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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MI 48105

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OFFICE OF
AIR AND RADIATION

MEMORANDUM

SUBJECT: Emission Factors for Recreational Marine Diesel Engines

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TO: Docket A-2000-01

The U.S. Environmental Protection Agency (EPA) has adopted emission standards for recreational marine diesel engines. To analyze the environmental benefits expected from these new standards, we calculated emission factors for these engines, which are summarized in this memo.

Estimated baseline emission rates

In support of the rulemaking finalizing the recreational marine diesel engine emission standards, EPA estimated average emission rates, given in grams per kilowatt-hour (g/kW-hr), for current uncontrolled engines. Table 1 presents the baseline emission rates used in this analysis for new engines and for engines deteriorated to the regulatory useful life (10 years). The emission rates are based on data collected on 25 recreational marine engines. This data is presented in Table 2. Deterioration rates are based on the EPA computer model for estimating emissions from nonroad engines.¹

¹ The Draft NONROAD model is available at: www.epa.gov/otaq/nonrdmdl.htm.

Table 1 - Estimated Baseline Emission Rates [g/kW-hr]				
	HC	NO _x	CO	PM
new engine	0.295	8.94	1.27	0.219
after 10 years	0.300	9.05	1.39	0.270

Table 2 - Emission Data from Recreational Marine Diesel Engines [g/kW-hr]						
Rated Power (kW)	Control Management	Aftercooling	HC	NO _x	CO	PM
120	electronic	raw-water	0.09	5.8	0.9	–
132	mechanical	raw-water	0.07	4.2	0.2	–
142	mechanical	separate circuit	0.79	8.6	1.1	–
162	mechanical	raw-water	0.11	4.0	0.2	–
164	electronic	raw-water	0.28	5.1	1.6	–
170	mechanical	raw-water	0.36	8.1	0.6	0.20
186	mechanical	raw-water	0.30	10.2	1.2	0.12
209	mechanical	raw-water	0.42	10.8	2.3	0.22
230	electronic	raw-water	0.28	5.5	1.8	0.39
235	mechanical	raw-water	0.45	9.8	1.8	0.20
265	mechanical	jacket-water	0.58	10.8	1.4	–
276	mechanical	raw-water	0.60	10.7	1.9	0.24
287	electronic	raw-water	0.28	7.9	–	0.12
321	mechanical	raw-water	0.37	7.7	0.9	0.23
324	mechanical	jacket-water	0.30	7.9	2.9	0.95
336	electronic	jacket-water	0.18	11.0	0.5	0.10
336	electronic	jacket-water	0.09	11.9	–	0.16
447	electronic	raw-water	0.12	9.3	–	0.17
447	mechanical	jacket-water	0.60	12.0	1.5	0.18
474	electronic	raw-water	0.34	7.7	0.5	0.07
537	electronic	jacket-water	0.08	10.7	–	0.19
820	electronic	separate circuit	0.33	9.5	0.8	0.13
1040	electronic	jacket-water	0.09	9.3	–	0.21
1080	electronic	separate circuit	0.18	7.6	1.2	0.15
1340	electronic	separate circuit	0.27	7.2	0.9	0.15

Projected future emission rates

With the new national emission standards for recreational marine diesel engines, future emission rates are projected to be lower for HC, NO_x, and PM. Because CO levels are already low and because the CO standard is intended to be a cap, we do not expect reductions in CO to result from these standards. Table 3 presents the emission standards and implementation dates which vary depending on engine size. Table 4 presents the projected controlled emission factors used in the EPA analysis for new engines and for engines deteriorated to the regulatory useful life (10 years).

Table 3 - Recreational Marine Diesel Emission Standards and Implementation Dates				
Displacement [liters/cylinder]	Implementation Date	HC+NO _x [g/kW-hr]	CO [g/kW-hr]	PM [g/kW-hr]
≥ 37 kW, disp < 0.9	2007	7.5	5.0	0.4
0.9 ≤ disp < 1.2	2006	7.2	5.0	0.3
1.2 ≤ disp < 2.5	2006	7.2	5.0	0.2
2.5 ≤ disp	2009	7.2	5.0	0.2

Table 4 - Projected Controlled Emission Rates [g/kW-hr]				
	HC	NO _x	CO	PM
Rated power ≥ 37 kW, Displacement < 0.9 liters/cylinder				
new engine	0.181	6.69	1.27	0.219
after 10 years	0.184	6.72	1.39	0.270
0.9 ≤ Displacement < 1.2 liters/cylinder				
new engine	0.181	6.41	1.27	0.219
after 10 years	0.184	6.44	1.39	0.270
Displacement ≥ 1.2 liters/cylinder				
new engine	0.182	6.42	1.27	0.181
after 10 years	0.184	6.44	1.39	0.184

Projected emission inventory

Total emissions were calculated using Equation 1. Based on data collected in developing the draft NONROAD model, we use a load factor of 35 percent, an annual usage factor of 200 hours, and an average operating life of 20 years. The draft NONROAD model also includes population estimates distributed by rated power. The metric tons estimate can be converted to standard tons (or short tons) per year by multiplying it by 1.1. EPA's estimates of the projected annual emissions inventory with and without the new standards are shown in Tables 5 and 6.

$$Emissions = \sum_{ranges} population \times power \times load \times annual\ use \times emission\ factor, \quad \text{Equation 1}$$

Table 5 - Estimated Nationwide Recreational Marine Diesel Baseline Emissions Inventory [short tons per year]				
Calendar Year	HC	NO _x	CO	PM
2000	1,270	38,000	5,850	1,000
2010	1,650	49,400	7,610	1,300
2020	2,030	60,800	9,360	1,600
2030	2,410	72,200	11,100	1,900

Table 6 - Estimated Nationwide Recreational Marine Diesel Controlled Emissions Inventory [short tons per year]				
Calendar Year	HC	NO _x	CO	PM
2000	1,270	38,000	5,850	1,000
2010	1,490	45,800	7,610	1,230
2020	1,450	48,000	9,360	1,310
2030	1,510	52,200	11,100	1,420