273K, 101.3 kPa
λ: Excess air factor, kg dry air/(kg fuel • A/Fst)
A/Fst: Stoichiometric air to fuel ratio</td><td></td></tr>
<tr><td>8</td><td>$EF^e_{gas}=\frac{\sum_{i=1}^{n} q_{mags,i}\bullet W_{F,i}}{\sum_{i=1}^{n} P_i\bullet W_{F,i}}\bullet 10^3$
q_{mgas} : the mass flow of individual gas
P_i: the measured power of the individual mode
W_F: weighting factor</td><td>g/kW•h</td></tr>
<tr><td>9</td><td>$f_a=(\frac{99}{p_s})^{0.7}\times(\frac{T_a}{298})^{1.5}$
$p_s=p_b-R_a\times p_a/100$
Ta: Intake air temperature, K;
Ra: Relative humidity of the intake air,%;
Pb: Atmospheric pressure, kPa;
Pa: Saturation vapour pressure of the engine intake air determined using a temperature value for the intake air measured at the same physical location as the measurements for pb and Ra, kPa.</td><td>1</td></tr>
</table>

Table S7. Marine diesel engine parameters under CHINA I emission standard (E3-cycle).

No.	Number of cylinders	Cylinder bore (mm)	Rated power(kW)	Rated speed (r/min)	Single-cylinder displacement (L)	V-type/ L-type
1	6	105	168	2230	1.1	L
2	4	105	56	1500	1.1	L
3	6	105	168	2230	1.1	L
4	6	105	168	2230	1.1	L
5	12	170	1103	1500	4.5	V
6	6	160	300	1000	4.5	L
7	6	160	441	1500	4.0	L
8	6	127	354	1800	2.1	L
9	6	126	240	1500	1.9	L
10	6	126	256	1800	1.6	L
11	6	108	197	1800	1.3	L
12	6	127	368	1800	2.1	L
13	6	126	205	1500	1.6	L
14	6	150	478	1500	3.3	L
15	6	150	368	1500	2.7	L
16	6	170	601	1500	4.5	L
17	6	170	601	1500	4.5	L
18	6	160	556	1500	4.3	L
19	6	190	750	1200	6.4	L
20	6	180	600	1500	5.3	L
21	6	210	920	1000	10.0	L
22	6	200	1103	1000	9.0	L
23	6	250	1400	1000	14.7	L
24	6	150	1470	1000	14.7	L
25	6	200	1320	1000	9.4	L
26	6	180	440	1000	5.3	L
27	8	200	1325	1200	8.6	L
28	6	250	1470	1000	14.7	L
29	6	200	810	1000	8.5	L
30	6	200	1200	1000	9.4	L
31	6	250	1470	850	15.7	L
32	6	270	2190	800	22.0	L
33	8	270	2720	800	21.8	L
34	6	280	2400	800	25.3	L

Table S8. Marine diesel engine parameters under CHINA I emission standard (E2-cycle).

No.	Number of cylinders	Cylinder bore (mm)	Rated power(kW)	Rated speed (r/min)	Single-cylinder displacement (L)	V-type/ L-type
1	12	170	1103	1500	4.5	V

2	6	230	1213	1000	11.5	L
3	6	200	1200	1000	9.4	L
4	6	180	600	1500	5.3	L
5	6	210	920	1000	10.0	L
6	6	200	1103	1000	9.0	L
7	6	250	1470	1000	14.7	L
8	6	200	810	1000	8.5	L
9	6	200	1320	1000	9.4	L
10	6	250	1470	1000	14.7	L
11	6	250	1324	825	15.7	L
12	6	230	1765	850	17.5	L
13	6	250	1470	850	15.7	L
14	6	270	2190	800	22.0	L
15	8	270	2640	750	21.8	L
16	6	280	2400	800	25.3	L

Table S9. Marine diesel engine parameters under CHINA I emission standard (D2-cycle).

No.	Number of cylinders	Cylinder bore (mm)	Rated power(kW)	Rated speed (r/min)	Single-cylinder displacement (L)	V-type/ L-type
1	4	105	56	1500	1.1	L
2	6	105	240	1500	1.1	L
3	6	105	138	1500	1.1	L
4	6	105	138	1500	1.1	L
5	6	127	287	1500	2.1	L
6	6	126	288	1500	1.9	L
7	12	170	1103	1500	4.5	V
8	6	127	350	1500	2.1	L
9	6	170	601	1500	4.5	L
10	6	150	500	1500	3.3	L
11	6	150	440	1500	2.7	L
12	6	160	441	1500	4.0	L
13	6	250	1470	1000	14.7	L
14	6	200	810	1000	8.5	L
15	6	250	1470	1000	14.7	L
16	6	200	1320	1000	9.4	L
17	8	200	1325	1200	8.6	L
18	6	230	1213	1000	11.5	L
19	6	200	1200	1000	9.4	L
20	6	180	600	1500	6.3	L
21	6	210	920	1000	10.0	L
22	6	200	1103	1000	9.0	L
23	6	260	1610	750	17.5	L
24	6	250	1213	750	15.7	L

25	6	270	1800	750	22.0	L
26	6	280	2250	750	25.3	L

Table S10. Marine diesel engine parameters under CHINA II emission standard (E3-cycle).

No.	Number of cylinders	Cylinder bore (mm)	Rated power(kW)	Rated speed (r/min)	Single-cylinder displacement (L)	V-type/ L-type
1	4	94	118	3000	0.7	L
2	4	89	75	2100	0.6	L
3	6	127	735	2300	2.1	L
4	6	108	197	1800	1.3	L
5	6	127	405	1800	2.1	L
6	6	170	601	1500	4.5	L
7	6	170	601	1500	4.5	L
8	12	170	1620	1500	4.5	V
9	6	140	390	1800	2.2	L
10	6	180	440	1000	5.3	L
11	12	180	2536	1800	5.5	V
12	6	170	810	1500	5.0	L
13	6	200	810	1350	6.6	L
14	8	200	1765	1000	9.4	L
15	6	200	810	1000	8.5	L
16	6	200	1000	1200	8.6	L
17	16	200	2400	1100	8.5	V
18	6	250	1800	1000	16.2	L
19	8	250	2680	1000	16.2	L
20	8	250	1912	1000	16.2	L
21	6	260	1765	850	17.5	L
22	6	250	1324	825	15.7	L
23	7	270	2555	800	21.8	L
24	6	280	2647	800	25.3	L
25	6	280	2400	800	25.3	L
26	6	280	2700	800	25.3	L
27	6	280	2647	800	25.3	L

Table S11. Marine diesel engine parameters under CHINA II emission standard (E2-cycle).

No.	Number of cylinders	Cylinder bore (mm)	Rated power(kW)	Rated speed (r/min)	Single-cylinder displacement (L)	V-type/ L-type
1	12	170	1620	1500	4.5	V
2	12	180	2200	1500	5.5	V
3	6	170	735	1500	5.0	L
4	6	180	440	1000	5.3	L

5	8	200	1700	1000	9.4	L
6	6	200	810	1000	8.5	L
7	6	250	1800	1000	16.2	L
8	8	250	2600	1000	16.2	L
9	8	250	1912	1000	16.2	L
10	6	260	1765	850	17.5	L
11	6	280	2647	800	25.3	L
12	8	280	2400	800	25.3	L
13	6	280	2700	800	25.3	L
14	6	280	2647	800	25.3	L

Table S12. Marine diesel engine parameters under CHINA II emission standard (D2-cycle).

No.	Number of cylinders	Cylinder bore (mm)	Rated power(kW)	Rated speed (r/min)	Single-cylinder displacement (L)	V-type/ L-type
1	4	89	60	1500	0.6	L
2	6	150	575	1500	3.3	L
3	6	127	350	1500	2.1	L
4	6	170	440	1000	4.5	L
5	12	170	1620	1500	4.5	V
6	12	180	2200	1500	5.5	V
7	6	170	735	1500	5.0	L
8	6	180	440	1000	5.3	L
9	8	200	1700	1000	9.4	L
10	6	200	810	1000	9.4	L
11	6	200	1000	1200	8.6	L
12	6	250	1800	1000	16.2	L
13	8	250	2600	1000	16.2	L
14	8	250	1912	1000	16.2	L
15	6	250	1213	750	15.7	L
16	6	260	1610	750	17.5	L
17	6	280	2365	750	25.3	L
18	6	280	2365	750	25.3	L