

Chapter 12

Criteria Air Pollutants

Summary Statistics from Tables in this Chapter

Source	
Table 12.1	<p>Transportation's share of U.S. emissions, 2011</p> <p style="padding-left: 40px;"><i>CO</i> 61.8%</p> <p style="padding-left: 40px;"><i>NO_x</i> 50.9%</p> <p style="padding-left: 40px;"><i>VOC</i> 29.8%</p> <p style="padding-left: 40px;"><i>PM-2.5</i> 4.2%</p> <p style="padding-left: 40px;"><i>PM-10</i> 2.7%</p> <p style="padding-left: 40px;"><i>SO₂</i> 2.1%</p>



Transportation accounts for the majority of carbon monoxide and nitrogen oxide emissions. Highway vehicles are responsible for the largest share of transportation emissions.

Table 12.1
Total National Emissions of the Criteria Air Pollutants by Sector, 2011
 (millions of short tons/percentage)

Sector	CO	NO _x	VOC	PM-10	PM-2.5	SO ₂
Highway vehicles	33.09	3.76	2.94	0.09	0.08	0.03
	53.0%	31.3%	24.3%	1.2%	0.1%	0.4%
Other off-highway	5.47	2.35	0.67	0.12	0.11	0.14
	8.8%	19.6%	5.5%	1.5%	1.4%	1.7%
Transportation total	38.56	6.11	3.61	0.21	0.19	0.17
	61.8%	50.9%	29.8%	2.7%	4.2%	2.1%
Stationary source fuel combustion	4.77	4.39	0.29	1.02	0.98	7.01
	7.6%	36.6%	2.4%	13.0%	21.3%	87.0%
Industrial processes	1.93	1.02	4.37	0.54	0.48	0.77
	3.1%	8.5%	36.0%	6.9%	10.3%	9.5%
Waste disposal and recycling total	1.56	0.13	0.17	0.28	0.27	0.03
	2.5%	1.1%	1.4%	3.5%	5.9%	0.3%
Miscellaneous	15.60	0.35	3.69	5.78	2.70	0.08
	25.0%	2.9%	30.4%	73.8%	58.4%	1.0%
Total of all sources	62.42	12.01	12.13	7.84	4.63	8.06
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source:

U. S. Environmental Protection Agency, National Emission Inventory Air Pollutant Emission Trends Web site www.epa.gov/ttn/chief/trends. (Additional resources: www.epa.gov/ttn/chief)

Note: CO = Carbon monoxide. NO_x = Nitrogen oxides. PM-10 = Particulate matter less than 10 microns. PM-2.5 = Particulate matter less than 2.5 microns. SO₂ = Sulfur dioxide. VOC = Volatile organic compounds. NH₃ = Ammonia.



The transportation sector accounted for more than 61% of the nation's carbon monoxide (CO) emissions in 2011. Highway vehicles are by far the source of the greatest amount of CO. For details on the highway emissions of CO, see Table 12.3.

Table 12.2
Total National Emissions of Carbon Monoxide, 1970–2011^a
(million short tons)

Source category	1970	1980	1990	2000	2010	2011	Percent of total, 2011
Highway vehicles	163.23	143.83	110.26	68.06	36.51	33.09	53.0%
Other off-highway	11.37	16.69	21.45	24.18	9.71	5.47	8.8%
Transportation total	174.60	160.51	131.70	92.24	45.31	38.56	61.8%
Stationary fuel combustion total	4.63	7.30	5.51	4.78	4.67	4.78	7.6%
Industrial processes total	9.84	6.95	4.77	2.63	1.86	1.93	3.1%
Waste disposal and recycling total	7.06	2.30	1.08	1.85	1.57	1.56	2.5%
Miscellaneous total	7.91	8.34	11.12	12.96	14.38	15.60	25.0%
Total of all sources	204.04	185.41	154.19	114.47	67.79	62.42	100.0%

Source:

U. S. Environmental Protection Agency, National Emission Inventory Air Pollutant Emission Trends Web site www.epa.gov/ttn/chief/trends (Additional resources: www.epa.gov/ttn/chief)

^a The sums of subcategories may not equal total due to rounding.



Though gasoline-powered light vehicles continue to be responsible for the majority of carbon monoxide emissions from highway vehicles, the total pollution from light vehicles in 2005 is about a third of what it was in 1970. This is despite the fact that there were many more light vehicles on the road in 2005.

Table 12.3
Emissions of Carbon Monoxide from Highway Vehicles, 1970–2005^a
(million short tons)

Source category	1970	1980	1990	1995	2000	2005	Percent of total, 2005
Gasoline powered							
Light vehicles & motorcycles	119.14	98.21	67.24	46.54	36.40	24.19	50.2%
Light trucks ^b	22.27	28.83	32.23	29.81	27.04	21.19	43.9%
Heavy vehicles	21.27	15.35	8.92	5.96	3.42	1.97	4.1%
Total	162.68	142.39	108.39	82.31	66.86	47.35	98.2%
Diesel powered							
Light vehicles	0.01	0.03	0.04	0.02	0.01	0.01	0.0%
Light trucks ^b	0.06	0.05	0.03	0.02	0.01	0.01	0.0%
Heavy vehicles	0.49	1.36	1.81	1.53	1.19	0.85	1.8%
Total	0.56	1.43	1.87	1.57	1.20	0.87	1.8%
Total							
Highway vehicle total	163.23	143.83	110.26	83.88	68.06	48.22	100.0%
Percent diesel	0.3%	1.0%	1.7%	1.9%	1.8%	1.8%	

Source:

U. S. Environmental Protection Agency, National Emission Inventory Air Pollutant Emission Trends Web site www.epa.gov/ttn/chief/trends. (Additional resources: www.epa.gov/oar/oaqps)

Note: Data beyond 2005 are not available.

^a The sums of subcategories may not equal total due to rounding.

^b Less than 8,500 pounds.



The transportation sector accounted for over half of the nation's nitrogen oxide (NO_x) emissions in 2011, with the majority coming from highway vehicles. For details on the highway emissions of NO_x, see Table 12.5.

Table 12.4
Total National Emissions of Nitrogen Oxides, 1970–2011^a
(million short tons)

Source category	1970	1980	1990	2000	2010	2011	Percent of total, 2011
Highway vehicles	12.62	11.49	9.59	8.39	4.28	3.76	31.3%
Other off-highway	2.65	3.35	3.78	4.17	2.87	2.35	19.6%
Transportation total	15.28	14.85	13.37	12.56	7.16	6.11	50.9%
Stationary fuel combustion total	10.06	11.32	10.89	8.82	4.23	4.39	36.6%
Industrial processes total	0.78	0.56	0.80	0.81	1.00	1.00	8.5%
Waste disposal and recycling total	0.44	0.11	0.09	0.13	0.13	0.13	1.1%
Miscellaneous total	0.33	0.25	0.37	0.28	0.32	0.35	2.9%
Total of all sources	26.88	27.08	25.53	22.60	12.91	12.01	100.0%

Source:

U. S. Environmental Protection Agency, National Emission Inventory Air Pollutant Emission Trends Web site www.epa.gov/ttn/chief/trends (Additional resources: www.epa.gov/ttn/chief)

^a The sums of subcategories may not equal total due to rounding.



Heavy diesel-powered vehicles were responsible for nearly one-half (44.1%) of highway vehicle nitrogen oxide emissions in 2005, while light gasoline vehicles were responsible for the rest.

Table 12.5
Emissions of Nitrogen Oxides from Highway Vehicles, 1970–2005^a
(million short tons)

Source category	1970	1980	1990	1995	2000	2005	Percent of total, 2005
Gasoline powered							
Light vehicles & motorcycles	8.54	6.63	4.26	3.05	2.31	1.63	25.5%
Light trucks ^b	1.54	1.58	1.50	1.46	1.44	1.56	24.4%
Heavy vehicles	0.72	0.62	0.57	0.52	0.45	0.38	5.9%
Total	10.81	8.83	6.33	5.03	4.20	3.57	55.9%
Diesel powered							
Light vehicles	0.00	0.03	0.04	0.02	0.01	0.00	0.0%
Light trucks ^b	0.07	0.05	0.02	0.01	0.01	0.01	0.2%
Heavy vehicles	1.76	2.59	3.19	3.82	4.18	2.81	44.0%
Total	1.83	2.66	3.26	3.85	4.19	2.82	44.1%
Total							
Highway vehicle total	12.64	11.49	9.59	8.88	8.39	6.39	100.0%
Percent diesel	14.5%	23.1%	34.0%	43.4%	49.9%	44.1%	

Source:

U. S. Environmental Protection Agency, National Emission Inventory Air Pollutant Emission Trends Web site www.epa.gov/ttn/chief/trends. (Additional resources: www.epa.gov/oar/oaqps)

Note: Data beyond 2005 are not available.

^a The sums of subcategories may not equal total due to rounding.

^b Less than 8,500 pounds.



The transportation sector accounted for almost 30% of the nation's volatile organic compound (VOC) emissions in 2011, with the majority coming from highway vehicles. For details on the highway emissions of VOC, see Table 12.7.

Table 12.6
Total National Emissions of Volatile Organic Compounds, 1970–2011^a
(million short tons)

Source category	1970	1980	1990	2000	2010	2011	Percent of total, 2011
Highway vehicles	16.91	13.87	9.39	5.33	3.15	2.94	24.3%
Off-highway	1.62	2.19	2.66	2.64	1.31	0.67	5.5%
Transportation total	18.53	16.06	12.05	7.97	4.46	3.61	29.8%
Stationary fuel combustion total	0.72	1.05	1.01	1.18	1.38	0.29	2.4%
Industrial processes total	12.33	12.10	9.01	7.21	5.11	4.37	36.0%
Waste disposal and recycling total	1.98	0.76	0.99	0.42	0.18	0.17	1.4%
Miscellaneous total	1.10	1.13	1.06	0.73	3.32	3.69	30.4%
Total of all sources	34.66	31.11	24.11	17.51	13.44	12.13	100.0%

Source:

U. S. Environmental Protection Agency, National Emission Inventory Air Pollutant Emission Trends Web site www.epa.gov/ttn/chief/trends (Additional resources: www.epa.gov/ttn/chief)

^a The sum of subcategories may not equal total due to rounding. The EPA's definition of volatile organic compounds excludes methane, ethane, and certain other nonphotochemically reactive organic compounds.



Gasoline-powered vehicles are responsible for over 95% of highway vehicle emissions of volatile organic compounds. VOC emissions from highway vehicles in 2005 were about one-quarter of the 1990 level.

Table 12.7
Emissions of Volatile Organic Compounds from Highway Vehicles, 1970–2005^a
(thousand short tons)

Source category	1970	1980	1990	1995	2000	2005	Percent of total, 2005
Gasoline powered							
Light vehicles & motorcycles	11,996	9,304	5,690	3,768	2,903	2,111	51.8%
Light trucks ^b	2,776	2,864	2,617	2,225	1,929	1,629	39.9%
Heavy vehicles	1,679	1,198	633	421	256	171	4.2%
Total	16,451	13,366	8,940	6,414	5,088	3,911	95.9%
Diesel powered							
Light vehicles	8	16	18	9	3	2	0.0%
Light trucks ^b	41	28	15	10	4	6	0.1%
Heavy vehicles	411	459	415	315	230	159	3.9%
Total	460	503	448	335	238	167	4.1%
Total							
Highway vehicle total	16,911	13,869	9,388	6,749	5,326	4,078	100.0%
Percent diesel	2.7%	3.6%	4.8%	5.0%	4.5%	4.1%	

Source:

U. S. Environmental Protection Agency, National Emission Inventory Air Pollutant Emission Trends Web site www.epa.gov/ttn/chief/trends (Additional resources: www.epa.gov/oar/oaqps)

Note: Data beyond 2005 are not available.

^a The sums of subcategories may not equal total due to rounding.

^b Less than 8,500 pounds.



The transportation sector accounted for almost 3% of the nation's particulate matter (PM-10) emissions in 2011. For details on the highway emissions of PM-10, see Table 12.9.

Table 12.8
Total National Emissions of Particulate Matter (PM-10), 1970–2011^a
(million short tons)

Source category	1970	1980	1990	2000	2010	2011	Percent of total, 2011
Highway vehicles	0.48	0.43	0.39	0.23	0.12	0.09	1.2%
Off-highway	0.16	0.26	0.33	0.32	0.17	0.12	1.5%
Transportation total	0.64	0.69	0.72	0.55	0.29	0.21	2.7%
Stationary fuel combustion total	2.87	2.45	1.20	1.47	1.02	1.02	13.0%
Industrial processes total	7.67	2.75	1.04	0.71	0.58	0.54	6.9%
Waste disposal and recycling total	1.00	0.27	0.27	0.36	0.29	0.28	3.5%
Miscellaneous total	0.84	0.85	24.54	20.65	8.60	5.78	73.8%
Total of all sources	13.02	7.01	27.75	23.75	10.78	7.84	100.0%

Source:

U. S. Environmental Protection Agency, National Emission Inventory Air Pollutant Emission Trends Web site www.epa.gov/ttn/chief/trends (Additional resources: www.epa.gov/ttn/chief)

Note: Because PM-10 is fine particle matter less than 10 microns, it also includes PM-2.5. Specific data for PM-2.5 are shown on Tables 12.10 and 12.11.

^a Fine particle matter less than 10 microns. The sums of subcategories may not equal total due to rounding.



Since the mid-1980's, diesel-powered vehicles have been responsible for more than half of highway vehicle emissions of particulate matter (PM-10). Heavy vehicles are clearly the main source.

Table 12.9
Emissions of Particulate Matter (PM-10) from Highway Vehicles, 1970–2005^a
(thousand short tons)

Source category	1970	1980	1990	1995	2000	2005	Percent of total, 2005
Gasoline powered							
Light vehicles & motorcycles	249	141	56	53	51	46	25.1%
Light trucks ^b	74	49	31	32	31	35	19.1%
Heavy vehicles	44	30	17	13	10	8	4.4%
Total	367	220	104	98	92	89	48.6%
Diesel powered							
Light vehicles	2	9	11	4	1	1	0.5%
Light trucks ^b	19	12	5	3	1	1	0.5%
Heavy vehicles	92	191	268	199	135	92	50.3%
Total	113	212	284	206	137	94	51.4%
Total							
Highway vehicle total	480	432	387	304	230	183	100.0%
Percent diesel	23.5%	49.1%	73.4%	67.8%	59.6%	51.4%	

Source:

U. S. Environmental Protection Agency, National Emission Inventory Air Pollutant Emission Trends Web site
www.epa.gov/ttn/chieftrends (Additional resources: www.epa.gov/oar/oaqps)

Note: Because PM-10 is fine particle matter less than 10 microns, it also includes PM-2.5. Specific data for PM-2.5 are shown on Tables 12.10 and 12.11. Data beyond 2005 are not available.

^a The sums of subcategories may not equal total due to rounding.

^b Less than 8,500 pounds.



The transportation sector accounted for only 4% of the nation's particulate matter (PM-2.5) emissions in 2011. For details on the highway emissions of PM-2.5, see Table 12.11.

Table 12.10
Total National Emissions of Particulate Matter (PM-2.5), 1990–2011
(million short tons)

Source category	1990	1995	2000	2005	2010	2011	Percent of total, 2011
Highway vehicles	0.32	0.25	0.17	0.14	0.09	0.08	1.7%
Off-highway	0.30	0.31	0.30	0.32	0.16	0.11	2.4%
Transportation total	0.62	0.56	0.47	0.46	0.25	0.19	4.2%
Stationary fuel combustion total	0.91	0.90	1.29	1.13	0.95	0.98	21.3%
Industrial processes total	0.56	0.50	0.50	0.53	0.44	0.48	10.3%
Waste disposal and recycling total	0.23	0.25	0.33	0.27	0.28	0.27	5.9%
Miscellaneous total	5.23	4.73	4.69	3.07	2.57	2.70	58.4%
Total of all sources	7.56	6.93	7.29	5.46	4.50	4.63	100.0%

Source:

U. S. Environmental Protection Agency, National Emission Inventory Air Pollutant Emission Trends Web site www.epa.gov/ttn/chief/trends (Additional resources: www.epa.gov/ttn/chief)



Diesel vehicles are responsible for the majority of highway vehicle PM-2.5 emissions. Nearly two-thirds of the highway vehicles' PM-2.5 emissions are from heavy diesel trucks.

Table 12.11
Emissions of Particulate Matter (PM-2.5) from Highway Vehicles, 1990–2005^a
(thousand short tons)

Source category	1990	1995	2000	2005	Percent of total, 2005
Gasoline powered					
Light vehicles & motorcycles	35	30	27	23	18.0%
Light trucks ^b	21	20	18	18	14.1%
Heavy vehicles	11	9	7	6	4.7%
Total	67	59	52	47	36.7%
Diesel powered					
Light vehicles	9	4	1	1	0.8%
Light trucks ^b	4	2	1	1	0.8%
Heavy vehicles	243	179	119	79	61.7%
Total	256	185	121	81	63.3%
Total					
Highway vehicle total	323	244	173	128	100.0%
Percent diesel	79.3%	75.8%	69.9%	63.3%	

Source:

U. S. Environmental Protection Agency, National Emission Inventory Air Pollutant Emission Trends Web site www.epa.gov/ttn/chief/trends (Additional resources: www.epa.gov/oar/oaqps)

Note: Data beyond 2005 are not available.

^a The sums of subcategories may not equal total due to rounding.

^b Less than 8,500 pounds.



EMISSION STANDARDS

The U.S. Environmental Protection Agency (EPA) regulates emissions from mobile sources including vehicles, engines, and motorized equipment that produce exhaust and evaporative emissions. Mobile sources contribute to four main air pollutants: carbon monoxide, hydrocarbons, nitrogen oxides, and particulate matter. The EPA not only sets standards for the vehicles, engines, and equipment, but also the fuels that they use. Tables 12.12 through 12.25 contain summaries of the current standards.

Acronyms Used on Tables 12.12 through 12.25

bhp	Brake horsepower-hour
CI	Compression-ignition
CO	Carbon Monoxide
DE	Diesel engine
g	Gram
g/kN	Grams per kilonewton
g/mi	Grams per mile
GVW	Gross vehicle weight
HC	Hydrocarbons
HCHO	Formaldehyde
HLDT	Heavy light-duty truck
Hp-hr	Horsepower-hour
kW	Kilowatt
kW-hr	Kilowatt-hour
LDT	Light-duty truck
LDV	Light-duty vehicle
LEV	Low-emission vehicle
LLDT	Light light-duty truck
LVW	Loaded vehicle weight
MDPV	Medium-duty passenger vehicle (8,500-10,000 lbs. GVWR)
NMHC	Non-methane hydrocarbon
NMOG	Non-methane organic gases
NO _x	Nitrogen oxides
PM	Particulate matter
ppm	Parts per million
rPR	Rated pressure ratio
SI	Spark-ignition
SULEV	Super-ultra-low-emission vehicle
ULEV	Ultra-low-emission vehicle
ZEV	Zero-emission vehicle



These exhaust emission standards were phased-in from 2004 to 2010.

Table 12.12
Light-Duty Vehicle, Light-Duty Truck, and Medium-Duty Passenger Vehicle – Tier 2 Exhaust Emission Standards

	Standard	Emission limits at 50,000 miles					Emission limits at full useful life (120,000 miles) ^a				
		NO _x (g/mi)	NMOG (g/mi)	CO (g/mi)	PM (g/mi)	HCHO (g/mi)	NO _x (g/mi)	NMOG (g/mi)	CO (g/mi)	PM (g/mi)	HCHO (g/mi)
Federal	Bin 1	-	-	-	-	-	0	0	0	0	0
	Bin 2	-	-	-	-	-	0.02	0.01	2.1	0.01	0.004
	Bin 3	-	-	-	-	-	0.03	0.055	2.1	0.01	0.011
	Bin 4	-	-	-	-	-	0.04	0.07	2.1	0.01	0.011
	Bin 5	0.05	0.075	3.4	-	0.015	0.07	0.09	4.2	0.01	0.018
	Bin 6	0.08	0.075	3.4	-	0.015	0.1	0.09	4.2	0.01	0.018
	Bin 7	0.11	0.075	3.4	-	0.015	0.15	0.09	4.2	0.02	0.018
	Bin 8	0.14	0.100 / 0.125 ^c	3.4	-	0.015	0.2	0.125 / 0.156	4.2	0.02	0.018
	Bin 9 ^b	0.2	0.075 / 0.140	3.4	-	0.015	0.3	0.090 / 0.180	4.2	0.06	0.018
	Bin 10 ^b	0.4	0.125 / 0.160	3.4 / 4.4	-	0.015 / 0.018	0.6	0.156 / 0.230	4.2 / 6.4	0.08	0.018 / 0.027
	Bin 11 ^b	0.6	0.195	5	-	0.022	0.9	0.28	7.3	0.12	0.032

Source:

40 CR 86 Subpart S. (Additional resources: www.epa.gov/otaq/standards)

Note: Tests Covered: Federal Test Procedure (FTP), cold carbon monoxide, highway, and idle. Definitions of acronyms are on page 12-13.

^a In lieu of intermediate useful life standards (50,000 miles) or to gain additional nitrogen oxides credit, manufacturers may optionally certify to the Tier 2 exhaust emission standards with a useful life of 150,000 miles.

^b Bins 9-11 expired in 2006 for light-duty vehicles and light light-duty trucks and 2008 for heavy light-duty trucks and medium-duty passenger vehicles.

^c Pollutants with two numbers have a separate certification standard (1st number) and in-use standard (2nd number).



Table 12.13
Light-Duty Vehicle, Light-Duty Truck, and Medium-Duty Passenger Vehicle – Tier 2 Evaporative Emission Standards

	Vehicle type	Model year	3 Day diurnal + hot soak (g/test)	Supplemental 2 day diurnal + hot soak (g/test)	Running loss (g/mi)
Federal	LDV/LLDTs ^a	2004	0.95	1.20	0.05
	HLDTs ^b	2004	1.20	1.50	0.05
	MDPVs ^{a, b}	2004	1.40	1.75	0.05
	LDV ^a	2009	0.50	0.65	0.05
	LLDT ^a	2009	0.65	0.85	0.05
	HLDT ^b	2010	0.90	1.15	0.05
	MDPV ^{a, b}	2010	1.00	1.25	0.05

Source:

40 CR 86 Subpart S. (Additional resources: www.epa.gov/otaq/standards)

Note: Multi-fuel vehicle phase-in applies. Definitions of acronyms are on page 12-13.

^a For liquefied petroleum gas-fueled light-duty vehicles (LDV), light-duty trucks (LDT), and medium-duty passenger vehicles (MDPV): 0.15 grams hydrocarbon per gallon (0.04 grams per liter) of fuel dispensed.

^b Refueling standards for heavy light-duty trucks (HLDT) are subject to phase-in requirements. MDPVs must also comply with the phase-in requirement and must be grouped with HLDTs to determine phase-in compliance.



Table 12.14
Heavy-Duty Highway Compression-Ignition Engines and Urban Buses – Exhaust
Emission Standards

Year	HC (g/bhp-hr)	NMHC (g/bhp-hr)	NMHC + NOx (g/bhp-hr)	NOx (g/bhp-hr)	PM (g/bhp-hr)	CO (g/bhp-hr)	Idle CO (percent Exhaust gas flow)	Smoke ^a (percentage)	Useful life (hours/years/miles)
1974-78	-	-	16	-	-	40	-	20 / 15 / 50	-
1979-84	1.5	-	10	-	-	25	-	20 / 15 / 50	-
1985-87	1.3	-	-	10.7	-	15.5	-	20 / 15 / 50	LHDDE: - / 8 / 110,000 MHDDE: - / 8 / 185,000 HHDDE: - / 8 / 290,000
1988-89	1.3 ^d	-	-	10.7	0.6	15.5	0.5 ^c	20 / 15 / 50	1990-97 and 1998+ for HC, CO, and PM:
1990	1.3 ^d	-	-	6.0	0.6	15.5	0.5 ^c	20 / 15 / 50	LHDDE: - / 8 / 110,000
1991-93	1.3	-	-	5.0 [ABT]	0.25 [ABT] 0.10 ^e	15.5	0.5 ^c	20 / 15 / 50	MHDDE: - / 8 / 185,000 HHDDE: - / 8 / 290,000
1994-97	1.3	-	-	5.0 [ABT]	0.1 [ABT] 0.07 ^f , 0.05 ^g	15.5	0.5 ^c	20 / 15 / 50	1994+ urban buses for PM only: LHDDE: - / 10 / 110,000
1998-2003	1.3	-	-	4.0 [ABT]	0.1 [ABT] 0.05 ^g	15.5	0.5 ^c	20 / 15 / 50	1998+ for NOx: LHDDE: - / 10 / 110,000 MHDDE: - / 10 / 185,000 HHDDE: - / 10 / 290,000
2004-2006 ^h	-	-	2.4 (or 2.5 with a limit of 0.5 on NMHC) ^o [ABT] ^h	-	0.1 0.05 ^e	15.5	0.5	20 / 15 / 50	For all pollutants: ^p LHDDE: - / 10 / 110,000 MHDDE: - / 10 / 185,000 HHDDE: 22,000 / 10 / 435,000
2007 ^{h,k,l,m,n}	-	0.14 ^o	2.4 (or 2.5 with a limit of 0.5 on NMHC) [ABT]	0.2 ^o	0.01	15.5	0.5	20 / 15 / 50	

Sources:

40 CFR 86.099-11 Emission standards for 1999 and later model year diesel heavy-duty engines and vehicles.

40 CFR 86.004-11 Emission standards for 2004 and later model year diesel heavy-duty engines and vehicles.

40 CFR 86.007-11 Emission standards and supplemental requirements for 2007 and later model year diesel heavy-duty engines and vehicles. (Additional resources: www.epa.gov/otaq/standards)

Note: The test procedures are the EPA Transient Test Procedure and the EPA Smoke Test Procedure. Definitions of acronyms are on page 12-13.

^a Percentages apply to smoke opacity at acceleration/lug/peak modes.

^b Standards for 1990 apply only to diesel-fueled heavy-duty engines (HDE). Standards for 1991+ apply to both diesel- and methanol-fueled HDEs. Standards that apply to urban buses specifically are footnoted.

^c This standard applies to the following fueled engines for the following model years: methanol - 1990+, natural gas and liquefied petroleum gas (LPG) - 1994+.

^d For petroleum-fueled engines, the standard is for hydrocarbons (HC). For methanol-fueled engines, the standard is for total hydrocarbon equivalent (THCE).

^e Certification standard for urban buses for 1993.

^f Certification standard for urban buses from 1994-95.

^g Certification standard for urban buses from 1996 and later. The in-use standard is 0.07.

^h Load Response Test certification data submittal requirements take effect for heavy-duty diesel engines beginning in model year 2004. The following requirements take effect with the 2007 model year: steady-state test requirement and Not-to-Exceed (NTE) test procedures for testing of in-use engines. On-board diagnostic requirements applicable to heavy-duty diesel vehicles and engines up to 14,000 pounds gross vehicle weight rating (GVWR) phase in from the 2005 through 2007 model years.



Table 12.14 (continued)
**Heavy-Duty Highway Compression-Ignition Engines and Urban Buses – Exhaust
 Emission Standards**

ⁱ The modified averaging, banking, and trading program for 1998 and later model year engines applies only to diesel cycle engines. Credits generated under the modified program may be used only in 2004 and later model years.

^j For heavy-duty diesel engines, there are three options to the measurement procedures currently in place for alternative fueled engines: (1) use a THC measurement in place of a non-methane hydrocarbon (NMHC) measurement; (2) use a measurement procedure specified by the manufacturer with prior approval of the Administrator; or (3) subtract two percent from the measured THC value to obtain an NMHC value. The methodology must be specified at time of certification and will remain the same for the engine family throughout the engines' useful life. For natural gas vehicles, EPA allows the option of measuring NMHC through direct quantification of individual species by gas chromatography.

^k Starting in 2006, refiners must begin producing highway diesel fuel that meets a maximum sulfur standard of 15 parts per million (ppm).

^l Subject to a Supplemental Emission Test (1.0 x Federal Test Procedure [FTP] standard (or Family Emission Limit [FEL]) for nitrogen oxides [NO_x], NMHC, and particulate matter [PM]) and a NTE test (1.5 x FTP standard [or FEL] for NO_x, NMHC, and PM).

^m EPA adopted the lab-testing and field-testing specifications in 40 CFR Part 1065 for heavy-duty highway engines, including both diesel and Otto-cycle engines. These procedures replace those previously published in 40 Code of Federal Regulations (CFR) Part 86, Subpart N. Any new testing for 2010 and later model years must be done using the 40 CFR Part 1065 procedures.

ⁿ Two-phase in-use NTE testing program for heavy-duty diesel vehicles. The program begins with the 2007 model year for gaseous pollutants and 2008 for PM. The requirements apply to diesel engines certified for use in heavy-duty vehicles (including buses) with GVWRs greater than 8,500 pounds. However, the requirements do not apply to any heavy-duty diesel vehicle that was certified using a chassis dynamometer, including medium-duty passenger vehicles with GVWRs of between 8,500 and 10,000 pounds.

^o NO_x and NMHC standards will be phased in together between 2007 and 2010. The phase-in will be on a percent-of-sales basis: 50 percent from 2007 to 2009 and 100 percent in 2010.

^p Note that for an individual engine, if the useful life hours interval is reached before the engine reaches 10 years or 100,000 miles, the useful life shall become 10 years or 100,000 miles, whichever occurs first, as required under Clean Air Act section 202(d).



Table 12.15
Heavy-Duty Highway Spark-Ignition Engines – Exhaust Emission Standards

Engine or vehicle	Year	Gross vehicle weight (lbs)	HC ^a (g/bhp-hr)	NMHC ^b (g/bhp-hr)	NOx (g/bhp-hr)	NOx + NMHC ^c (g/bhp-hr)	PM (g/bhp-hr)	CO (g/bhp-hr)	Idle CO (% exhaust gas flow)	Formaldehyde	Useful life (years / miles)	
Federal	Prior to Control	-	12.7	-	-	6.86	-	155	-	-	5 / 50,000	
	1970-73	-	275 ppm	-	-	-	-	1.50%	-	-		
	1974-78	-	-	-	16	-	-	40	-	-		
	1979-84	-	1.5	-	10	-	-	25	-	-		
	1985-86	-	1.9	-	-	10.6	-	-	37.1	-		-
		1987	≤ 14,000	1.1	-	-	10.6	-	14.4	0.5		-
	> 14,000		1.9	-	-	10.6	-	37.1	-			
	1988-90	≤ 14,000	1.1	-	-	6.0	-	-	14.4	-		-
		> 14,000	1.9	-	-	6.0	-	-	37.1	-		-
	1990 ^e	≤ 14,000	1.1	-	-	6.0	-	-	14.4	-		-
		> 14,000	1.9	-	-	6.0	-	-	37.1	-	-	
	1991-97 ^f	≤ 14,000	1.1 ^g	-	-	5.0	-	-	14.4	0.5 ⁱ	-	
		> 14,000	1.9 ^h	-	-	5.0	-	-	37.1		-	
	1998-2004 ^f	≤ 14,000	1.1 ^g	-	-	4.0 ⁱ	-	-	14.4		-	
		> 14,000	1.9 ^h	-	-	-	-	-	37.1		-	
	2005-2007 ^f	≤ 14,000	1.1 ^g	-	-	1.0 ^j	-	-	14.4		-	
		> 14,000	1.9 ^h	-	-	-	-	-	37.1		-	
	2008+	All	-	0.14	0.2	-	0.01	-	14.4		-	
	Complete heavy-duty vehicles ^{n,4}	2005-2007	8,500 - 10,000	-	0.280 ^m	-	0.9	-	7.3		-	-
			10,000 - 14,000	-	0.330 ^m	-	1.0	-	8.1		-	
2008+ ^p		8,500 - 10,000	-	0.195 ^o	-	0.2	0.02	-	7.3		0.032	
		10,000 - 14,000	-	0.230 ^o	-	0.4	0.02	-	8.1	0.04		

Sources:

40 CFR 86.1816-05, 86.1816-08 Emission standards for complete heavy-duty vehicles

40 CFR 86.1806-01, 86.1806-04, 86.1806-05 Onboard diagnostics requirements

40 CFR 86.1817-05, 86.1817-08 Complete heavy-duty vehicle averaging, banking, and trading program

40 CFR 86.091-10 Heavy-duty engine averaging, banking, and trading program for 1991 and later - Not available in the e-CFR

40 CFR Part 86 Subpart B Vehicle test procedures (Additional resources: www.epa.gov/otaq/standards)**Note:** Definitions of acronyms are on page 12-13.^a For methanol-fueled engines, the standard is for total hydrocarbon equivalent (THCE).^b For methanol and alcohol fueled vehicles the standard is for non-methane hydrocarbon equivalent (NMHCE).^c For methanol fueled engines the standard is for nitrogen oxides (NOx) plus NMHCE.^d Standards for heavy-duty engines are expressed in grams per brake horsepower-hour (g/bhp-hr). Starting with the 1998 model year, crankcase emissions are not allowed.^e Standards for 1990 apply to gasoline and methanol-fueled engines.^f Standards for 1991 and later apply to gasoline and methanol engines and are optional for natural gas and Liquefied Petroleum Gas-fueled engines through the 1996 model year.^g For natural gas fueled engines the standard is 0.9 g/bhp-hr non-methane hydrocarbon (NMHC).

Table 12.15 (continued)
Heavy-Duty Highway Spark-Ignition Engines – Exhaust Emission Standards

^h For natural gas fueled engines the standard is 1.7 g/bhp-hr NMHC.

ⁱ The NO_x standard is 5.0 for all natural gas-fueled engines.

^j This standard applies to the following engines utilizing aftertreatment technology (except for methanol) for the following model years: gasoline/1990+; natural gas and LPG/1991+; methanol/1990+. Starting in 2005, engines certified to on-board diagnostics requirements are not required to meet the idle carbon monoxide (CO) standard.

^k Useful life is expressed in years or miles, whichever comes first. Useful life for the 1998 and later NO_x standard and for all 2004 standards is 10 years or 110,000 miles, whichever comes first.

^l Manufacturers can choose this standard or one of the following options: (1) a standard of 1.5 g/bhp-hr NMHC+NO_x that applies to the 2004 through 2007 model years, with complete heavy-duty vehicle standards taking effect in 2005; or (2) a standard of 1.5 g/bhp-hr NMHC + NO_x that would apply to the 2003 through 2007 heavy-duty engines and optionally to 2003 through 2006 complete heavy-duty vehicles.

^m Standard is expressed as non-methane organic gas, but compliance can optionally be shown using measurement of NMHC or total hydrocarbon (THC).

ⁿ Complete heavy-duty vehicles have the primary load-carrying container or device attached. Incomplete heavy-duty vehicles are certified to heavy-duty engine standards. Standards for complete heavy-duty vehicles are expressed in grams per mile (g/mi). Starting in 2005 (or 2003 or 2004 depending on the selected phase in option; see footnote l), complete heavy-duty vehicles under 14,000 lbs gross vehicle weight are tested on chassis-based rather than engine-based procedures and must meet these complete heavy-duty vehicle standards.

^o Although expressed as NMHC, compliance can optionally be shown using measurement of NMOG or THC.

^p At least 50 percent of a manufacturer's sales must meet these standards in 2008, with 100 percent required in 2009.

^q Gross vehicle weight ranges are more accurately specified as follows: $8,500 \leq \text{GVW} \leq 10,000$ and $10,000 < \text{GVW} < 14,000$.



Table 12.16
Heavy-Duty Highway Compression-Ignition and Spark-Ignition Engines – Evaporative Emission Standards

	Engine type	Year	Gross vehicle weight (lbs)	Conventional diurnal + hot soak (g/test) ^a	Three-diurnal test sequence (g/test) ^b	Supplemental two-diurnal test sequence (g/test) ^c	Running loss (gpm) ^c	Spitback (g/test) ^c	Useful life ^d
Federal	SI	1991-95	≤ 14,000	3.0	-	-	-	-	8 / 110,000
			> 14,000 ^e	4.0	-	-	-		
		1996-2007 (Enhanced) ^f	≤ 14,000	-	3.0	3.5	0.05	1.0	10 / 120,000
			> 14,000 ^e	-	4.0	4.5		-	
		2008+ (Enhanced)	8500-14,000	-	1.4	1.75	0.05	1.0	11 / 110,000
			> 14,000 ^e	-	1.9	2.3		-	
	CI	1996-97	≤ 14,000	-	3.0	-	-	-	MHDDE: 8 / 185,000 HHDDE: 8 / 290,000 MHDDE: 8 / 185,000 HHDDE: 8 / 290,000
			> 14,000 ^e	-	4.0	-	-	-	
		1998+ (Enhanced) ^g	≤ 14,000	-	3.0	3.5	0.05	1.0	
			> 14,000 ^e	-	4.0	4.5		-	

Sources:

40 CFR 86.099-11 Emission standards for 1999 and later model year diesel heavy-duty engines and vehicles.

40 CFR 86.004-11 Emission standards for 2004 and later model year diesel heavy-duty engines and vehicles.

CFR 86.007-11 Emission standards and supplemental requirements for 2007 and later model year diesel heavy-duty engines and vehicles. (Additional resources: www.epa.gov/otaq/standards)

Note: Definitions of acronyms are on page 12-13.

^a Applies to gasoline and methanol engines. Standard is hydrocarbon (HC) for gasoline engines, total hydrocarbon equivalent (THCE) for methanol engines.

^b For spark-ignition (SI) engines, standard applies to gasoline, methanol, natural gas, and liquefied petroleum gas engines. For compression-ignition (CI) engines, standard applies to methanol, natural gas, and liquefied petroleum gas engines. Standard is THCE for methanol engines, HC for others.

^c For SI engines, standard applies to gasoline and methanol engines. For CI engines, standard applies to methanol engines. Standard is THCE for methanol engines, HC for others.

^d Useful life is expressed in years or miles, whichever comes first.

^e Vehicles over 26,000 pounds gross vehicle weight may demonstrate compliance with an engineering design evaluation in lieu of testing.

^f A new enhanced evaporative test procedure applies, which is considerably more stringent than the previous test procedure despite the fact that the standard values do not change from prior years. Gasoline and methanol engines are phased in at the following rates of a manufacturer's sales for the specified model year: 1996: 20 percent; 1997: 40 percent; 1998: 90 percent; 1999: 100 percent.

^g A new enhanced evaporative test procedure applies, which is considerably more stringent than the previous test procedure despite the fact that the standard values do not change from prior years. Methanol-fueled vehicles are phased in at a rate of 90 percent of a manufacturer's production in 1998 and 100 percent in 1999.



Table 12.17
California Car, Light Truck and Medium Truck Emission Certification Standards

Vehicle type	Durability vehicle basis (mi)	Vehicle emission category	NMOG (g/mi)	Carbon monoxide (g/mi)	Oxides of nitrogen (g/mi)	Formaldehyde (mg/mi)	Particulates (g/mi)
All passenger cars; LDTs 8,500 lbs GVW or less	50,000	LEV	0.075	3.4	0.05	15	n/a
		LEV, Option 1	0.075	3.4	0.07	15	n/a
		ULEV	0.040	1.7	0.05	8	n/a
Vehicles in this category are tested at their loaded vehicle weight	120,000	LEV	0.090	4.2	0.07	18	0.01
		LEV, Option 1	0.090	4.2	0.10	18	0.01
		ULEV	0.055	2.1	0.07	11	0.01
		SULEV	0.010	1.0	0.02	4	0.01
	150,000 (Optional)	LEV	0.090	4.2	0.07	18	0.01
		LEV, Option 1	0.090	4.2	0.10	18	0.01
		ULEV	0.055	2.1	0.07	11	0.01
		SULEV	0.010	1.0	0.02	4	0.01
MDVs 8,501-10,000 lbs GVW	120,000	LEV	0.195	6.4	0.2	32	0.12
		ULEV	0.143	6.4	0.2	16	0.06
		SULEV	0.100	3.2	0.1	8	0.06
	150,000 (Optional)	LEV	0.195	6.4	0.2	32	0.12
		ULEV	0.143	6.4	0.2	16	0.06
		SULEV	0.100	3.2	0.1	8	0.06
MDVs 10,000-14,000 lbs GVW	120,000	LEV	0.230	7.3	0.4	40	0.12
		ULEV	0.167	7.3	0.4	21	0.06
		SULEV	0.117	3.7	0.2	10	0.06
	150,000 (Optional)	LEV	0.230	7.3	0.4	40	0.12
		ULEV	0.167	7.3	0.4	21	0.06
		SULEV	0.117	3.7	0.2	10	0.06

Source:California LEV Regulations with amendments effective 12/8/10. (Additional resources: www.arb.ca.gov)**Note:** Definitions of acronyms are on page 12-13.

These exhaust emission standards apply to commercial aircraft engines.

Table 12.18
Aircraft – Exhaust Emission Standards

	Year	Pressure ratio (PR)	Applicability ^a	HC (g/kN)	NOx	CO (g/kN)	Smoke
Federal ^b	1974+	-	T8	-	-	-	30
	1976+	-	TF with rO ^c ≥ 129 kN	-	-	-	83.6(rO) ^{-0.274}
	1978+	-	T3 ^d	-	-	-	25
	1983+	-	TF with rO < 26.7 kN	-	-	-	83.6(rO) ^{-0.274} NTE max of SN=50
	1984+	-	T3, T8, TF with rO ≥ 26.7 kN	19.6	-	-	83.6(rO) ^{-0.274} NTE max of SN=50
		-	TSS	140(.92) ^{rPR}	-	-	83.6(rO) ^{-0.274} NTE max of SN=50
		-	TSS with rO ≥ 26.7 kN	140(.92) ^{rPR}	-	-	83.6(rO) ^{-0.274} NTE max of SN=50
		-	TP with rO ≥ 1,000 kW	-	-	-	187(rO) ^{-0.168}
	1997+	-	T3, T8, TF with rO > 26.7 kN	19.6	40+2(rPR)	118	83.6(rO) ^{-0.274} NTE max of SN=50
		-	T3, T8, TF newly certified with rO > 26.7 kN	19.6	32+1.6(rPR)	118	83.6(rO) ^{-0.274} NTE max of SN=50
	2000+	-	T3, T8, TF newly manufactured with rO > 26.7 kN	19.6	32+1.6(rPR)	118	83.6(rO) ^{-0.274} NTE max of SN=50
	2005+	PR ≤ 30	T3, T8, TF newly certified with rO > 89 kN	-	19+1.6(rPR)	-	-
			T3, T8, TF newly certified with 26.7 kN < rO ≤ 89 kN	-	37.572+1.6(rPR)-0.2087(rO)	-	-
		30 < PR < 62.5	T3, T8, TF newly certified with rO > 89 kN	-	7+2.0(rPR)	-	-
			T3, T8, TF newly certified with 26.7kN < rO ≤ 89kN	-	42.71+1.4286(rPR)-0.4013(rO)+0.00642(rPR)(rO)	-	-
PR ≤ 62.5		T3, T8, TF	-	32+1.6(rPR)	-	-	

Source:

40 CFR Part 87, Aircraft emission standards, test procedures, certification requirements (Additional resources: www.epa.gov/otaq/standards)

Note: The test procedures are the International Civil Aviation Organization (ICAO) Smoke Emission Test Procedure and the ICAO Gaseous Emissions Test Procedure. There is no useful life or warranty period for purposes of compliance with aircraft emissions standards. Definitions of acronyms are on page 12-13.

^a T8=all aircraft gas turbine engines of the JT8D model family

TF=all turbofan and turbojet aircraft engines except engines of Class T3, T8, and TSS

T3=all aircraft gas turbine engines of the JT3D model family

TSS=all aircraft gas turbine engines for aircraft operations at supersonic flight speeds

TP=all aircraft turboprop engines

^b Federal standards apply to planes operating in the United States, regardless of where they were manufactured.

^c Rated output (rO) is the maximum power/thrust available for takeoff.

^d T3 engines are no longer manufactured but are in the existing fleet.



These standards apply to construction and agricultural equipment, such as excavators, paving equipment, tractors, combines, bulldozers, and skidders.

**Table 12.19
Nonroad Compression-Ignition Engines – Exhaust Emission Standards**

	Rated power (kW)	Tier	Model year	NMHC (g/kW-hr)	NMHC + NOx (g/kW-hr)	NOx (g/kW-hr)	PM (g/kW-hr)	CO (g/kW-hr)	Smoke ^a percentage	Useful life (hours/years) ^b
Federal	kW < 8	1	2000-2004	--	10.5	--	1.0	8.0	20 / 15 / 50	3,000 / 5
		2	2005-2007	--	7.5	--	0.80	8.0		
		4	2008+	--	7.5	--	0.40 ^c	8.0		
	8 ≤ kW < 19	1	2000-2004	--	9.5	--	0.80	6.6		3,000 / 5
		2	2005-2007	--	7.5	--	0.80	6.6		
		4	2008+	--	7.5	--	0.40	6.6		
	19 ≤ kW < 37	1	1999-2003	--	9.5	--	0.80	5.5		5,000 / 7 ^d
		2	2004-2007	--	7.5	--	0.60	5.5		
		4	2008-2012	--	7.5	--	0.30	5.5		
			2013+	--	4.7	--	0.03	5.5		
	37 ≤ kW < 56	1	1998-2003	--	--	9.2	--	--		20 / 15 / 50
		2	2004-2007	--	7.5	--	0.40	5.0		
		3 ^e	2008-2011	--	4.7	--	0.40	5.0		
		4 (Option 1) ^f	2008-2012	--	4.7	--	0.30	5.0		
		4 (Option 2) ^f	2012	--	4.7	--	0.03	5.0		
		4	2013+	--	4.7	--	0.03	5.0		
	56 ≤ kW < 75	1	1998-2003	--	--	9.2	--	--		20 / 15 / 50
		2	2004-2007	--	7.5	--	0.40	5.0		
		3	2008-2011	--	4.7	--	0.40	5.0		
		4	2012-2103 ^g	--	4.7	--	0.02	5.0		
			2014+ ^h	0.19	--	0.4	0.02	5.0		
	75 ≤ kW < 130	1	1997-2002	--	--	9.2	--	--		20 / 15 / 50
		2	2003-2006	--	6.6	--	0.3	5.0		
		3	2007-2011	--	4.0	--	0.3	5.0		
		4	2012-2013 ^g	--	4.0	--	0.02	5.0		
			2014+	0.19	--	0.4	0.02	5.0		
	130 ≤ kW < 225	1	1996-2002	1.3 ⁱ	--	9.2	0.54	11.4		8,000 / 10
		2	2003-2005	--	6.6	--	0.20	3.5		
		3	2006-2010	--	4.0	--	0.20	3.5		
		4	2011-2013 ^g	--	4.0	--	0.02	3.5		
2014+ ^h			0.19	--	0.4	0.02	3.5			
225 ≤ kW < 450	1	1996-2000	1.3 ⁱ	--	9.2	0.54	11.4	8,000 / 10		
	2	2001-2005	--	6.4	--	0.20	3.5			
	3	2006-2010	--	4.0	--	0.20	3.5			
	4	2011-2013 ^g	--	4.0	--	0.02	3.5			
		2014+ ^h	0.19	--	0.4	0.02	3.5			
450 ≤ kW < 560	1	1996-2001	1.3 ⁱ	--	9.2	0.54	11.4	8,000 / 10		
	2	2002-2005	--	6.4	--	0.20	3.5			
	3	2006-2010	--	4.0	--	0.20	3.5			
	4	2011-2013 ^g	--	4.0	--	0.02	3.5			
		2014+ ^h	0.19	--	0.4	0.02	3.5			
560 ≤ kW < 900	1	2000-2005	1.3 ⁱ	--	9.2	0.54	11.4	8,000 / 10		
	2	2006-2010	--	6.4	--	0.20	3.5			
	4	2011-2014	0.4	--	3.5	0.10	3.5			
		2015+ ^h	0.19	--	3.5 ^j	0.04 ^k	3.5			



Table 12.19 (continued)
Nonroad Compression-Ignition Engines – Exhaust Emission Standards

	Rated power (kW)	Tier	Model year	NMHC (g/kW-hr)	NMHC + NOx (g/kW-hr)	NOx (g/kW-hr)	PM (g/kW-hr)	CO (g/kW-hr)	Smoke ^a percentage	Useful life (hours/years) ^b
Federal	kW > 900	1	2000-2005	1.3 ⁱ	--	9.2	0.54	11.4	20 / 15 / 50	8,000 / 10
		2	2006-2010	--	6.4	--	0.20	3.5		
		4	2011-2014	0.4	--	3.5 ^j	0.10	3.5		
			2015+ ^h	0.19	--	3.5 ^j	0.04 ^k	3.5		

Source:

40 CFR 98.112 = Exhaust emission standards

40 CFR 1039.101 = Exhaust emission standards for after 2014 model year

40 CFR 1039.102 = Exhaust emission standards for model year 2014 and earlier

40 CFR 1039 Subpart F = Exhaust emissions transient and steady state test procedures

40 CFR Part 86 Subpart I = Smoke emission test procedures

40 CFR Part 1065 = Test equipment and emissions measurement procedures (Additional resources: www.epa.gov/otaq/standards)

Note: Definitions of acronyms are on page 12-13.

^a Smoke emissions may not exceed 20 percent during the acceleration mode, 15 percent during the lugging mode, and 50 percent during the peaks in either mode. Smoke emission standards do not apply to single-cylinder engines, constant-speed engines, or engines certified to a PM emission standard of 0.07 grams per kilowatt-hour (g/kW-hr) or lower. Smoke emissions are measured using procedures in 40 CFR Part 86 Subpart I.

^b Useful life and warranty period are expressed hours and years, whichever comes first.

^c Hand-startable air-cooled direct injection engines may optionally meet a PM standard of 0.60 g/kW-hr. These engines may optionally meet Tier 2 standards through the 2009 model years. In 2010 these engines are required to meet a PM standard of 0.60 g/kW-hr.

^d Useful life for constant speed engines with rated speed 3,000 revolutions per minute (rpm) or higher is 5 years or 3,000 hours, whichever comes first.

^e These Tier 3 standards apply only to manufacturers selecting Tier 4 Option 2. Manufacturers selecting Tier 4 Option 1 will be meeting those standards in lieu of Tier 3 standards.

^f A manufacturer may certify all their engines to either Option 1 or Option 2 sets of standards starting in the indicated model year. Manufacturers selecting Option 2 must meet Tier 3 standards in the 2008-2011 model years.

^g These standards are phase-out standards. Not more than 50 percent of a manufacturer's engine production is allowed to meet these standards in each model year of the phase out period. Engines not meeting these standards must meet the final Tier 4 standards.

^h These standards are phased in during the indicated years. At least 50 percent of a manufacturer's engine production must meet these standards during each year of the phase in. Engines not meeting these standards must meet the applicable phase-out standards.

ⁱ For Tier 1 engines the standard is for total hydrocarbons.

^j The NOx standard for generator sets is 0.67 g/kW-hr.

^k The PM standard for generator sets is 0.03 g/kW-hr.



These standards apply to gasoline and propane industrial equipment such as forklifts, generators, airport service equipment, compressors and ice-grooming machines.

Table 12.20
Nonroad Large Spark-Ignition Engines – Exhaust and Evaporative Emission Standards

	Tier	Year	General duty-cycle standards		Alternative standards for severe-duty engines		Field testing standards		Useful life (years/hours)	
			HC+NO _x ^a (g/kW-hr)	CO (g/kW-hr)	HC+NO _x ^a (g/kW-hr)	CO (g/kW-hr)	HC+NO _x ^a (g/kW-hr)	CO (g/kW-hr)		
Federal ^b	1 ^c	2004-2006	4.0 ^d	50.0	4.0 ^d	130.0	-	-	7 / 5,000 ^e	
			2.7 ^f	4.4 ^f	2.7	130.0	3.8 ^f	6.5 ^f	7 / 5,000 ^e	
			Evaporative emission standards (for engines fueled by a volatile liquid fuel)							
		2 ^f	2007+	Fuel line permeation	Nonmetallic fuel lines must meet the permeation specifications of SAE J2260 (November 1996)					5 / -
				Diurnal emissions	Evaporative HC emissions may not exceed 0.2 grams per gallon of fuel tank capacity					
			Running loss	Liquid fuel in the fuel tank may not reach boiling during continuous engine operation in the final installation at an ambient temperature of 30°C						

Sources:

40 CFR 1048.101 = Exhaust emission standards

40 CFR 1048.105 = Evaporative emission standards

40 CFR 1048.110 = Engine diagnostic requirements (Additional resources: www.epa.gov/otaq/standards)

^a The numerical emission standards for hydrocarbons (HC) must be met based on the following types of hydrocarbon emissions for engines powered by the following fuels: (1) non-methane hydrocarbons (NMHC) for natural gas; (2) total hydrocarbon equivalent (THCE) for alcohol; and (3) total hydrocarbons (THC) for other fuels.

^b Voluntary Blue Sky standards for large spark-ignition (SI) engines are available. Engines with displacement at or below 1,000 cubic centimeters (cc) and maximum power at or below 30 kilowatts (kW) may be certified under the program for small SI engines.

^c Emission standards are based on testing over a steady-state duty-cycle.

^d The Tier 1 HC plus nitrogen oxides (NO_x) emission standard for in-use testing is 5.4 grams per kW-hour (g/kW-hr).

^e Useful life is expressed in years and hours, whichever comes first. These are the minimum useful life requirements. For severe-duty engines, the minimum useful life is seven years or 1,500 hours of operation, whichever comes first. A longer useful life in hours is required if: (a) the engine is designed to operate longer than the minimum useful life based on the recommended rebuild interval; or (b) the basic mechanical warranty is longer than the minimum useful life.

^f Optional engine certification is allowed according to the following formula: $(\text{HC}+\text{NO}_x) \times \text{CO}^{0.784} \leq 8.57$. The HC+NO_x and carbon monoxide (CO) emission levels selected to satisfy this formula, rounded to the nearest 0.1 g/kW-hr, become the emission standards that apply for those engines. One may not select an HC+NO_x emission standard higher than 2.7 g/kW-hr or a CO emission standard higher than 20.6 g/kW-hr.



Table 12.21
Locomotives – Exhaust Emission Standards

	Duty-cycle ^b	Tier	Year ^c	HC ⁱ (g/hp-hr)	NOx (g/bhp-hr)	PM (g/bhp-hr)	CO (g/bhp-hr)	Smoke (percentage) ^m	Minimum useful life (hours / years / miles) ⁿ
Federal ^a	Line-haul	Tier 0	1973-1992 ^{d,e}	1.0	9.5 [ABT]	0.22 [ABT]	5.0	30 / 40 / 50	(7.5 x hp) / 10 / 750,000 ^o
		Tier 1	1993-2004 ^{d,e}	0.55	7.4 [ABT]	0.22 [ABT]	2.2	25 / 40 / 50	(7.5 x hp) / 10 / 750,000 ^o
		Tier 2	2005-2011 ^d	0.30	5.5 [ABT]	0.10 ^k [ABT]	1.5	20 / 40 / 50	(7.5 x hp) / 10 / -
		Tier 3	2012-2014 ^f	0.30	5.5 [ABT]	0.10 [ABT]	1.5	20 / 40 / 50	(7.5 x hp) / 10 / -
		Tier 4	2015+ ^g	0.14	1.3 [ABT]	0.03 [ABT]	1.5	-	(7.5 x hp) / 10 / -
	Switch	Tier 0	1973-2001	2.10	11.8 [ABT]	0.26 [ABT]	8.0	30 / 40 / 50	(7.5 x hp) / 10 / 750,000 ^o
		Tier 1	2002-2004 ^h	1.20	11.0 [ABT]	0.26 [ABT]	2.5	25 / 40 / 50	(7.5 x hp) / 10 / -
		Tier 2	2005-2010 ^h	0.60	8.1 [ABT]	0.13 ^l [ABT]	2.4	20 / 40 / 50	(7.5 x hp) / 10 / -
		Tier 3	2011-2014	0.60	5.0 [ABT]	0.10 [ABT]	2.4	20 / 40 / 50	(7.5 x hp) / 10 / -
		Tier 4	2015+	0.14 ^l	1.3 ^l [ABT]	0.03 [ABT]	2.4	-	(7.5 x hp) / 10 / -

Sources:

40 CFR 1033.101 = Emission Standards and Useful Life

^a These standards apply to locomotives that are propelled by engines with total rated horsepower (hp) of 750 kilowatts (kW) (1006 hp) or more, unless the owner chooses to have the equipment certified to meet the requirements of locomotives. This does not include vehicles propelled by engines with total rated horsepower of less than 750 kW (1006 hp); see the requirements in 40 Code of Federal Regulations (CFR) Parts 86, 89 and 1039. The test procedures specify chassis-based testing of locomotives. These test procedures include certification testing, production line testing, and in-use testing using the Federal Test Procedure (FTP) when the locomotive has reached between 50-70 percent of its useful life.

^b Line-haul locomotives are powered by an engine with a maximum rated power (or a combination of engines having a total rated power) greater than 2300 hp. Switch locomotives are powered by an engine with a maximum rated power (or a combination of engines having a total rated power) of 2300 hp or less.

^c The Tier 0 standards apply to locomotives manufactured after 1972 when they are manufactured or remanufactured. Note that interim standards may apply for Tier 0 or Tier 1 locomotives remanufactured in 2008 or 2009, or for Tier 2 locomotives manufactured or remanufactured in 2008-2012.

^d Line-haul locomotives subject to the Tier 0 through Tier 2 emission standards must also meet switch standards of the same tier.

^e The Tier 0 standards apply for 1993-2001 locomotives not originally manufactured with a separate loop intake air cooling system.

^f Tier 3 line-haul locomotives must also meet Tier 2 switch standards.

^g Manufacturers using credits may elect to meet a combined nitrogen oxides (NOx) plus hydrocarbon (HC) standard of 1.4 grams per brakehorsepower-hour (g/bhp-hr) instead of the otherwise applicable Tier 4 NOx and HC standards.

^h Tier 1 and Tier 2 switch locomotives must also meet line-haul standards of the same tier.

ⁱ The numerical emission standards for HC must be met based on the following types of hydrocarbon emissions for locomotives powered by the following fuels: (1) alcohol: total hydrocarbon equivalent (THCE) emissions for Tier 3 and earlier locomotives, and non-methane hydrocarbon equivalent (NMHCE) for Tier 4; (2) natural gas and liquefied petroleum gas: non-methane hydrocarbon (NMHC) emissions; and (3) diesel: total hydrocarbon (THC) emissions for Tier 3 and earlier locomotives, and NMHC for Tier 4.



Table 12.21 (continued)
Locomotives – Exhaust Emission Standards

^j Manufacturers may elect to meet a combined NO_x+HC standard of 1.4 g/bhp-hr instead of the otherwise applicable Tier 4 NO_x and HC standards.

^k The line-haul particulate matter (PM) standard for newly remanufactured Tier 2 locomotives is 0.20 g/bhp-hr until January 1, 2013, except as specified in 40 CFR Part 1033.150(a).

^l The switch PM standard for new Tier 2 locomotives is 0.24 g/bhp-hr until January 1, 2013, except as specified in 40 CFR Part 1033.150(a).

^m The smoke opacity standards apply only for locomotives certified to one or more PM standards or Family Emission Limits (FEL) greater than 0.05 g/bhp-hr. Percentages apply to smoke opacity at steady state/30-second peak/3-second peak, as measured continuously during testing.

ⁿ Useful life and warranty period are expressed in megawatt-hours (mw-hr), years, or miles, whichever comes first. Manufacturers are required to certify to longer useful lives if their locomotives are designed to last longer between overhauls than the minimum useful life value.

^o For locomotives originally manufactured before January 1, 2000, and not equipped with mw-hr meters.



These standards apply to auxiliary and propulsion engines used by all types of recreational and commercial vessels, from small fishing boats to ocean-going ships.

**Table 12.22
Marine Compression-Ignition (CI) Engines – Exhaust Emission Standards**

	Category ^{a, b}	Tier	Displacement (L/cylinder)	Power ^c (kW)	Speed (rpm)	Model Year	NOx (g/kW-hr)	HC (g/kW-hr)	HC+NOx ^d (g/kW-hr)	PM (g/kW-hr)	CO (g/kW-hr)	Useful Life ^e (years/hours)
Federal ^f	C1 Commercial	1	≥ 2.5	≥ 37	rpm < 130	2004 ^h	17.0	-	-	-	-	10 / 10,000
					130 ≤ rpm < 2000		45.0 x N ^{0.201}	-	-	-		
					rpm ≥ 2000		9.8	-	-	-		
		2	disp. < 0.9	≥ 37	-	2005 ^h	-	-	7.5 (ABT)	0.40 (ABT)	5.0	10 / 10,000
			0.9 ≤ disp < 1.2	all	-	2004 ^h	-	-	7.2 (ABT)	0.30 (ABT)	5.0	
			1.2 ≤ disp < 2.5		2004 ^h	-	-	7.2 (ABT)	0.20 (ABT)	5.0		
	2.5 ≤ disp < 5.0	-	2007 ^h	-	-	7.2 (ABT)	0.20 (ABT)	5.0				
	C1 Commercial & Recreational	1	≥ 2.5	≥ 37	rpm < 130	2004	17.0	-	-	-	-	10 / 1,000
					130 ≤ rpm < 2000		45.0 x N ^{0.201}	-	-	-		
					rpm ≥ 2000		9.8	-	-	-		
		2	disp < 0.9	≥ 37	-	2007	-	-	7.5 (ABT)	0.40 (ABT)	5.0	10 / 1,000
			0.9 ≤ disp < 1.2	all	-	2006	-	-	7.2 (ABT)	0.30 (ABT)	5.0	
			1.2 ≤ disp < 2.5		2006	-	-	7.2 (ABT)	0.20 (ABT)	5.0		
	2.5 ≤ disp < 5.0	-	2009	-	-	7.2 (ABT)	0.20 (ABT)	5.0				
	C1 Commercial & Recreational < 75 kW	3	< 0.9	< 8	-	2009+	-	-	7.5 (ABT)	0.40 (ABT)	8.0	5 / 3,000 10 / 1,000 for CI Recreational
				8 ≤ kW < 19	-	2009+	-	-	7.5 (ABT)	0.40 (ABT)	6.6	
				19 ≤ kW < 37	-	2009-2013	-	-	7.5 ⁱ (ABT)	0.30 ^j (ABT)	5.5	
				-	2014+	-	-	4.7 ⁱ (ABT)	0.20 (ABT)	5.0		
				37 ≤ kW < 75	-	2009-2013	-	-	7.5 ⁱ (ABT)	0.30 ^j (ABT)	5.0	
				-	2014+	-	-	4.7 ⁱ (ABT)	0.20 (ABT)	5.0		
	C1 Commercial Engines with ≤ 35 kW/L power density ^k	3 ^l	< 0.9	-	-	2012+	-	-	5.4 (ABT)	0.14 (ABT)	8.0 for < 8 kW	5 / 3,000 for commercial engines < 19 kW
			0.9 ≤ disp < 1.2	All	-	2013+	-	-	5.4 (ABT)	0.12 (ABT)	6.6 for 8 ≤ kW < 19	7 / 5,000 for commercial engines 19 ≤ kW < 37
			1.2 ≤ disp < 2.5	< 600	-	2014-2017	-	-	5.6 (ABT)	0.11 (ABT)	5.5 for 19 ≤ kW < 37	10 / 10,000 for C1 Commercial ≤ 37 kW
					-	2018+	-	-	5.6 (ABT)	0.10 (ABT)	5.0 for ≤ 37 kW	
2.5 ≤ disp < 3.5			< 600	≥ 600	2014+	-	-	5.6 (ABT)	0.11 (ABT)			
				-	2013-2017	-	-	5.6 (ABT)	0.11 (ABT)			
3.5 ≤ disp < 7.0			< 600	≥ 600	2018+	-	-	5.6 (ABT)	0.10 (ABT)			
				-	2013+	-	-	5.6 (ABT)	0.11 (ABT)			
3.5 ≤ disp < 7.0			≥ 600	-	2012-2017	-	-	5.8 (ABT)	0.11 (ABT)			
				-	2018+	-	-	5.8 (ABT)	0.10 (ABT)			
≥ 600			2012+	-	-	5.8 (ABT)	0.11 (ABT)					
C1 Commercial engines with > 35 kW/L power density & All Recreational Engines ^k			3 ^l	< 0.9	≥ 75	-	2012+	-	-	5.8 (ABT)	0.15 (ABT)	8.0 for < 8 kW
	0.9 ≤ disp < 1.2	All		-	2013+	-	-	5.8 (ABT)	0.14 (ABT)	6.6 for 8 ≤ kW < 19	7 / 5,000 for commercial engines 19 ≤ kW < 37	
	1.2 ≤ disp < 2.5			-	2014+	-	-	5.8 (ABT)	0.14 (ABT)	5.5 for 19 ≤ kW < 37	10 / 10,000 for C1 Commercial ≥ 37 kW	
	2.5 ≤ disp < 3.5			-	2013+	-	-	5.8 (ABT)	0.12 (ABT)	5.0 for ≥ 37 kW	10 / 1,000 for CI Recreational	
	3.5 ≤ disp < 7.0			-	2012+	-	-	5.8 (ABT)	0.11 (ABT)			

(Continued on next page)



Table 12.22 (continued)
Marine Compression-Ignition (CI) Engines – Exhaust Emission Standards

	Category ^{a,b}	Tier	Displacement (L/cylinder)	Power ^c (kW)	Speed (rpm)	Model Year	NOx (g/kW-hr)	HC (g/kW-hr)	HC+NOx ^d (g/kW-hr)	PM (g/kW-hr)	CO (g/kW-hr)	Useful Life ^e (years/hours)			
Federal ^g	C1 Commercial > 600 kW	4 th	All	600 ≤ kW < 1,400	-	2017+	1.8 (ABT)	-	0.19 HC ³	0.04 (ABT)	5.0	10 / 10,000			
			All	1,400 ≤ kW < 2,000	-	2016+	1.8 (ABT)	-	0.19 HC ³	0.04 (ABT)					
			All	2,000 ≤ kW < 3,700	-	2014+	1.8 (ABT)	-	0.19 HC ³	0.04 (ABT)					
			< 7.0	≥ 3,700	-	2014-2015	1.8 (ABT)	-	0.19 HC ³	0.12 (ABT)					
					-	2016+	1.8 (ABT)	-	0.19 HC ³	0.06 (ABT)					
	C2	1	≥ 2.5	≥ 37	rpm < 130	2004	17.0	-	-	-	-	10 / 20,000			
					130 ≤ rpm < 2,000		45.0 × N ^{0.201}	-	-	-					
					rpm ≥ 2,000		9.8	-	-	-					
		2	5.0 ≤ disp < 15.0	all	-	2007	-	-	7.8 (ABT)	0.27 (ABT)	5.0	10 / 20,000			
							15.0 ≤ disp < 20.0	-	-	8.7 (ABT)	0.50 (ABT)		5.0		
							15.0 ≤ disp < 20.0	≥ 3,300	-	-	-		9.8 (ABT)	0.50 (ABT)	5.0
							20.0 ≤ disp < 25.0	all	-	-	-		9.8 (ABT)	0.50 (ABT)	5.0
							25.0 ≤ disp < 30.0	all	-	-	-		11.0 (ABT)	0.50 (ABT)	5.0
		3 ^{rd-P}	7.0 ≤ disp < 15.0	2,000 ≤ kW < 3,700	-	2013+	-	-	6.2 (ABT)	0.14 (ABT)	5.0	10 / 20,000			
							-	-	7.8 (ABT)	0.14 (ABT)	5.0				
			15.0 ≤ disp < 20.0	< 2,000	-	2014+	-	-	7.0 (ABT)	0.34 (ABT)	5.0				
							-	-	9.8 (ABT)	0.27 (ABT)	5.0				
		4 ^{th-P}	7.0 ≤ disp < 15.0	600 ≤ kW < 1,400	-	2017+	1.8 (ABT)	-	0.19 HC ³	0.04 (ABT)	5.0	10 / 20,000			
							1400 ≤ kW < 2,000	-	2016+	1.8 (ABT)			-	0.19 HC ³	0.04 (ABT)
			All	2,000 ≤ kW < 3,700 ^h	-	2014+	1.8 (ABT)	-	0.19 HC ³	0.04 (ABT)					
			< 15.0	≥ 3,700	-	2014-2015	1.8 (ABT)	-	0.19 HC ³	0.12 (ABT)					
			15.0 ≤ disp < 30.0		-	2014-2015	1.8 (ABT)	-	0.19 HC ³	0.25 (ABT)					
			All		-	2016+	1.8 (ABT)	-	0.19 HC ³	0.06 (ABT)					
		All	-		2016+	1.8 (ABT)	-	0.19 HC ³	0.06 (ABT)						
	C3	1	≥ 30.0	All	rpm < 130	2004	17.0	-	-	-	-	3 / 10,000			
					130 ≤ rpm < 2,000		45.0 × N ^{0.201}	-	-	-					
					rpm ≥ 2,000		9.8	-	-	-					
2		≥ 30.0	All	rpm < 130	2011	14.4	2.0	-	-	5.0	3 / 10,000				
				130 ≤ rpm < 2,000		44.0 × N ^{0.2231}		-	-						
				rpm ≥ 2,000		7.7		-	-						
3		≥ 30.0	All	rpm < 130	2016	3.4	2.0	-	-	5.0	3 / 10,000				
				130 ≤ rpm < 2,000		9.0 × N ^{0.201}		-	-						
				rpm ≥ 2,000		2.0		-	-						

Sources:

- 40 CFR 89.104 = Tiers 1 and 2 useful life & warranty period for marine CI engines less than 37 kW
- 40 CFR 89.112 = Tiers 1 and 2 emission standards for marine CI engines less than 37 kW
- 40 CFR 89 Subpart E = Tiers 1 and 2 test procedures for marine CI engines less than 37 kW
- 40 CFR 94.8 = Tiers 1 and 2 emission standards for C1 (both commercial & recreational), C2 and C3 engines
- 40 CFR 94.9 = Tiers 1 and 2 useful life for C1 (both commercial & recreational), C2 and C3 engines
- 40 CFR 94 Subpart B = Tiers 1 and 2 test procedures for C1 (both commercial & recreational), C2 and C3 engines
- 40 CFR 1042.101 = Tiers 3 and 4 exhaust emission standards and useful life



Table 12.22 (continued)
Marine Compression-Ignition (CI) Engines – Exhaust Emission Standards

Sources (continued):

40 CFR 1042.107 = Tiers 3 and 4 evaporative emission standards engines using a volatile liquid fuel (e.g., methanol)

40 CFR 1042.120 = Tiers 3 and 4 warranty period

40 CFR 1042 Subpart F = Tiers 3 and 4 test procedures (Additional resources: www.epa.gov/otaq/standards)

^a For Tiers 1 and 2, Category 1 marine engines are greater than or equal to 37 kilowatts (kW) and have a displacement less than 5.0 liters per cylinder (L/cylinder); Category 2 marine engines have a displacement greater than or equal to 5.0 L/cylinder and less than 30 L/cylinder; and Category 3 marine engines have a displacement greater than or equal to 30.0 L/cylinder. For Tiers 3 and 4, Category 1 represents engines up to 7 L/cylinder displacement; and Category 2 includes engines from 7 to 30 L/cylinder. The definition of Category 3 marine engines remains the same.

^b Tiers 1 and 2 for marine engines less than 37 kW are subject to the same emission standards as for land-based engines. See Table 1 in 40 Code of Federal Regulations (CFR) Part 89.112 and 40 CFR Part 89.104.

^c For Tiers 1 and 2, this refers to the rated power; for Tiers 3 and 4, this refers to the maximum engine power.

^d Total hydrocarbon (THC) plus nitrogen oxides (NOx) for Tier 2 standards.

^e Useful life is expressed in hours or years, whichever comes first. For Tiers 3 and 4, a longer useful life in hours for an engine family must be specified if either: 1) the engine is designed, advertised, or marketed to operate longer than the minimum useful life; or 2) the basic mechanical warranty is longer than the minimum useful life.

^f Warranty period is expressed in years and hours, whichever comes first.

^g For Tiers 3 and 4, there are no evaporative emission standards for diesel-fueled engines, or engines using other nonvolatile or nonliquid fuels (e.g., natural gas). If an engine uses a volatile liquid fuel, such as methanol, the engine's fuel system and the vessel in which the engine is installed must meet the evaporative emission requirements of 40 Code of Federal Regulations (CFR) Part 1045 that apply with respect to spark-ignition engines. Manufacturers subject to evaporative emission standards must meet the requirements of 40 CFR 1045.112 as described in 40 CFR 1060.1(a)(2).

^h Indicates the model years for which the specified standards start.

ⁱ N is the maximum test speed of the engine in revolutions per minute (rpm).

^j Manufacturers of Tier 3 engines greater than or equal to 19 kW and less than 75 kW with displacement below 0.9 L/cylinder may alternatively certify some or all of their engine families to a particulate matter (PM) emission standard of 0.20 grams per kilowatt-hour (g/kW-hr) and a NOx+HC emission standard of 5.8 g/kW-hr for 2014 and later model years.

^k The applicable Tier 2 NOx+HC standards continue to apply instead of the Tier 3 values for engines at or above 2000 kW.

^l These Tier 3 standards apply to Category 1 engines below 3700 kW except for recreational marine engines at or above 3700 kW (with any displacement), which must meet the Tier 3 standards specified for recreational marine engines with a displacement of 3.5 to 7.0 L/cylinder.

^m The following provisions are optional: 1) Manufacturers may use NOx credits to certify Tier 4 engines to a NOx+HC emission standard of 1.9 g/kW-hr instead of the NOx and HC standards. See 40 CFR 1042.101(a)(8)(i) for more details. 2) For engines below 1000 kW, manufacturers may delay complying with the Tier 4 standards until October 1, 2017. 3) For engines at or above 3700 kW, manufacturers may delay complying with the Tier 4 standards until December 31, 2016.

ⁿ The Tier 4 standard is for HC (not HC+NOx) in g/kW-hr.

^o These Tier 3 standards apply to Category 2 engines below 3700 kW; no Tier 3 standards apply for Category 2 engines at or above 3700 kW, although there are Tier 4 standards that apply.



Table 12.22 (continued)
Marine Compression-Ignition (CI) Engines – Exhaust Emission Standards

^p An alternative set of Tier 3 and Tier 4 standards for PM, NO_x, and HC are available for Category 2 engines at or above 1400 kW, but must be applied to all of a manufacturer's engines in a given displacement category in model years 2012 through 2015.

Tier	Maximum engine power	Model year	PM (g/kW-hr)	NO _x (g/kW-hr)	HC (g/kW-hr)
3	kW ≥ 1400	2012-2014	0.14	7.8 NO _x +HC	
4	1400 ≤ kW < 3700	2015	0.04	1.8	0.19
	kW ≥ 3700	2015	0.06	1.8	0.19

^q Interim Tier 4 PM standards apply for 2014 and 2015 model year Category 2 engines with per-cylinder displacement at or above 15.0 liters: 0.34 g/kW-hr for engines 2000 = kW < 3000, and 0.27 g/kW-hr for engines 3300 = kW < 3700.



These standards apply to gasoline boats and personal watercraft, such as pleasure boats, jet-skis, outboard engines and sterndrive/inboard engines.

Table 12.23
Marine Spark-Ignition Engines and Vessels – Exhaust Emission Standards

Engine type	Model year	HC + NO _x ^a (g/KW-hr)		CO ^c (g/KW-hr)		Useful life (hours/years) ^d	
		P ≤ 4.3 kW ^b	P > 4.3 kW ^b	P ≤ 4.3 kW ^b	P > 4.3 kW ^b		
Federal ^e	Personal watercraft & outboard marine engines	1998	278 ABT	$(0.917 \times (151 + 557/P^{0.9}) + 2.44)$ [ABT]	--	--	350 / 5
		1999	253 ABT	$(0.833 \times (151 + 557/P^{0.9}) + 2.89)$ [ABT]	--	--	
		2000	228 ABT	$(0.750 \times (151 + 557/P^{0.9}) + 3.33)$ [ABT]	--	--	
		2001	204 ABT	$(0.667 \times (151 + 557/P^{0.9}) + 3.78)$ [ABT]	--	--	
		2002	179 ABT	$(0.583 \times (151 + 557/P^{0.9}) + 4.22)$ [ABT]	--	--	
		2003	155 ABT	$(0.500 \times (151 + 557/P^{0.9}) + 4.67)$ [ABT]	--	--	
		2004	130 ABT	$(0.417 \times (151 + 557/P^{0.9}) + 5.11)$ [ABT]	--	--	
		2005	105 ABT	$(0.333 \times (151 + 557/P^{0.9}) + 5.56)$ [ABT]	--	--	
		2006-2009	81 ABT	$(0.250 \times (151 + 557/P^{0.9}) + 6.00)$ [ABT]	--	--	
		2010 + ^g	30 ABT [ABT]	$2.1 + 0.09 \times (151 + 557/P^{0.9})$ [ABT]	500 - 5.0 x P	300	Personal Watercraft: 350 / 5 ^h Outboard: 350 / 10 ^h
Sterndrive/ inboard engines	Conventional engines ^g	2010 +	5.0 [ABT]		75 [ABT]	480 / 10 ⁱ	
		High-performance engines	P ≤ kW ^b	P > 485 kW ^b	350	P ≤ 485 kW: 150 / 3	
	2010		20.0	25.0		P > 485 kW: 50 / 1	
		2011+	16.0	22.0			

Sources:

40 CFR 91.104 = Outboard and personal watercraft (PWC) exhaust emission standards (1998-2009)

40 CFR 91.105 = Outboard and PWC useful life (1998-2009)

40 CFR 1045.103 = Outboard and PWC exhaust emission standards (2010+)

40 CFR 1045.105 = Sterndrive/Inboard exhaust emission standards

40 CFR 1045.107 = Not-to-exceed exhaust emission standards (Additional resources: www.epa.gov/otaq/standards)

^a The numerical emission standards for hydrocarbons (HC) must be met based on the following types of HC emissions for engines powered by the following fuels: (1) total hydrocarbon equivalent for alcohol; (2) non-methane hydrocarbon for natural gas; and (3) total hydrocarbons for other fuels.



Table 12.23 (continued)
Marine Spark-Ignition Engines and Vessels – Exhaust Emission Standards

^b P stands for the maximum engine power in kilowatts.

^c Manufacturers may generate or use emission credits for averaging, but not for banking or trading.

^d Useful life and warranty period are expressed hours or years of operation (unless otherwise indicated), whichever comes first.

^e The test procedure for federal standards uses the International Organization for Standardization (ISO) 8178 E4 5-Mode Steady-State Test Cycle.

^f Also applies to model year (MY) 1997 engine families certified pursuant to 40 Code of Federal Regulations (CFR) 91.205.

^g Not-to-exceed emission standards specified in 40 CFR 1045.107 also apply.

^h A longer useful life in terms of hours must be specified for the engine family if the average service life is longer than the minimum value as described in 40 CFR 1045.103(e)(3).

ⁱ The useful life may not be shorter than: (1) 150 hours of operation; (2) the recommended overhaul interval; or (3) the engine's mechanical warranty. A longer useful life must be specified in terms of hours if the average service life is longer than the minimum value as described in 40 CFR 1045.105(e)(3).



These standards apply to land-based recreational vehicles, such as snowmobiles, dirt bikes, all-terrain vehicles and go-karts.

Table 12.24
Nonroad Recreational Engines and Vehicles – Exhaust Emission Standards

Vehicle	Phase	Year	HC ^a g/kW-hr	HC + NOx g/km	CO		Minimum useful life (hours/years/km) ^b	
					g/kW-hr	g/km		
Federal	Snowmobiles ^c	1 ^d	2006+	100 [ABT]	-	275 [ABT]	-	400 / 5 / 8,000
		2	2010- 2011	75 [ABT]	-	275 [ABT]	-	
		3 ^e	2012+	150 ^f [ABT]	-	400 ^f [ABT]	-	
	Off-highway motorcycles ^g	1 ^d	2006+	-	2.0 ^{h,i} [ABT]	-	25 ^{h,i} [ABT]	> 70 cc Displacement: - / 5 / 10,000
								≤ 70 cc Displacement: - / 5 / 5,000
	ATVs ^g	1 ^d	2006+	-	1.5 ^{i,k} [ABT]	-	35 ^k [ABT]	≥ 100 cc Displacement: 1000 / 5 / 10,000 < 100 cc Displacement: 500 / 5 / 5,000

Sources:

40 CFR 1051.101-115 = Emission standards (Additional resources: www.epa.gov/otaq/standards)

^a The numerical emission standards for hydrocarbons (HC) must be met based on the following types of hydrocarbon emissions for recreational engines and vehicles powered by the following fuels: (1) non-methane hydrocarbons for natural gas; (2) total hydrocarbon equivalent for alcohol; and (3) total hydrocarbons for other fuels.

^b Useful life is expressed in hours, years, or kilometers, whichever comes first; warranty period is expressed in hours, months, or kilometers (km), whichever comes first. Nonroad recreational engines and vehicles must meet emission standards over their full useful life. A longer useful life in terms of km and hours must be specified for the engine family if the average service life is longer than the minimum value as described in 40 Code of Federal Regulations (CFR) 1051 Subpart B.

^c Test procedures for snowmobiles use the equipment and procedures for spark-ignition engines in 40 CFR Part 1065.

^d Phase 1 standards will be phased in: 50 percent by 2006, 100 percent by 2007.

^e Litigation on the November 2002 final rule resulted in a court decision that requires EPA to clarify the evidence and analysis upon which the Phase 3 carbon monoxide (CO) and HC standards were based. EPA will address this in a future rulemaking.

^f These are the maximum allowable family emission limits (FEL). The HC and CO standards are defined by a functional relationship as described in 40 CFR 1051.103(a)(2).

^g For off-highway motorcycles and ATVs, chassis dynamometer emissions test procedures are specified in 40 CFR Part 86, Subpart F and engine dynamometer emissions test procedures are specified in 40 CFR Part 1065.

^h Maximum allowable FEL: 20.0 grams per kilometer (g/km) for HC plus nitrogen oxides (NOx) and 50 g/km for CO.



Table 12.24 (continued)
Nonroad Recreational Engines and Vehicles – Exhaust Emission Standards

ⁱ Manufacturers may certify off-highway motorcycles with engines that have total displacement of 70 cubic centimeters (cc) or less to an HC+NO_x standard of 16.1 grams per kilowatt-hour (g/kW-hr) (with an FEL cap of 32.2 g/kW-hr) and a CO standard of 519 g/kW-hr.

^j Maximum allowable FEL for HC+NO_x is 20.0 g/km.

^k Manufacturers may certify all-terrain vehicles with engines that have total displacement of less than 100 cc to an HC+NO_x standard of 25.0 g/KW-hr (with an FEL cap of 40.0 g/kW-hr) and a CO standard of 500 g/kW-hr.



These standards were established in conjunction with the Tier 2 light vehicle standards to maintain the performance of catalytic converters.

Table 12.25
Gasoline Sulfur Standards

	Regulated entity	Refinery average and per-gallon cap by year (ppm)							
		2004	2005	2006	2007	2008	2009	2010	2010
Federal	Large refiners / importers ^a	120 ^b / 300 ^c	30 / 90 ^b / 300	30 / 80	30 / 80	30 / 80	30 / 80	30 / 80	30 / 80
	GPA refiners ^{d, e}	150 / 300 ^c	150 / 300	150 / 300	30 / 80	30 / 80	30 / 80	30 / 80	30 / 80
	Small refiners ^{f, g, h}	k	k	k	k	30 / 80	30 / 80	30 / 80	30 / 80
	Downstream standards ^{i, j}	378	326	95	95	95	95	95	95

Source:

40 CFR Part 80 Subpart H (Additional resources: www.epa.gov/otaq/standards)

^a Standards effective January 1 at the refinery gate.

^b No Refinery Average Standard applies in 2004; Corporate Average Standard applies in 2004 (120 ppm) and 2005 (90 ppm).

^c Cap exceedances up to 50 ppm in 2004 must be made up in 2005.

^d Geographic Phase-in Area (GPA) refiners must also comply with the corporate average standards in 2004 and 2005 if less than 50% of the refiner's gasoline is designated as GPA gasoline in a given compliance period.

^e GPA refiners may receive an additional two years (i.e., through 2008) to comply with the 30 / 80 ppm gasoline sulfur standards in exchange for producing 95% of their highway diesel fuel at the 15 ppm sulfur standard by June 1, 2006.

^f Small refiners may receive an additional two years (i.e., through 2009) to comply with the 30 / 80 ppm gasoline sulfur standards via a hardship demonstration.

^g Small refiners may receive an additional three years (i.e., through 2010) to comply with the 30 / 80 ppm gasoline sulfur standards in exchange for producing 95% of their highway diesel fuel at the 15 ppm sulfur standard by June 1, 2006.

^h Small refiners may receive a 20% increase in their annual average and per-gallon cap standards in exchange for producing 95% of their highway, nonroad, locomotive, and marine diesel fuel at the 15 ppm sulfur standard by June 1, 2006.

ⁱ Downstream standards are effective February 1 at any downstream location other than at a retail outlet or wholesale purchaser-consumer (e.g., pipelines and terminals) and March 1 at any downstream location.

^j Downstream standards for gasoline that is not blended with small refiner gasoline are shown. Refer to the Code of Federal Regulations (CFR) for the downstream standards that apply when a gasoline blend includes small refiner gasoline.

^k

1997-98 Refinery baseline sulfur level (ppm)	Small refiner interim gasoline sulfur standards (ppm) 2004 - 2007	
	Average	Cap
0 to 30	30	300
31 to 200	baseline level	300
201 to 400	200	300
401 to 600	50% of baseline	1.5 x avg. standard
601 and above	300	450



Ultra-low sulfur diesel (ULSD) fuel is necessary for new advanced emission control technologies. It also reduces particulate matter in the existing fleet of nonroad engines and equipment.

Table 12.26
Highway, Nonroad, Locomotive, and Marine (NRLM) Diesel Fuel Sulfur Standards

	Regulated entity	Covered fuel	Per-gallon maximum sulfur level by year (ppm)								
			2006 ^a	2007 ^b	2008	2009	2010 ^{c,d}	2011	2012	2013	2014
Federal	Large refiners & importers	Highway	80% 15 20% 500				15				
	Small refiners	Highway	500								
	Large refiners & importers	NR	-	500	500	500	15	15	15	15	15
		LM	-	500	500	500	500	500	15	15	15
		NRLM with credits ^e	-	HS	HS	HS	500	500	500	500	15
	Small refiners	NRLM ^f	-	HS	HS	HS	500	500	500	500	15
	Transmix processor & in-use	NR ^e	-	HS	HS	HS	500	500	500	500	15
LM ^e		-	HS	HS	HS	500	500	500	500	500	

Source:

40 CFR Part 80 Subpart I (Additional resources: www.epa.gov/otaq/standards)

^a For highway diesel fuel, standards are effective June 1 for refiners/importers, September 1 for pipelines and terminals, and October 15 for retailers and wholesale purchaser-consumers. Anti-downgrading provisions effective October 16, 2006.

^b For Nonroad, Locomotive, and Marine (NRLM) diesel fuel, standards are effective June 1 for refiners; downstream requirements apply for Northeast/Mid-Atlantic area only (August 1 for terminals, October 1 for retailers and wholesale purchaser-consumers, and December 1 for in-use).

^c For highway diesel fuel, standards are effective June 1 for refiners/importers, October 1 for pipelines and terminals, and December 1 for retailers and wholesale purchaser-consumers.

^d For NRLM diesel fuel, standards are effective June 1 for refiners, August 1 for terminals, October 1 for retailers and wholesale purchaser-consumers, and December 1 for in-use.

^e Excluding the Northeast and Alaska.

^f Excluding the Northeast, with approval in Alaska.



