Default Inputs in the NONROAD model: *Recreational Equipment and Large Spark-Ignition Engines*

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Recreational Equipment

- Applications
  - Snowmobiles
  - All-terrain vehicles (ATVs)
  - Off-Highway Motorcycles (OHMCs)
- Include two-stroke and four-stroke engines
- Substantial changes in most inputs since release of HDD 2007 NONROAD

Emission factors	*Load factor*
Deterioration factors	*Median Life*
Activity	

Emission Factors: *Snowmobiles*

(All values in g/hp-hr for 2-stroke engines)

Category	Pollutant	HDD 2007	NR2002	Final Rule
Uncontrolled	THC	110	110	110
	CO	295	295	295
	NOx	0.86	0.86	0.86
	PM	2.7	2.7	2.7
"Modified 2S"	THC			54
	CO			147
	NOx			0.86
	PM			2.7
"Direct Injection"	THC			22
	CO			90
	NOx			2.8
	PM			0.57

Additional Inputs: *Snowmobiles*

	Units	HDD07	NR2002	Final Rule
Load Factor	---	0.34	0.34	0.34
Activity	hr/yr	30	57	57
Population	sleds	1,289,000	1,567,000	1,567,000
Expected Life	years	9	9	13

Emission Factors: *ATV/OHMCs*

Category	Pollutant	HDD 2007 (g/hp-hr)	NR2002 (g/mi)	Final Rule (g/mi)
Uncontrolled 2S	THC	110	56	54
	CO	300	53	54
	NOx	0.86	0.15	0.15
	PM	2.7	0.016	2.1
Uncontrolled 4S	THC	5.2	2.2	2.4
	CO	409	49	49
	NOx	3.5	0.34	0.41
	PM	0.06	0.022	0.06
Phase 1 (4S)	THC			1.6
	CO			43
	NOx			0.26
	PM			0.06

Basis of emissions calculation changed from work-output to distance travelled

Additional Inputs: *ATV/OHMCs*

Four-Stroke Deterioration Factors

Pollutant	HDD07	NR2002	Final Rule
THC	2.1	1.15	1.15
CO	1.9	1.17	1.17
NOx	1	1	1
PM	2.1	1.15	1.15

Additional Inputs

Parameter	Units	HDD07	NR2002	
		ATV/OHMC	ATV	OHMC
Load Factor	---	0.34	---	---
Activity	hr/yr	34		
	mi/yr		1,570	2,400
Population, 2S	units	1,238,000	405,000	801,000
Population, 4S	units	3,868,000	3,505,000	395,000
Expected Life	years	12	13	9

Large Spark-Ignition Equipment
(SI Engines Rated @ 19 kW)

- Commercial/Industrial
  - <u>Forklifts</u>
  - Generators
  - Commercial Turf
  - Aerial Lifts
  - Pumps

- Marine Engines
  - Stern drive
  - Inboard

- Include 2-stroke and 4-stroke engines
- Multiple fuels
  - Gasoline
  - LPG
  - CNG

Large Spark-Ignition Equipment:
Changes to NONROAD Inputs

- Emission factors
- Transient-adjustment factor (TAF) for HC, CO (large-SI only)
- Deterioration factors, all engines
- Stern-drive and Inboard marine engines
  - Emission Factors
  - Technology mix (carbureted vs. fuel-injected)
  - Median Life
- Activity and base-year population, forklifts

Large Spark-Ignition Equipment:
Emission Factors

Category	Pollutant	HDD 2007	NR2002	Final Rule
Gasoline, 2S	THC	208	n/c	
	CO	486	n/c	
	NOx	0.29	n/c	
	PM	7.7	n/c	
Gasoline, 4S	THC	6.22	n/c	3.9
	CO	203	n/c	107
	NOx	7.13	n/c	8.4
	PM	0.06	n/c	
LPG	THC	1.68	n/c	
	CO	28.23	n/c	
	NOx	11.99	n/c	
	PM	0.05	n/c	
CNG	THC	1.68	24.64	
	CO	28.23	n/c	
	NOx	11.99	n/c	
	PM	0.05	n/c	

Large Spark-Ignition Equipment:
Transient-Adjustment Factor

- <u>Definition</u>: coefficient representing the difference between steady-state cycle results and in-use transient operation

$$TAF = \frac{E_{transient}}{E_{steady-state}}$$

- <u>Results:</u> HC TAF = 1.30
    CO TAF = 1.45

- <u>Application</u>: $E_{base} = E_{ss} \times TAF$
    – TAF applied outside of model

Large Spark-Ignition Equipment:
Deterioration Factors

- <u>NONROAD's deterioration equation:</u>

$$D_y = B\left(1 + d\left(\frac{\text{age}}{I_y}\right)^b\right)$$

- <u>Previous assumption:</u> Large-SI engines deteriorate similarly to small-SI engines

- <u>Revised assumption:</u> Large-SI engines deteriorate similarly to pre-controlled highway engines (MY 1960-79)

- <u>Basis for revision:</u> deterioration for carbureted highway gasoline engines

Large Spark-Ignition Equipment:
Deterioration Factors

- <u>Derivation:</u> adapt deterioration factors from MOBILE for MY 1960-79

$$d \quad = \quad \left(\frac{E_{\text{det},100,000}}{E_{\text{base}}} \right) - 1$$

- <u>Results</u>: (value in table = 1+d)

Pollutant	HDD07	NR2002
THC	2.1	1.26
CO	1.9	1.35
NOx	1.0	1.03
PM	2.1	1.26

Coefficient 'b'
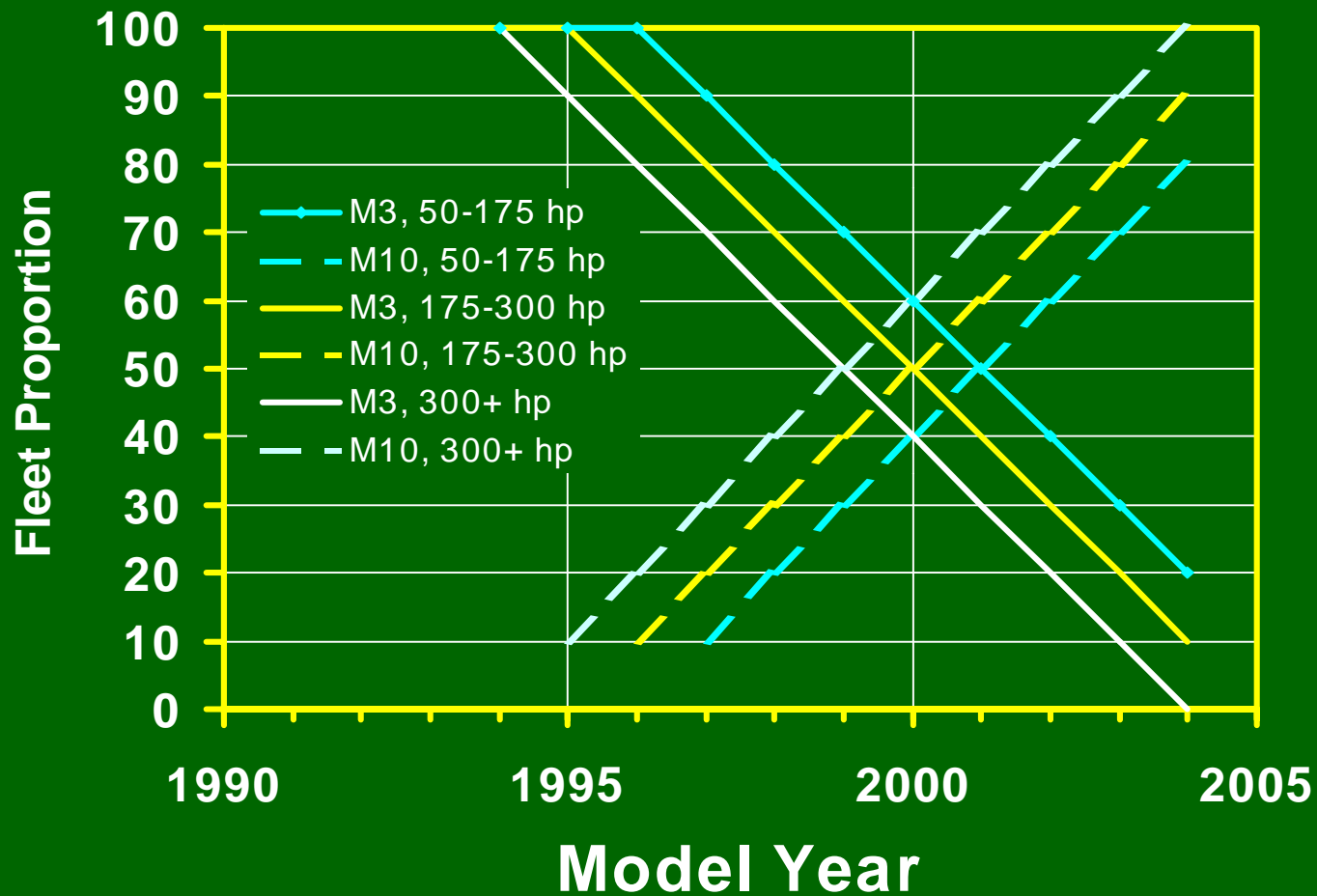HDD 2007   0.5
NR2002   1.0

Marine SD/I Engines:
Emission Factors

- <u>Basis for revision</u>: measurements for 10 SD/I engines
  - five carbureted (ISO E4 cycle)
  - five fuel-injected (EFI)
- Apply single value for all engine sizes
- <u>Results</u>:

Version	Tech Group	THC	CO	NOx
HDD 2007	M3 < 175 hp	5.21	130.50	5.67
	M10 < 175 hp	4.70	130.50	4.70
	M3 > 175 hp	4.03	129.50	7.72
	M10 > 175 hp	4.70	127.20	5.00
NONROAD2002	M3	5.88	153.70	5.35
	M10	3.02	71.80	8.48

Marine SD/I Engines: Median Life

- HDD 2007 draft used value of 3,000 hours @ full load

- When annualized, result was unreasonable

$$l_y = \frac{l_h}{A \cdot L} = \frac{3{,}000 \text{ hours}}{48 \text{ hours/year} \cdot 0.21} \approx 300 \text{ years}$$

- $\therefore$, revise to assume median life of 20 years for all gasoline SD/I engines

Large Spark-Ignition Engines:
Activity and Population for Forklifts

- Forklifts are single largest Large-SI application
- Basis for revision: market study of forklift population
  - total population ~ 490,000 (class 4-6)
  - 80% fueled by propane, 20% gas & diesel
  - assume equal fractions for gas and diesel

	Units	HDD07	NR2002
Activity	hr/yr	1,664	1,800
Population	forklifts	402,000	442,000