United States Environmental Protection Agency

Office of Transportation and Air Quality

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Regulatory Update

Overview of EPA's Emission Standards for Marine Engines

The U.S. Environmental Protection Agency's (EPA) emission control program for marine engines consists of several sets of standards which vary based on the type of engine (gasoline or diesel powered) and engine size. These standards apply to newly manufactured products produced after the effective date of the standards.

This fact sheet gives an overview of the final and proposed rules for marine engines and vessels as of July 2004. Refer to our Web site for additional information about the standards and the certification and compliance programs, as well as for regulatory updates.

What are the compression-ignition (diesel) marine engine standards?

Marine diesel engines are grouped into the five categories shown in Table 1. Each of these are subject to different standards.

Acronyms Used in This Fact Sheet

kW = kilowatts
g/kW-hr = grams per kilowatt-hour
rpm = revolutions per minute
HC + NOx = hydrocarbons plus nitrogen oxides
PM = particulate matter
CO = carbon monoxide

Table 1: Marine Diesel Engine Categories

Category	Rated Power	Displacement per Cylinder	Final Rule Publication
Small	<37 kW	any	1998
Commercial C1	≥37 kW	<5 liters	1999
C2		≥5 liters and < 30 liters	
C3		≥30 liters	2003
Recreational C1	≥37 kW	<5 liters	2002

Small Marine Diesel Engines (<37 kW)

Small marine diesel engines were included in our Tier 1 and Tier 2 nonroad diesel engine rules and are subject to the same emission limits as their land-based counterparts, as shown in Table 2.

Table 2: Small Marine Diesel Engines[a]
See: www.epa.gov/nonroad-diesel

Tier	Rulemaking	CFR	Effective Dates
Tier 1	Control of Emissions of Air Pollution from Nonroad Diesel Engines (published October 23, 1998, 63 FR 56968)	40 CFR 89	1999 or 2000, depending on engine size
Tier 2			2004 or 2005, depending on engine size

[a] The emission limits are set out in Tables 6 and 7.

Category 1 Commercial and Category 2 Marine Diesel Engines

Category 1 marine diesel engines are similar to land-based nonroad diesel engines. Most Category 2 marine diesel engines are similar to locomotive engines.

The Tier 1 standards for these engines are equivalent to the nitrogen oxides (NOx) limits adopted by the Annex VI to the International Convention on the Prevention of Pollution from Ships, 1973, as Modified by the Protocol of 1978 Relating Thereto (this convention

is also known as MARPOL 73/78).[1] The Annex VI standards apply to engines over 130 kW installed on vessels constructed on or after January 1, 2000, or engines that undergo a major conversion on or after January 1, 2000. However, those standards are not enforceable until the Annex goes into effect in May 2005.[2] In the meantime, we adopted these standards into our federal emission control program as Tier 1 standards. The Tier 1 standards are voluntary for all Category 1 and Category 2 engines through 2003. Beginning in 2004, they will be mandatory for engines ≥2.5 l/cyl installed on U.S. vessels. For all engines subject to the Tier 1 standards, EPA's Tier 2 standards supersede the Annex VI limits by 2007 (or 2009 for recreational engines above 2.5 l/cyl).

Table 3: Category 1 (Commercial only) and Category 2 Marine Diesel Engines[a]
See: www.epa.gov/otaq/marine.htm

Tier	Rulemaking	CFR	Effective Dates
Tier 1	Control of Emissions from New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder (published February 28, 2003, 68 FR 9746)	40 CFR 94	Voluntary through 2003; mandatory for engines ≥2.5 l/cyl beginning in 2004[b]
Tier 2	Control of Emissions of Air Pollution from New Marine Compression-Ignition Engines at or Above 37 kW (published December 29, 1999, 64 FR 73300)		2004 to 2007, depending on engine size

[a] The emission limits are set out in Tables 6 and 7.
[b] MARPOL Annex VI applies these standards to any engine >130 kW installed on a vessel constructed on or after 1/1/2000 and any engine that undergoes a major conversion on or after 1/1/2000. However, those requirements are not enforceable until the Annex goes into effect in May 2005. Annex VI limits are superseded by the Tier 2 standards for these engines.

Category 3 Marine Diesel Engines

Category 3 marine diesel engines are very large engines used for propulsion power on ocean-going vessels. The EPA standards for these engines are equivalent to the Annex VI standards.

[1] Copies of the conference versions of the Annex and the NOx Technical Code can be found in Docket A-97-50, Document II.B.01 or at www.epa.gov/otaq/marine.htm. Copies of the updated versions can be obtained from the International Maritime Organization (www.imo.org).

[2] The IMO Web site, www.imo.org, contains the latest information on the status of this convention.

Table 4: Category 3 Marine Diesel Engines[a]
See www.epa.gov/otaq/marine.htm

Tier	Rulemaking	CFR	Effective Dates
Tier 1	Control of Emissions from New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder (published February 28, 2003, 68 FR 9746)	40 CFR 94	Voluntary through 2003; mandatory 2004[b]

[a] The emission limits are set out in Tables 6 and 7.
[b] MARPOL Annex VI applies these standards to any engine >130 kW installed on a vessel constructed on or after 1/1/2000 and any engine that undergoes a major conversion on or after 1/1/2000. However, those requirements are not enforceable until the Annex goes into effect in May 2005.

Recreational Marine Diesel Engines

Recreational marine diesel engines are those that will be installed on vessels used for recreational purposes. They must be at or above 37 kW and less than 5 liters per cylinder displacement to be considered recreational for the purposes of our standards. The Tier 1 standards for engines ≥2.5 liters/cylinder displacement are equivalent to the MARPOL standards (described above). Once the MARPOL standards take effect, they will apply to recreational engines >130 kW. The more stringent Tier 2 standards will supersede the Tier 1 and MARPOL NOx limits.

Table 5: Recreational Marine Diesel Engines[a]
See www.epa.gov/otaq/marine.htm

Tier	Rulemaking	CFR	Effective Dates
Tier 1	Control of Emissions from New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder (published February 28, 2003, 68 FR 9746)	40 CFR 94	Voluntary through 2003; mandatory for engines ≥2.5 l/cyl beginning in 2004[b]
Tier 2	Control of Emissions from Nonroad Large Spark-Ignition Engines, and Recreational Engines (Marine and Land-Based) (published November 8, 2002, 67 FR 68242)		2006 to 2009, depending on engine size

[a] The emission limits are set out in Tables 6 and 7.
[b] MARPOL Annex VI applies these standards to any engine >130 kW installed on a vessel constructed on or after 1/1/2000 and any engine that undergoes a major conversion on or after 1/1/2000. However, those requirements are not enforceable until the Annex goes into effect in May 2005. Annex VI limits are superseded by the Tier 2 standards for these engines.

Tables 6 and 7 present the emission standards for marine diesel engines. These standards are for hydrocarbons (HC), oxides of nitrogen (NOx), and particulate matter (PM) and are expressed in units of grams per kilowatt-hour (g/kW-hr).

Table 6: Tier 1 Standards for Marine Diesel Engines

Category	Power (kW) & Displacement (liter/cylinder)	Speed (rpm)	Tier 1 Model Year	NOx (g/kW-hr)	HC+NOx (g/kW-hr)	PM (g/kW-hr)	CO (g/kW-hr)
Small	<8 kW 8≤ kW <19 19≤ kW <37	- - -	2000 2000 1999	- - -	10.5 9.5 9.5	1.0 0.8 0.8	8.0 6.6 5.5
1, 2, 3, including Recreational	≥37 kW & ≥2.5 l/cyl[a]	rpm ≥2000 130≤ rpm <2000 rpm<130	2004 2004 2004	9.8 45 x $rpm^{-0.2}$ 17	- -	- -	- -

[a] These standards are voluntary for all engines through 2003; they are mandatory for engines ≥2.5 l/cyl beginning in 2004. For Category 1 and Category 2 engines, they will remain mandatory through 2006; beginning in 2007 for commercial and 2009 for recreational, EPA standards supersede the Annex VI limits for these engines.

Table 7: Tier 2 Standards for Marine Diesel Engines

Category[a]	Displacement (liter/cylinder)	Power (kW)	Tier 2 Model Year	HC+NOx (g/kW-hr)	PM (g/kW-hr)	CO (g/kW-hr)
Small	- - -	<8 kW 8≤ kW <19 19≤ kW <37	2005 2005 2004	7.5 7.5 7.5	0.80 0.80 0.60	8.0 6.6 5.5
Commercial C1	disp. <0.9 0.9≤ disp. <1.2 1.2≤ disp. <2.5 2.5≤ disp. <5.0	≥37kW - - -	2005 2004 2004 2007	7.5 7.2 7.2 7.2	0.40 0.30 0.20 0.20	5.0 5.0 5.0 5.0
C2	5.0≤ disp. <15 15≤ disp. <20 15≤ disp. <20 20≤ disp. <25 25≤ disp. <30	- <3300kW ≥3300kW - -	2007 2007 2007 2007 2007	7.8 8.7 9.8 9.8 11.0	0.27 0.50 0.50 0.50 0.50	5.0 5.0 5.0 5.0 5.0
Recreational C1	disp. <0.9 0.9≤ disp. <1.2 1.2≤ disp. <2.5 2.5≤ disp. <5.0	≥37kW ≥37kW ≥37kW ≥37kW	2007 2006 2006 2009	7.5 7.2 7.2 7.2	0.40 0.30 0.20 0.20	5.0 5.0 5.0 5.0

[a] There are no Tier 2 standards for Category 3 marine engines.

What emissions standards apply to spark-ignition (gasoline) marine engines?

We also have several sets of standards for gasoline marine engines. For these engines we distinguish between:

- Outboards and personal watercraft
- Sterndrive and inboard engines
- Gasoline auxiliary engines

Outboards and Personal Watercraft Exhaust Standards

The outboard and personal watercraft exhaust standards phase in over nine years from 1998 to 2006. Because it is an averaging standard,[3] manufacturers are typically offering a mix of new and old technology throughout the phase-in period. The standard is based on a curve function that is intended to represent the relationship between rated power and brake-specific emissions. In addition, California has two additional tiers of standards that are more stringent than the EPA standards (see www.arb.ca.gov).

Table 8: Outboard and Personal Watercraft Standards[a]
See www.epa.gov/otaq/marinesi.htm

Tier	Rulemaking	CFR	Effective Date
1	Final Rule for New Gasoline Spark-Ignition Marine Engines; Exemptions for New Nonroad Compression-Ignition Engines at or Above 37 Kilowatts and New Nonroad Spark-Ignition Engines at or below 19 Kilowatts (published October 4, 1996, 61 FR 52088)	40 CFR 91	1998 to 2006; standard becomes more stringent over time

[a] The emission limits are set out in Table 11 below.

Gasoline Sterndrive and Inboard Engines

There are currently no federal standards for gasoline sterndrive and inboard engines. However, we gave notice of our intent to develop emission standards for these engines (published August 14, 2002, 67 FR 53050, see www.epa.gov/otaq/marinesi.htm). Although there are no federal requirements for these engines, California has adopted exhaust emission standards (see: www.arb.ca.gov).

[3] This means that emission credits may be earned for engines certified below the emission standard. These credits may be used to sell engines certified above the standard provided that, on average, the engines meet the emission standard.

Marine Generators

Gasoline auxiliary engines used onboard marine vessels are covered in our gasoline nonroad engine programs. There are two sets of EPA standards for these engines which are covered in our programs for land-based spark-ignition engines, as shown in Tables 9 and 10.

Table 9: Spark-Ignition Marine Generators <19 kW[a]
See www.epa.gov/otaq/equip-ld.htm

Tier	Rulemaking	CFR	Effective Dates
Tier 1	Emission Standards for New Nonroad Spark-Ignition Engines at or Below 19 Kilowatts (published July 3, 1995, 60 FR 34581) Revised Carbon Monoxide (CO) Standard for Class I and II Nonhandheld New Nonroad Phase 1 Small Spark-Ignition Engines (published November 13, 1996, 61 FR 58296)	40 CFR 90	1997
Tier 2	Phase 2 Emission Standards for New Nonroad Spark-Ignition Nonhandheld Engines at or below 19 Kilowatts (published March 30, 1999, 64 FR 15208)		2001 to 2007, depending on engine size

[a] The emission limits are set out in Table 12 below.

Table 10: Spark-Ignition Marine Generators >19 kW[a]
See www.epa.gov/otaq/largesi.htm

Tier	Rulemaking	CFR	Effective Dates
Tier 1	Control of Emissions from Nonroad Large Spark-Ignition Engines, and Recreational Engines (Marine and Land-Based) (published November 8, 2002, 67 FR 68242)	40 CFR 1048	2004
Tier 2			2007

[a] The emission limits are set out in Table 13 below.

Table 11: Standards for Outboard and Personal Watercraft Spark-Ignition Marine Engines

Model Year	HC+NOx (g/kW-hr)	
	<4.3 kW	>4.3 kW[a]
1998	278	$0.917x(151 + 557/P^{0.9})+2.44$
1999	253	$0.833x(151 + 557/P^{0.9})+2.89$
2000	228	$0.750x(151 + 557/P^{0.9})+3.33$
2001	204	$0.667x(151 + 557/P^{0.9})+3.78$
2002	179	$0.583x(151 + 557/P^{0.9})+4.22$
2003	155	$0.500x(151 + 557/P^{0.9})+4.67$
2004	130	$0.417x(151 + 557/P^{0.9})+5.11$
2005	105	$0.333x(151 + 557/P^{0.9})+5.56$
2006	81	$0.250x(151 + 557/P^{0.9})+6.00$

[a] For engines over 4.3 kW, the emission standard is a function of rated engine power (P), in Kilowatts.

Table 12: Standards for Spark-Ignition Marine Generators ≤19kW

Phase	Class	Total Displacement (cubic centimeters)	Model Year	HC+NOx (g/kW-hr)	CO (g/kW-hr)
Phase 1 [a]	I	cc <225	1997	16.1	519
	II	cc ≥225	1997	13.4	519
Phase 2	I-A	cc <66	2001	50	610
	I-B	66≤ cc <100	2001	40	610
	I	100≤ cc <225	August 2007 [b]	16.1	610
	II	cc ≥0.225	2001 2002 2003 2004 2005	18.0 16.6 15.0 13.6 12.1	610

[a] Zero hour standards (no deterioration considered in standards).
[b] Effective date. (If a new engine family is introduced after August 1, 2003, it must meet the Phase 2 standards.)

Tier	Model Year	HC+NOx (g/kW-hr)	CO (g/kW-hr)
1	2004	4.0	50
2[a]	2007	2.7	4.4

Table 13: Standards for Spark-Ignition Marine Generators >19kW

[a] Alternatively, can meet standard of (HC+NOx) × $CO^{0.784}$ ≤8.57 g/kW-hr.

How can I get more information?

You can access documents on marine engine emission standards from EPA's main non-road engines, equipment, and vehicles Web page at:

www.epa.gov/nonroad

You can also contact the OTAQ library for document information at:

U.S. Environmental Protection Agency
Office of Transportation and Air Quality Library
2000 Traverwood Drive
Ann Arbor, MI 48105
(734) 214-4311 & 214-4434
E-mail: Group_AALibrary@epa.gov