

Emission Standards Reference Guide for Heavy-Duty and Nonroad Engines

HOW TO USE THIS REFERENCE GUIDE

This guide contains air pollutant emission standards for the following mobile source engine categories:

- Heavy-duty highway spark ignition (SI) and compression ignition (CI)
- Nonroad CI
- Nonroad SI less than or equal to 25 horsepower (hp)
- Marine SI
- Nonroad recreational vehicles and engines
- Locomotives
- Aircraft

Standards for each engine category are included in a separate table. This guide presents, when applicable, federal (U.S. Environmental Protection Agency [EPA]) current and proposed standards, as well as current California, European Union, and international emission standards. The key shown below indicates the color used for each of these standards in all of the tables. In addition to emission standards, this guide also includes information on useful life, warranty period, and test procedures. The availability of averaging, banking, and trading (ABT) and nonconformance penalties (NCP) is indicated as well.

This guide does not include standards for nonroad SI engines greater than 25 hp or marine CI engines. Although EPA regulates some fuels, fuel standards also are not included in this guide. This guide also does not include detailed

information about all variations and restrictions associated with the standards. This guide is for reference only; users should refer to the Code of Federal Regulations for complete information on all standards to ensure compliance.

The following guidelines will help you in reading the tables:

- To keep the tables more manageable, the guide contains standards only from 1990 and later. EPA began regulating mobile sources in the late 1960s, however.
- The years listed in the tables refer to model years for federal and international standards and for California standards for heavy-duty engines. The years listed in the California nonroad standards refer to calendar years, however. For European Union standards, the dates listed are effective dates.
- The term CI refers to diesel-cycle engines, and SI refers to Otto-cycle engines.
- For purposes of consistency and comparability, most standards are expressed in grams per brake horsepower-hour (g/bhp-hr), even though some federal regulations express standards in grams per kilowatt-hour (g/kW-hr). The conversion factors are as follows: 1.341 hp equals 1 kilowatt, and 0.7457 kilowatt equals 1 hp. To convert a standard from g/bhp-hr to g/kW-hr, multiply it by 1.341. To convert a standard from g/kW-hr to g/bhp-hr, multiply it by 0.7457.


- ABT and NCP appear in parentheses after standards for which they apply. Although restrictions may apply to ABT and NCP availability, they are not included in this guide.
- When year and mileage figures are given for useful life and warranty period (e.g., 5 years/50,000 miles), the rule “whichever comes first” always applies.
- The proposed federal standards are listed as they were published in the Federal Register. The standards and/or related information are subject to change when the regulations are finalized.
- For many standards, EPA and California use the same test procedures. California test procedures vary slightly for some standards, however.

Additional information on mobile source emission standards can be found on the Internet at:

<http://www.epa.gov/omswww/> (for EPA standards)

<http://www.arb.ca.gov/> (for California Air Resources Board standards)

Key

	Federal		California
	Proposed Federal		ICAO
	European Union		

Mention of trade names or products does not convey, and should not be interpreted as conveying, official EPA approval, endorsement, or recommendation.

Acronyms and Abbreviations Used in This Guide

ABT	averaging, banking, and trading	kW	kilowatt
cc	cubic centimeter	lbs	pounds
CFF	Clean-Fuel Fleet	LDT	light-duty truck
CI	compression ignition	LHDE	light heavy-duty engine
CO	carbon monoxide	LLDT	light light-duty truck
EPA	U.S. Environmental Protection Agency	LEV	low-emission vehicle
FR	Federal Register	LHDDE	light heavy-duty diesel engine
g/bhp-hr	grams per brake horsepower-hour	LPG	liquefied petroleum gas
g/km	grams per kilometer	m	meter
g/kN	grams per kilonewton	MDV	medium-duty vehicle
g/kW-hr	grams per kilowatt-hour	MHDDE	medium heavy-duty diesel engine
gpm	grams per mile	MW-hrs	megawatt-hours
g/test	grams per test	NCP	nonconformance penalties
GVWR	gross vehicle weight rating	NMHC	nonmethane hydrocarbons
HC	hydrocarbons	NOx	oxides of nitrogen
HCHO	formaldehyde	P	rated power of engine family in kilowatts
HDE	heavy-duty engine	PM	particulate matter
HDV	heavy-duty vehicle	rO	rated output
HLDT	heavy light-duty truck	RPM	revolutions per minute
HHDE	heavy heavy-duty diesel engine	rPR	rated pressure ratio
HHDE	heavy heavy-duty engine	SI	spark ignition
hp	horsepower	SN	smoke number
ICAO	International Civil Aviation Organization	SULEV	super-ultra-low emission vehicle
ILEV	inherently low-emission vehicle	THC	total hydrocarbons
ISO	International Standards Organization	THCE	total hydrocarbon equivalent
km	kilometer	ULEV	ultra low-emission vehicle
kN	kilonewton	ZEV	zero emission vehicle

HEAVY-DUTY HIGHWAY ENGINES—CI AND URBAN BUSES

	Year	CO (g/bhp-hr)	Idle CO (percent exhaust gas flow)	HC (g/bhp-hr)	NMHC + NO _x (g/bhp-hr)	NO _x (g/bhp-hr)	PM (g/bhp-hr)	Smoke ^a (percentage)	Useful Life	Warranty Period
Federal ^b	1990	15.5	0.5 ^c	1.3 ^d		6.0 (NCP)	0.60 (NCP)	20/15/50	1990-97 and 1998+ for HC, CO, and PM: LHDDE: 8 years/110,000 miles MHDDE: 8 years/185,000 miles HHDE: 8 years/290,000 miles 1994+ urban buses for PM only: 10 years/290,000 miles 1998+ for NO _x : LHDDE: 10 years/110,000 miles MHDDE: 10 years/185,000 miles HHDE: 10 years/290,000 miles	5 years/100,000 miles (but not less than the basic mechanical warranty for the engine family)
	1991-93	15.5	0.5 ^c	1.3		5.0 (ABT, NCP)	0.25 (ABT, NCP), 0.10 ^e	20/15/50		
	1994-97	15.5	0.5 ^c	1.3		5.0 (ABT, NCP)	0.10 (ABT, NCP), 0.07 ^f , 0.05 ^g	20/15/50		
	1998+	15.5	0.5 ^c	1.3		4.0 (ABT, NCP)	0.10 (ABT, NCP), 0.05 ^g	20/15/50		
Proposed Federal ^h	2004+	15.5	0.5		2.4 or 2.5 with a limit of 0.5 on NMHC (ABT)		0.10 (ABT, NCP), 0.05 ^g	20/15/50	LHDDE: 10 years/110,000 miles MHDDE: 10 years/185,000 miles HHDE and urban buses: 435,000 miles, 13,000 hours, or 10 years (but not less than 290,000 miles)	5 years/100,000 miles (but not less than the basic mechanical warranty of the engine)
European Union ⁱ	10/96	3.0		0.8		5.2	0.19	42/2.26 ^k 100/1.495 ^k 200/1.065 ^k		
	10/98						0.11 ^j			
California	1987-90 ^l	15.5	0.5 ^m	1.3/1.2 ⁿ		6.0	0.60	20/15/50	LHDDE: 8 years/110,000 miles MHDDE: 8 years/185,000 miles HHDE: 8 years/290,000 miles	5 years, 100,000 miles, or 3,000 hours (for 1994 and earlier engines greater than 8,500 lbs and for 1995+ engines greater than 14,000 lbs)
	1991-93 ^{l,o}	15.5	0.5 ^m	1.3/1.2 ⁿ		5.0	0.25 ^p /0.10 ^q			
	1994+ ^{l,o}	15.5	0.5 ^m	1.3/1.2 ⁿ		5.0	0.10			
	1994-95 ^{o,q}	15.5	0.5 ^m	1.3/1.2 ⁿ		5.0 (0.5-3.5 ^r)	0.07 ^p			
	1996+ ^{o,q}	15.5	0.5 ^m	1.3/1.2 ⁿ		4.0 ^s (0.5-2.5 ^r)	0.05			

Notes:

The test procedures for current and proposed federal standards are the EPA Transient Test Procedure and the EPA Smoke Test Procedure. The test procedures for California standards are the Transient Test Procedure and the Smoke Opacity Test Procedure. The test procedures for European Union standards are the 13-mode Steady-State Test Procedure and the European Smoke Test Procedure. Due to the significant difference in the test procedures, the European Union standards are not directly comparable to EPA and California standards.

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

^b Standards for 1990 apply only to diesel-fueled HDEs. 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 LPG/1994+.

^d For petroleum-fueled engines, the standard is for HC. For methanol-fueled engines, the standard is for THCE.

^e Standard for urban buses for 1993.

^f Standard for urban buses from 1994-95.

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

^h The proposed standards were published in the *Federal Register* on June 27, 1996 (61FR33421). They are subject to change when the regulations are finalized. NCP will be addressed during the 1999 Technology Review. As a signatory to the Statement of Principles outlining the proposed federal standards, California plans to propose the same standards.

ⁱ The European Union standards apply to both heavy-duty highway CI engines and urban buses. The standards for urban buses, however, are voluntary.

^j The standard applies to engines over 3,000 RPM and swept volume over 0.7 liter/cycle.

^k Nominal flow (liters/second)/absorbent coefficient (m^{-1}). Opacity under free acceleration should not exceed the approved level by more than $0.5 m^{-1}$.

^l The standards apply to diesel, methanol, and all applicable gaseous-fueled engines.

^m The standard applies to engines utilizing exhaust aftertreatment technology.

ⁿ The first number is the THC standard and the second number is the NMHC standard. Manufacturers of diesel, natural gas, or LPG engines may choose to certify to the total HC standard or the optional NMHC standard. The NMHC standard applies to 1990+.

^o The following HCHO standards apply to all methanol and alcohol-fueled engines: 0.010 g/bhp-hr for model years 1993-95; 0.05 g/bhp-hr for model years 1996+.

^p Emission averaging may be used to meet the standard.

^q Applies to urban buses only.

^r These standards for urban buses are optional.

^s A manufacturer may apply for an exemption from this standard based on demonstrated technological need for up to 10 percent of the average of the manufacturer's sales for the three previous model years.

HEAVY-DUTY HIGHWAY ENGINES—SI

	Year	Weight (lbs)	CO (g/bhp-hr)	Idle CO (percent exhaust gas flow)	HC (g/bhp-hr)	NMHC ^a (g/bhp-hr)	NMHC + NO _x (g/bhp-hr)	NO _x (g/bhp-hr)	Useful Life	Warranty Period
Federal	1990 ^b	≤ 14,000	14.4	0.5 ^e	1.1 ^c			6.0 (ABT, NCP)	8 years/110,000 miles; 10 years/110,000 miles (for NO _x standards for 1998 +)	5 years/50,000 miles (but not less than the basic mechanical warranty for the engine family)
		> 14,000	37.1		1.9 ^c			6.0 (ABT, NCP)		
	1991-97 ^d	≤ 14,000	14.4		1.1 ^f	0.9		5.0 (ABT, NCP)		
		> 14,000	37.1		1.9 ^f	1.7		5.0 (ABT, NCP)		
	1998 +	≤ 14,000	14.4		1.1 ^f	0.9		4.0 (ABT, NCP) ^g		
		> 14,000	37.1		1.9 ^f	1.7		4.0 (ABT, NCP) ^g		
Proposed Federal ^h	2004 +	≤ 14,000	14.4				2.4 or 2.5 with a limit of 0.5 on NMHC (ABT)		10 years/110,000 miles	5 years/100,000 miles (but not less than the basic mechanical warranty of the engine)
		> 14,000	37.1							
California	1988-90	8,501-14,000	14.4		1.1			6.0	HDVs: 8 years/110,000 miles 10 years/110,000 miles (for NO _x standards for 1998 +) MDVs (model years 1995 +): 11 years/120,000 miles	5 years/50,000 miles (for 1994 and earlier engines greater than 8,500 lbs and for 1995+ engines greater than 14,000 lbs) ^k
		> 14,000	37.1		1.9			6.0		
	1991 +	8,501-14,000	14.4		1.1 ⁱ	0.9 ^j		5.0		
		> 14,000	37.1		1.9 ⁱ	1.7 ^j		5.0		

Notes:

The test procedure for current and proposed federal and California exhaust standards is the EPA Transient Test Procedure.

^a NMHC standards apply only to natural gas-fueled engines.

^b Standards for 1990 apply to gasoline and methanol-fueled engines.

^c For gasoline-fueled engines, the standard is for HC. For methanol-fueled engines, the standard is for THCE.

^d Standards for 1991+ apply to gasoline, methanol, and LPG-fueled engines.

^e This standard applies to the following fueled engines utilizing aftertreatment technology (except for methanol) for the following model years: gasoline/1990+; LPG/1991+; natural gas/1998+; methanol/1990+.

^f For gasoline and LPG-fueled engines, the standard is for HC. For methanol-fueled engines, the standard is for THCE.

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

^h The proposed standards were published in the *Federal Register* on June 27, 1996 (61FR33421). They are subject to change when the regulations are finalized. NCPs will be addressed during the 1999 Technology Review. As a signatory to the Statement of Principles outlining the proposed federal standards, California plans to propose the same standards.

ⁱ For gasoline and LPG-fueled engines, the standard is for HC. For methanol-fueled engines, the standard is for Organic Material HC Equivalent.

^j Manufacturers of gasoline, natural gas, or LPG engines may choose to certify to the total or the optional NMHC standard.

^k For model year 1995+ MDVs, the following warranty period applies: 3 years/50,000 miles for basic warranty; and 7 years/70,000 miles for high cost parts warranty.

VEHICLE WEIGHT DEFINITIONS

Model Year		GVWR (lbs)					
		6,000	8,500	14,000	19,500	33,000	
Federal		LDT ≤ 8,500		HDV > 8,500			
		LLDT ≤ 6,000	6,000 < HLDT ≤ 8,500	8,500 < LHDDE < 19,500		19,500 ≤ MHDDE ≤ 33,000	HHDE/Urban Bus > 33,000
California		HDV > 6,000					
	1994 and earlier	LDT ≤ 6,000	6,000 < MDV ≤ 8,500	8,500 < LHDDE < 19,500		19,500 ≤ MHDDE ≤ 33,000	HHDE/Urban Bus > 33,000
				8,500 < LHDE-SI ≤ 14,000	HHDE-SI > 14,000		
	1995+	LDT ≤ 6,000	6,000 < MDV ≤ 14,000	14,000 < LHDDE < 19,500	19,500 ≤ MHDDE ≤ 33,000	HHDE/Urban Bus > 33,000	
	HHDE-SI > 14,000						
1992+ (LEVs, ULEVs, SULEVs, ZEVs only)			6,000 < MDV ≤ 14,000				

CLEAN-FUEL FLEET PROGRAM FOR HEAVY-DUTY SI AND CI ENGINES

Emission Category		CO (g/bhp-hr)	NMHC + NO _x (g/bhp-hr)	PM (g/bhp-hr)	HCHO (g/bhp-hr)
Federal ^a	LEV (Federal Fuel)		3.8		
	LEV (California Fuel)		3.5		
	ILEV	14.4	2.5		0.050
	ULEV	7.2	2.5	0.05	0.025
	ZEV	0	0	0	0

Notes:

The test procedure for the CFF standards is the EPA Transient Test Procedure.

^a The standards apply to 1998-2003 model year engines over 8,500 lbs. Beginning in 2004, the new emission standards for heavy-duty highway engines will apply. In addition to CFF standards, vehicles have to comply with applicable conventional standards for other pollutants.

HEAVY-DUTY HIGHWAY SI AND CI ENGINES— EVAPORATIVE HYDROCARBON STANDARDS

Engine Type	Year	Weight (lbs)	Conventional Diurnal + Hot Soak (g/test)	Three-Diurnal Test Sequence (g/test)	Supplemental Two-Diurnal Test Sequence (g/test)	Running Loss (gpm)	Spitback (g/test)	Useful Life	
Federal	SI	1990	≤ 14,000	3.0 ^{a,b}				8 years, 110,000 miles	
			> 14,000	4.0 ^{a,b}					
		1991-95	≤ 14,000	3.0 ^{a,b}					
			> 14,000	4.0 ^{a,b}					
	1996+ (Enhanced) ^c	≤ 14,000		3.0 ^{a,b,d,e}	3.5 ^{a,b}	0.05 ^{a,b}	1.0 ^{a,b}	10 years, 110,000 miles	
		> 14,000		4.0 ^{a,b,d,e}	4.5 ^{a,b}	0.05 ^{a,b}			
	CI	1990-95	≤ 14,000	3.0 ^b					LHDDE: 8 years/110,000 miles MHDDE: 8 years/185,000 miles HHDE: 8 years/290,000 miles
			> 14,000	4.0 ^b					
		1996-97	≤ 14,000	3.0 ^b	3.0 ^{d,e}				
			> 14,000	4.0 ^b	4.0 ^{d,e}				
1998+ (Enhanced) ^c		≤ 14,000		3.0 ^{b,d,e}	3.5 ^b	0.05 ^b	1.0 ^b		
		> 14,000		4.0 ^{b,d,e}	4.5 ^b	0.05 ^b			
California	SI	1995+	> 14,000		2.0		0.05		
		1996+	> 14,000			4.5			

Notes:

The test procedure for federal evaporative HC standards is the EPA Heavy-Duty Federal Test Procedure. The test procedure for the federal spitback standard is the Fuel Dispensing Spitback Procedure. (Vehicles over 26,000 lbs GVWR may demonstrate compliance with the standards through an engineering demonstration in lieu of testing.) The test procedure for California evaporative HC standards is the California Evaporative Emission Test Procedure. (Vehicles over 8,500 lbs GVWR may demonstrate compliance with the standards through an engineering demonstration in lieu of testing.)

^a The standard applies to gasoline-fueled engines for HC.

^b The standard applies to methanol-fueled engines for THCE. For 1996+ SI engines, the supplemental two-diurnal test sequence for methanol-fueled engines is grams carbon per test.

^c 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. These standards will be phased in by the following percentages of production for the following model years: (for gasoline) 20 percent/1996, 40 percent/1997, 90 percent/1998, and 100 percent/1999; (for methanol) 90 percent/1998 and 100 percent/1999.

^d The standard applies to natural gas-fueled engines for HC.

^e The standard applies to LPG-fueled engines for HC.

NONROAD SI ENGINES 25 HP AND BELOW

Class ^a		Year	CO (g/bhp-hr)	HC (g/bhp-hr)	HC + NO _x (g/bhp-hr)	NMHC + NO _x (g/bhp-hr)	NO _x (g/bhp-hr)	PM (g/bhp-hr)	Useful Life (hours)	Warranty Period
Federal ^{b,c,d}	I	1997+	387		12.0					2 years
	II	1997+	387		10.0					
	III	1997+	600	220			4.0			
	IV	1997+	600	180			4.0			
	V	1997+	450	120			4.0			
Proposed Federal ^e	I	2001+	455		18.7 (ABT)	17.2 ^f			66/250/500 ^g	2 years
	II	2001	455		13.4 (ABT)	12.4 ^f			250/500/1,000 ^g	
		2002	455		12.4 (ABT)	11.4 ^f				
		2003	455		11.2 (ABT)	10.4 ^f				
		2004	455		10.1 (ABT)	9.5 ^f				
		2005+	455		9.0 (ABT)	8.4 ^f				
	III	2002+ ^h	600		157				50 (residential) or 300 (commercial)	
	IV	2002+ ^h	600		128					
V	2002+ ^h	450		87						
California	I	1995-98	350		12.0					2 years
		1999+	100		3.2					
	II	1995-98	350		10.0					
		1999+	100		3.2					
	III	1995-98	600	220			4.0			
		1999+	130	50			4.0	0.25		
	IV	1995-98	600	180			4.0			
		1999+	130	50			4.0	0.25		
V	1995-98	300	120			4.0				
	1999+	130	50			4.0	0.25			

Notes:

The test procedure for federal and California standards is the Small SI Engine Federal Steady-State Test Procedure.

^a Classes I and II refer to nonhandheld nonroad small SI engines; Classes III, IV, and V refer to handheld nonroad small SI engines. The classes have the following displacements (in cc): Class I/<225; Class II/≥225; Class III/<20; Class IV/≥20<50; Class V/≥50.

^b The federal standards are expressed in g/kW-hr in the *Code of Federal Regulations*.

^c Engines must meet the 1997 standards as new engines, but are not required to meet these standards throughout their useful life.

^d Federal nonroad small SI standards also apply to golf carts. In California, golf carts must meet the recreational vehicles standards.

^e Although the standards have not been formally proposed, they were published in an Advance Notice of Proposed Rulemaking in the *Federal Register* on March 27, 1997 (62FR14740). While in some cases the proposed federal standards are numerically higher than the 1997 standards, they are in fact more stringent because the engines are required to meet these proposed standards throughout their useful life.

^f The NMHC+NO_x standard is an optional standard for natural gas-fueled engines only.

^g Manufacturers can certify for any of the three time periods given but must certify at least the shortest time period.

^h Proposed standards for Classes III, IV, and V will be phased in by the following percentages of production for the following model years: 20 percent/2002, 40 percent/2003, 70 percent/2004, and 100 percent/2005.

NONROAD RECREATIONAL VEHICLES AND ENGINES

	Vehicle Type	Displacement (cc)	Year	CO (g/bhp-hr)	HC (g/km)	HC + NO _x (g/bhp-hr)	NO _x (g/bhp-hr)	PM (g/bhp-hr)	Useful Life	Warranty Period
California ^a	Specialty vehicle engines (< 25 hp)	< 225	1995-98	350		12.0		0.9 ^b		2 years
		≥ 225		350		10.0		0.9 ^b		
		all	1999+	100		3.2		0.25 ^b		
	Specialty vehicle engines and go-karts (≥ 25 hp)	all	1997+	100		3.2		0.25 ^b		
	Off-road motorcycles and all-terrain vehicles ^c	> 90	1997+	15.0	1.2				5 years or 6,250 miles	
		< 90	1999+	15.0	1.2					
	Golf carts ^d		1997+	0	0		0	0		

Notes:

The test procedure for off-road motorcycles and all-terrain vehicles is the Motorcycle Emission Test Procedure. (The Nonroad Small SI Federal Steady-State Test Procedure is optional.) The test procedure for all other vehicle types is the Nonroad Small SI Federal Steady-State Test Procedure.

^a No federal standards exist for the vehicle types included in this table. Golf carts, however, are subject to federal standards for nonroad small SI engines. Golf carts are not defined federally as recreational vehicles.

^b Applies to all diesel and 2-stroke engines.

^c As an option, all-terrain vehicles may elect to certify to equivalent SI/CI standards for Class I and II non-road engines below 25 hp.

^d The zero emission golf cart standard is applicable in federal ozone nonattainment areas in California only.

NONROAD CI ENGINES

	Rated Power	Year	CO (g/bhp-hr)	HC (g/bhp-hr)	HC+NO _x (g/bhp-hr)	NMHC + NO _x (g/bhp-hr)	NO _x (g/bhp-hr)	PM (g/bhp-hr)	Smoke (percentage)	Useful Life	Warranty Period	
Federal ^a	50 ≤ hp < 100	1998+					6.9 (ABT)		20/15/50 ^b	10 years/8,000 hours	5 years/3,000 hours	
	100 ≤ hp < 175	1997+					6.9 (ABT)		20/15/50 ^b			
	175 ≤ hp < 750	1996+	8.5	1.0			6.9 (ABT)	0.4	20/15/50 ^b			
	hp = 750+	2000+	8.5	1.0			6.9 (ABT)	0.4	20/15/50 ^b			
Proposed Federal ^{c,d}	11 < hp ^e	2000	6.0			7.8 (ABT)		0.74 (ABT)	EPA is proposing to replace its current smoke test with the ISO test procedure for the sake of harmonization and improved smoke control, provided that it provides for a level of smoke control at least as adequate as the current test. EPA will also propose to extend the smoke standards that were adopted in the Tier 1 rule to the under 50 hp engine category, and will evaluate the appropriateness of any changes to the smoke standards for all engine categories in formulating the proposal.	10 years/8,000 hours	10 years/8,000 hours	
		2005+	6.0			5.6 (ABT)		0.60 (ABT)				
	11 ≤ hp < 25 ^e	2000	4.9			7.0 (ABT)		0.60 (ABT)				
		2005+	4.9			5.6 (ABT)		0.60 (ABT)				
	25 ≤ hp < 50 ^e	1999	4.1			7.0 (ABT)		0.60 (ABT)				
		2004+	4.1			5.6 (ABT)		0.44 (ABT)				
	50 ≤ hp < 100	2004	3.7			5.6 (ABT)		0.30 (ABT)				
		2008+	3.7			3.5 (ABT)						
	100 ≤ hp < 175	2003	3.7			4.9 (ABT)		0.22 (ABT)				
		2007+	3.7			3.0 (ABT)						
	175 ≤ hp < 300	2003	2.6			4.9 (ABT)		0.15 (ABT)				
		2006+	2.6			3.0 (ABT)						
	300 ≤ hp < 600	2001	2.6			4.8 (ABT)		0.15 (ABT)				
		2006+	2.6			3.0 (ABT)						
600 ≤ hp < 750	2002	2.6			4.8 (ABT)		0.15 (ABT)					
	2006+	2.6			3.0 (ABT)							
hp = 750+	2006+	2.6			4.8 (ABT)		0.15 (ABT)					
California	25 < hp Class I	1995-98	350		12.0			0.9			2 years	
		1999+	100		3.2			0.25				
	25 < hp Class II	1995-98	350		10.0			0.9				
		1999+	100		3.2			0.25				
	175 ≤ hp ≤ 750	1996-2000	8.5	1.0			6.9	0.4			20/15/50 ^b	5 years or 3,000 hours
		2001+	8.5	1.0			5.8	0.16			20/15/35 ^b	
hp = 751+	2000+	8.5	1.0			6.9	0.4	20/15/50 ^b				

Notes:

The test procedures for current and proposed federal standards and for California standards for engines greater than 25 hp use the ISO 8178-C1 Steady-State Test Cycle and the EPA Smoke Test Procedure. The test procedure for California standards for engines less than or equal to 25 hp is the Small Engine Federal Steady-State Test Procedure.

^a Federal standards are expressed in g/kW-hr in the *Code of Federal Regulations*.

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

^c Emission regulations for on-highway engines have required that crankcase emissions be eliminated, except in the case of turbocharged diesel engines, which present special difficulties in designing closed

crankcases. EPA will propose to extend this requirement to covered nonroad engines (including the provision for exempting turbocharged diesel engines).

^d Although the proposed standards have not been formally proposed, they were published in a Supplemental Advance Notice of Proposed Rulemaking in the *Federal Register* on January 2, 1997 (62FR200). As a signatory to the Statement of Principles outlining the proposed federal standards, California plans to propose the same standards.

^e The proposed standards for engines less than 50 hp also apply to marine CI engines under 50 hp.

MARINE ENGINES

	Year	HC + NO _x (g/kW-hr) P < 4.3 ^a	HC + NO _x (g/kW-hr) P ≥ 4.3 ^a	Useful Life	Warranty Period
Federal ^b	1998	278 (ABT)	$(0.917 \times (151 + 557/P^{0.9})) + 2.44$ (ABT)	Outboard: 350 hours/10 years Personal watercraft: 350 hours/5 years	1 year for all emission-related components
	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)		1 year for all emission-related components; 3 years or 200 hours for specified major emission control components
	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)		2 years or 200 hours for all emission-related components; 3 years or 200 hours for specified major emission control components
	2005	105 (ABT)	$(0.333 \times (151 + 557/P^{0.9})) + 5.56$ (ABT)		
	2006+	81 (ABT)	$(0.250 \times (151 + 557/P^{0.9})) + 6.00$ (ABT)		

Notes:

The test procedures for current federal standards use the ISO 8178 E4 5-Mode Steady-State Test Cycle.

^a P stands for the rated power of the engine family in kilowatt.

^b These standards apply to marine SI outboard/personal watercraft and jet boat engines only. The standards are expressed in g/kW-hr in the *Code of Federal Regulations*. There are currently no federal stan-

dards for marine SI sterndrive/inboard engines; previously proposed federal standards were not finalized. Marine CI engines under 50 hp are covered under the proposed nonroad CI standards. Federal standards are currently in development for marine CI engines over 50 hp. There are no California or European Union standards for marine SI or CI engines. The standard for personal watercraft does not go into effect until 1999, although the standard goes into effect for outboard engines in 1998.

AIRCRAFT

	Year	Applicability ^a	CO (g/kN)	HC (g/kN)	NO _x (g/kN)	Smoke
Federal ^b	1974+	T8				30
	1976+	TF with rO ^c of 129kN and above				83.6(rO) ⁻²⁷⁴
	1978+	T3 ^d				25
	1983+	TF < 26.7kN of rO				83.6(rO) ⁻²⁷⁴ not to exceed maximum of SN=50
	1984+	T3, T8, TF with rO of 26.7kN and above		19.6		83.6(rO) ⁻²⁷⁴ not to exceed maximum of SN=50
		TSS		140(.92) ^{rPR}		
		TSS with rO above 26.7kN		140(.92) ^{rPR}		83.6(rO) ⁻²⁷⁴ not to exceed maximum of SN=50
		TP with rO of 1,000kW and above				187(rO) ⁻¹⁶⁸
	1997+	T3, T8, TF with rO of 26.7kN and above	118	19.6	40+(2rPR)	83.6(rO) ⁻²⁷⁴ not to exceed maximum of SN=50
		T3, T8, TF newly certified (above 26.7kN)	118	19.6	32+(1.6rPR)	83.6(rO) ⁻²⁷⁴ not to exceed maximum of SN=50
2000+	T3, T8, TF newly manufactured (above 26.7kN)	118	19.6	32+(1.6rPR)	83.6(rO) ⁻²⁷⁴ not to exceed maximum of SN=50	
ICAO ^e	1982+	TSS	4550(rPR) ^{-1.03}	140(.92) ^{rPR}	36+2.42(rPR)	83.6(rO) ⁻²⁷⁴ not to exceed maximum of SN=50
	1983+	TF, T8				83.6(rO) ⁻²⁷⁴ not to exceed maximum of SN=50
	1986+	TF, T8 with rO above 26.7kN	118	19.6	40+(2rPR)	83.6(rO) ⁻²⁷⁴ not to exceed maximum of SN=50
	1996+	T8, TF newly certified (above 26.7kN)	118	19.6	32+(1.6rPR)	83.6(rO) ⁻²⁷⁴ not to exceed maximum of SN=50
	2000+	T8, TF newly manufactured (above 26.7kN)	118	19.6	32+(1.6rPR)	83.6(rO) ⁻²⁷⁴ not to exceed maximum of SN=50

Notes:

The test procedures for federal and ICAO standards are the 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.

^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 rO stands for rated output, which is the maximum power/thrust available for takeoff.

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

^e ICAO standards apply to every member country. A member country of ICAO is obligated either to adopt and implement an "international standard" as internal law or to note a difference from the standard. A country that breaks this obligation may be unable to operate its airlines within territories of other member countries, and its rights in ICAO may be suspended.

LOCOMOTIVES

		Year ^a	Duty-Cycle ^b	CO (g/bhp-hr)	THC ^c (g/bhp-hr)	NMHC ^d (g/bhp-hr)	THCE ^e (g/bhp-hr)	Aldehyde ^e (g/bhp-hr)	NOx (g/bhp-hr)	PM (g/bhp-hr)	Smoke (percentage) ^{f,g}	Useful Life ^h
Proposed Federal ⁱ	1973-1999 (Tier 0)	Line-haul duty-cycle	5.0	1.0	1.0	1.0		9.5 (ABT)	0.60 (ABT)	SINGLE EXHAUST STACK: – total plume: 30/40/55 MULTIPLE EXHAUST STACKS: – total for any one plume: 30/40/55 – sum of stacks: 40/50/60	750,000 miles or $7.5 \frac{\text{MW-hrs}}{\text{hp}}$ x hp (e.g., 30,000 MW-hrs) ^j	
		Switch duty-cycle	8.0	2.1	2.1	2.1		14.0 (ABT)	0.72 (ABT)			
	2000-2004 (Tier I)	Line-haul duty-cycle	2.2	0.55	0.55	0.55	0.035	7.4 (ABT)	0.45 (ABT)		$8.0 \frac{\text{MW-hrs}}{\text{hp}}$ x hp (e.g., 32,000 MW-hrs) ^j	
		Switch duty-cycle	2.5	1.2	1.2	1.2	0.076	11.0 (ABT)	0.54 (ABT)			
	2005+ (Tier II)	Line-haul duty-cycle	1.5	0.3	0.3	0.3	0.018	5.5 (ABT)	0.20 (ABT)		$9.0 \frac{\text{MW-hrs}}{\text{hp}}$ x hp (e.g., 36,000 MW-hrs) ^j	
		Switch duty-cycle	2.4	0.6	0.6	0.6	0.036	8.1 (ABT)	0.24 (ABT)			

Notes:

The test procedure for proposed federal standards is the Locomotive Steady-State Test.

^a The Tier 0 standards apply to engines manufactured from 1973-1999 when they are remanufactured after 2000. Tier I and II standards apply to engines manufactured in 2000 and later when they are newly manufactured and remanufactured.

^b All locomotives would be required to comply with standards for both duty-cycles.

^c Applicable to any fuel except natural gas or alcohol.

^d Only applicable to natural gas, or any combination of fuels where natural gas is the primary fuel.

^e Applicable to alcohol(s), or any combination of fuels where alcohol is the primary fuel.

^f Percentages apply to smoke opacity at steady state/30-second peak/3-second peak.

^g Measurement performed continuously during testing.

^h EPA is proposing that useful life and warranty period be the same.

ⁱ The proposed standards were published in the *Federal Register* on February 11, 1997 (62FR6366). They are subject to change when the regulations are finalized. They are proposed to take effect in 2000.

^j The example calculates MW-hrs for a 4,000 hp locomotive.