MOVES
Future Emission Rates

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FACA Modeling Workgroup Meeting
August 8, 2006

EPA Office of Transportation & Air Quality

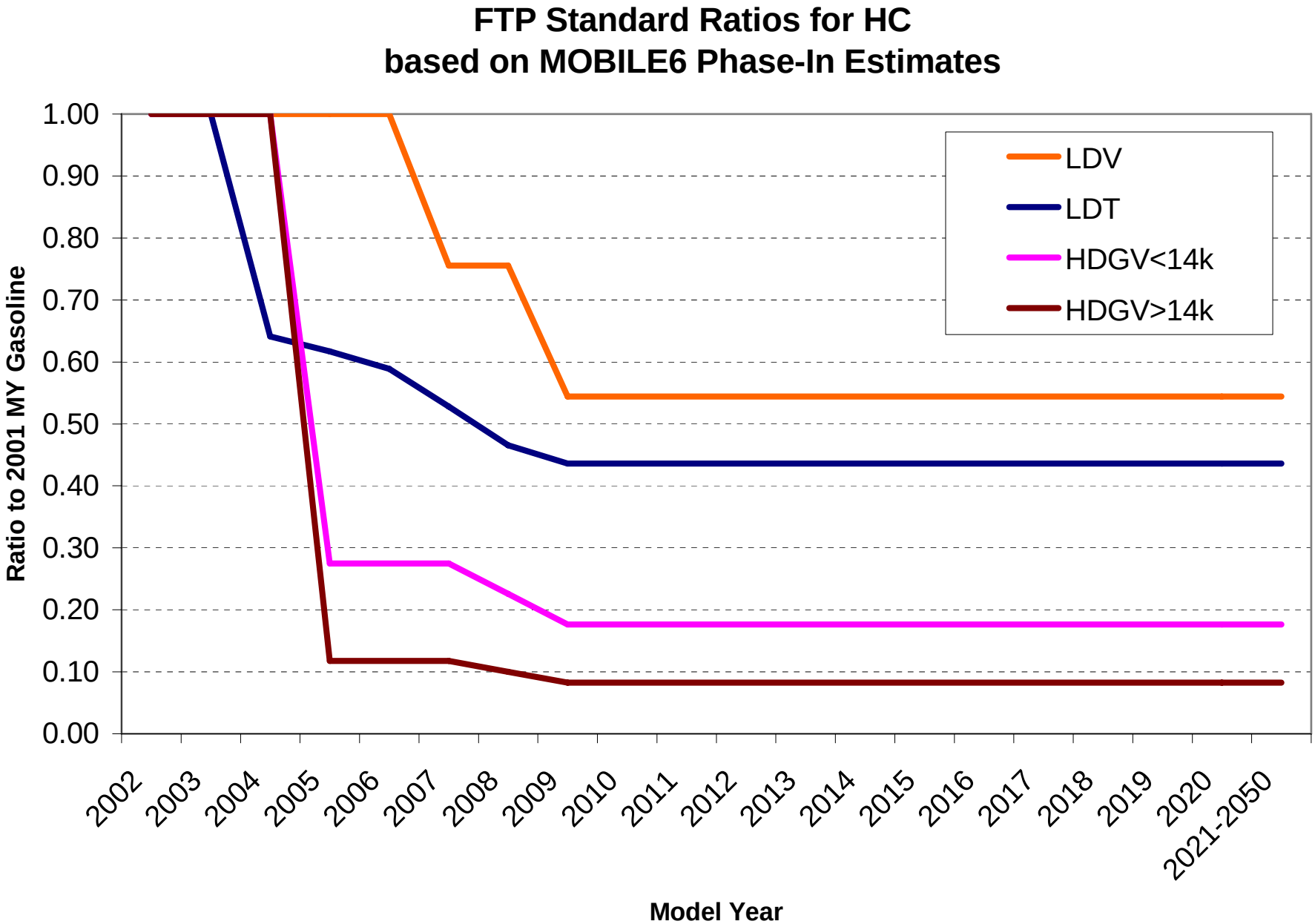
Projecting Future Emission Rates

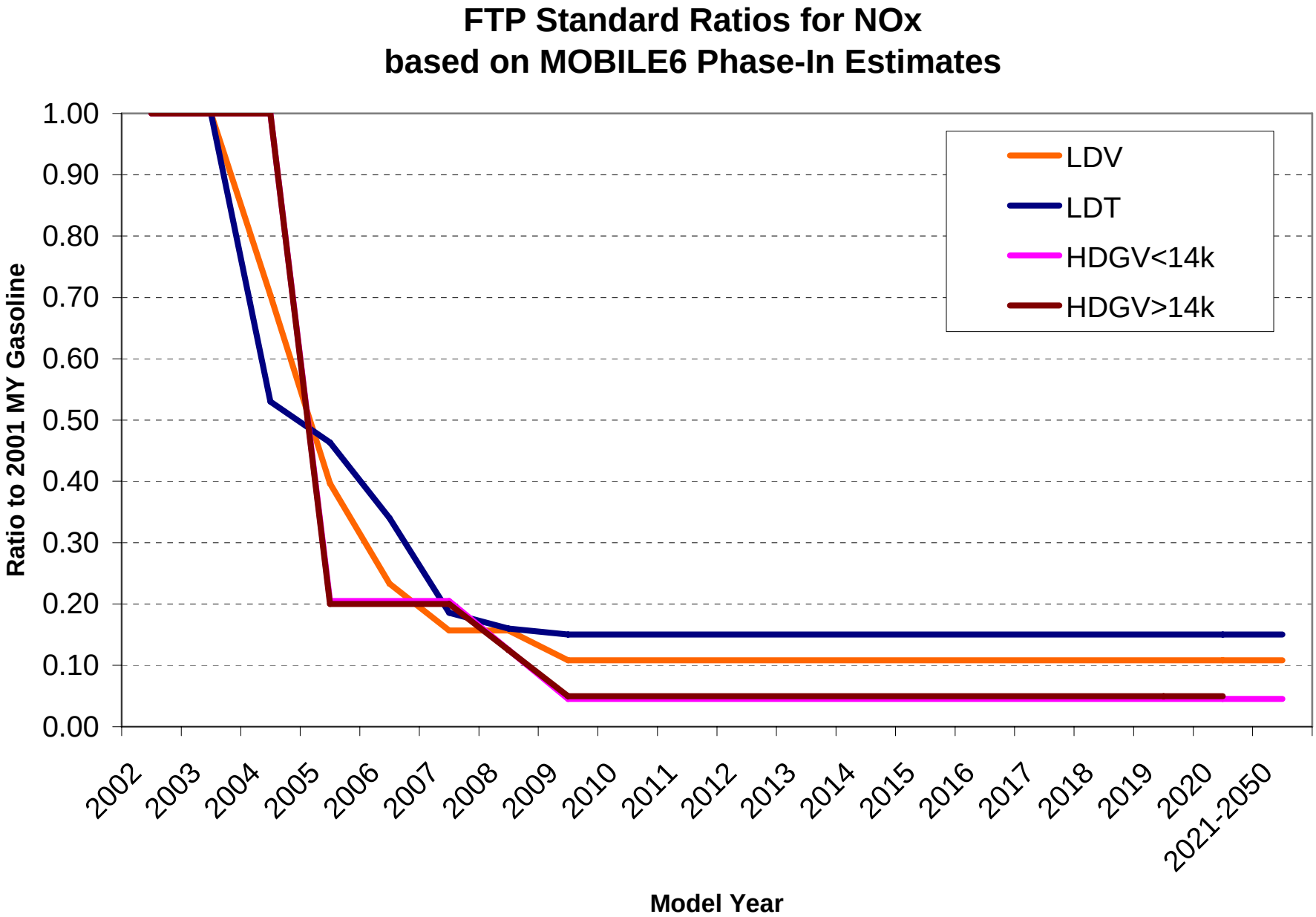
- **Light Duty & Heavy Duty Gas**
  - Tier 2 vehicles represent same basic technology as LEVs
  - We propose to ratio current data by applicable standards
    - "Ratio approach"
- **Heavy Duty Diesel**
  - 2007/2010 standards will result in the introduction of aftertreatment technologies that do not exist in today's HD fleet
  - We are evaluating whether and how current data can be used to project future rates
  - The analysis presented here is one possible approach, based on developing new rates without consideration of current data
    - "Engineering approach"

Ratio Approach for Estimating Future Light-Duty and Heavy-Duty Gasoline Exhaust Emission Rates

Emission Standards

- **Proposal is to ratio to standards using 2001 model year gasoline rates as base**
  - First year of nationwide LEVs
  - Most complete recent model year
- **Ratio would depend on pollutant, LDV or LDT, and model year, VSP bin**
  - VSP bins only distinguished for “on-cycle” vs. “off-cycle”
  - Start emissions use “FTP” ratios
  - CO and PM would use HC ratios
- **Treatment of high emitters requires further evaluation**
  - E.g., for gas PM will smokers of tomorrow emit like smokers of today?


FTP Standard Ratios for HC
based on MOBILE6 Phase-In Estimates
Ratio to 2001 MY Gasoline
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
LDV
LDT
HDGV<14k
HDGV>14k
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021-2050
Model Year


FTP Standard Ratios for NOx
based on MOBILE6 Phase-In Estimates
Ratio to 2001 MY Gasoline
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
LDV
LDT
HDGV<14k
HDGV>14k
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021-2050
Model Year

Future "Off-Cycle" Rates

- Off cycle operating mode bins = 28-30, 38-40
- 2001 model year not fully SFTP compliant
- Analysis of MSOD data indicates early compliance with SFTP → 2001 a reasonable surrogate for SFTP compliant vehicles
- Tier 2 did not lower SFTP standards; different set of ratios used to reflect this

Future Alternative Fuel Rates

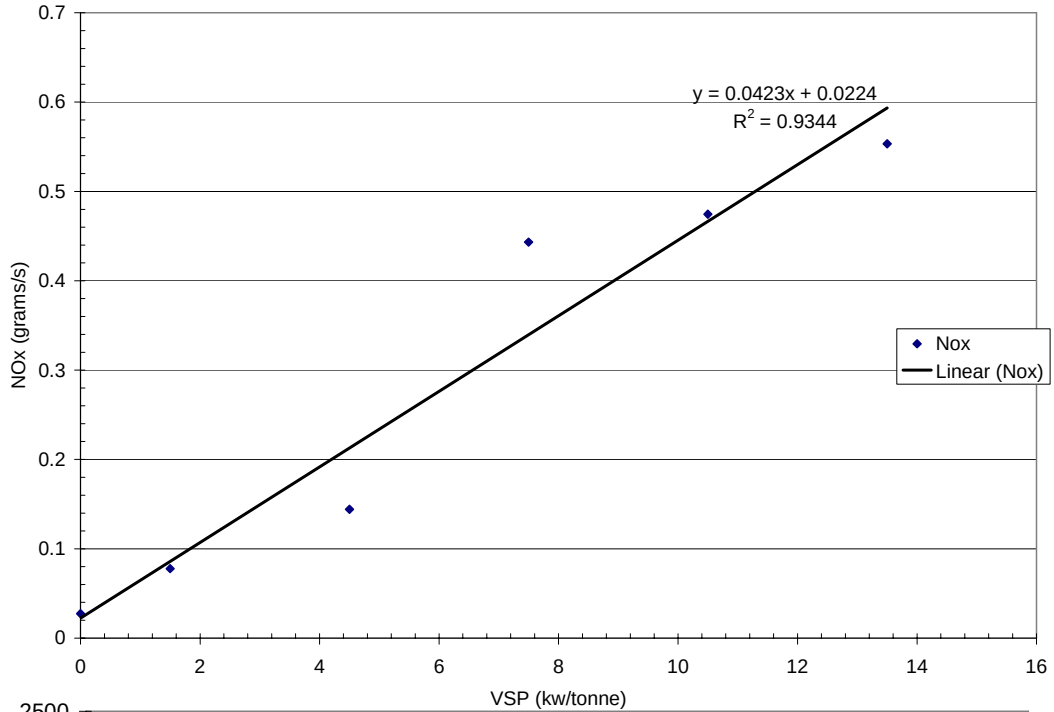
- **Ratios to gasoline emissions by model year**
  - depend on pollutant and fuel type
  - Fuel type is defined as unique engine technology; within fuel formulations (e.g. E10, BD20) handled as fuel adjustments
- **CNG**
  - GREET1.6 → ratios based on 1990's cert data
- **LPG**
  - HD only → ratios based on early 2000's HD certification data
- **E85**
  - Ratios based on Tier 2 certification data
  - Separate for running and start
- **Electric & Hydrogen**
  - zero emissions (ptw)

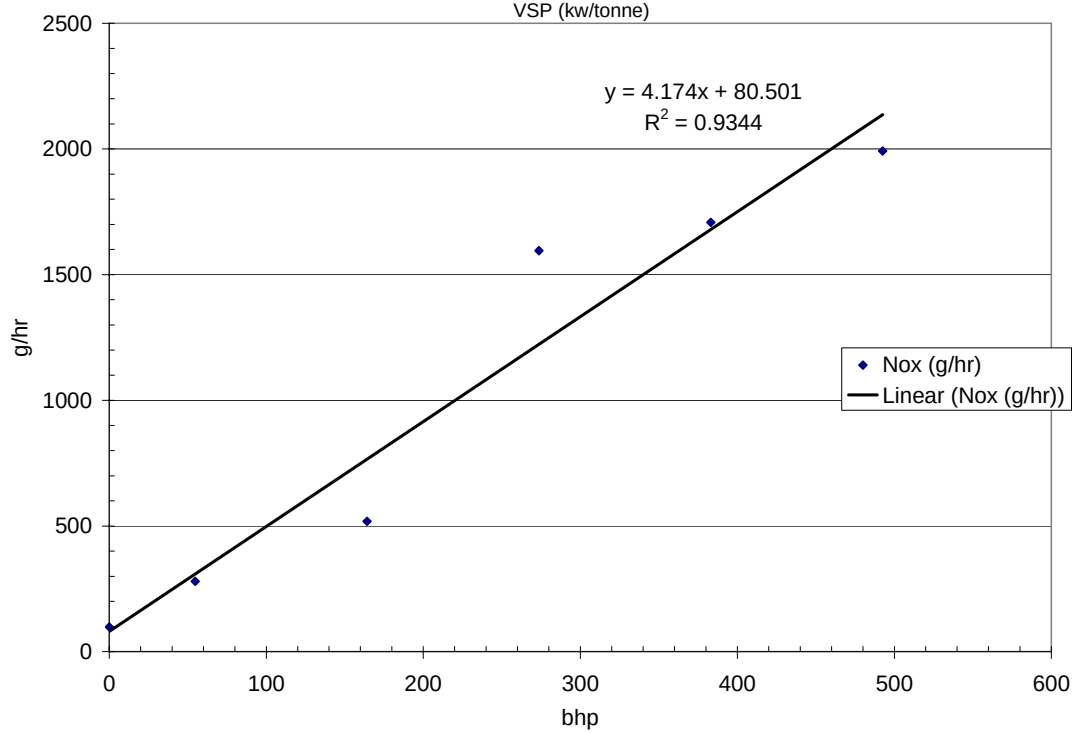
Engineering Approach for Estimating Future Heavy Duty Diesel Emission Rates

Heavy Duty Emission Standards

- Based on work or g/bhp-hr
- MOVES rates are based on specific power or kw/tonne
- By knowing vehicle weight, can compare like units
- bhp-hr to mile conversion factors are NOT required!

On-road emission rate example from CE-CERT (UC Riverside)





Emission Rate Calculation

- **ER [g/hr] = ER_aa [g/bhp-hr] * VSP [kW/ton] * 1.34 * weight [lb] *1/2205* compRatio + idleOffSet [g/hr]**

  where

  - ER_aa is the age adjusted emission standard in g/bhp-hr
  - VSP is mean vehicle specific power for operating mode
  - compRatio is compliance ratio and is assumed to be 1 at this point
    - Tampering and mal-maintenance were not included
  - idleOffSet is the idle emission value set to zero for VSP > 0
    - Value estimated based on measured data samples

Deterioration

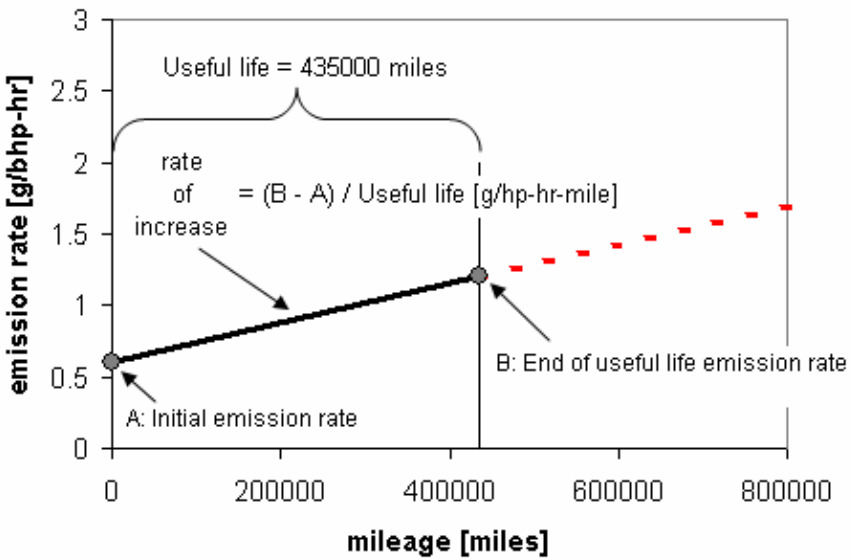
- **Estimates for initial and final emission rates in g/bhp-hr over useful life**
  - Based on discussions with EPA personnel
  - Assume compliance over useful life of vehicle
  - Useful life is defined as 435,000 miles
  - Used to determine deterioration rate

Rate of Emission Increase

- **Rate of emission increase due to deterioration calculated based on emission rate estimates**

  incRate = (final_rate – initial_rate)/ul_mileage [g/hp-hr-mile]

  where ul_ mileage is useful life mileage



Age Adjusted Emission Rate

emRate_aa = initial_rate + mileage * incRate

where

mileage is mileage for a particular age group

incRate is rate of emission increase due to deterioration

Vehicle Mileage Estimations

- **Vehicle mileage estimated for HDD class and age group**
  - Based on VIUS
  - HDD classes include
  - LHDD, MHDD, HHDD, and Urban Bus
- **Age groups include current to 20+ years old vehicles**

Age Group Id	Age, years
3	0-3
405	4-5
607	6-7
809	8-9
1014	10-14
1519	15-19
2099	20+

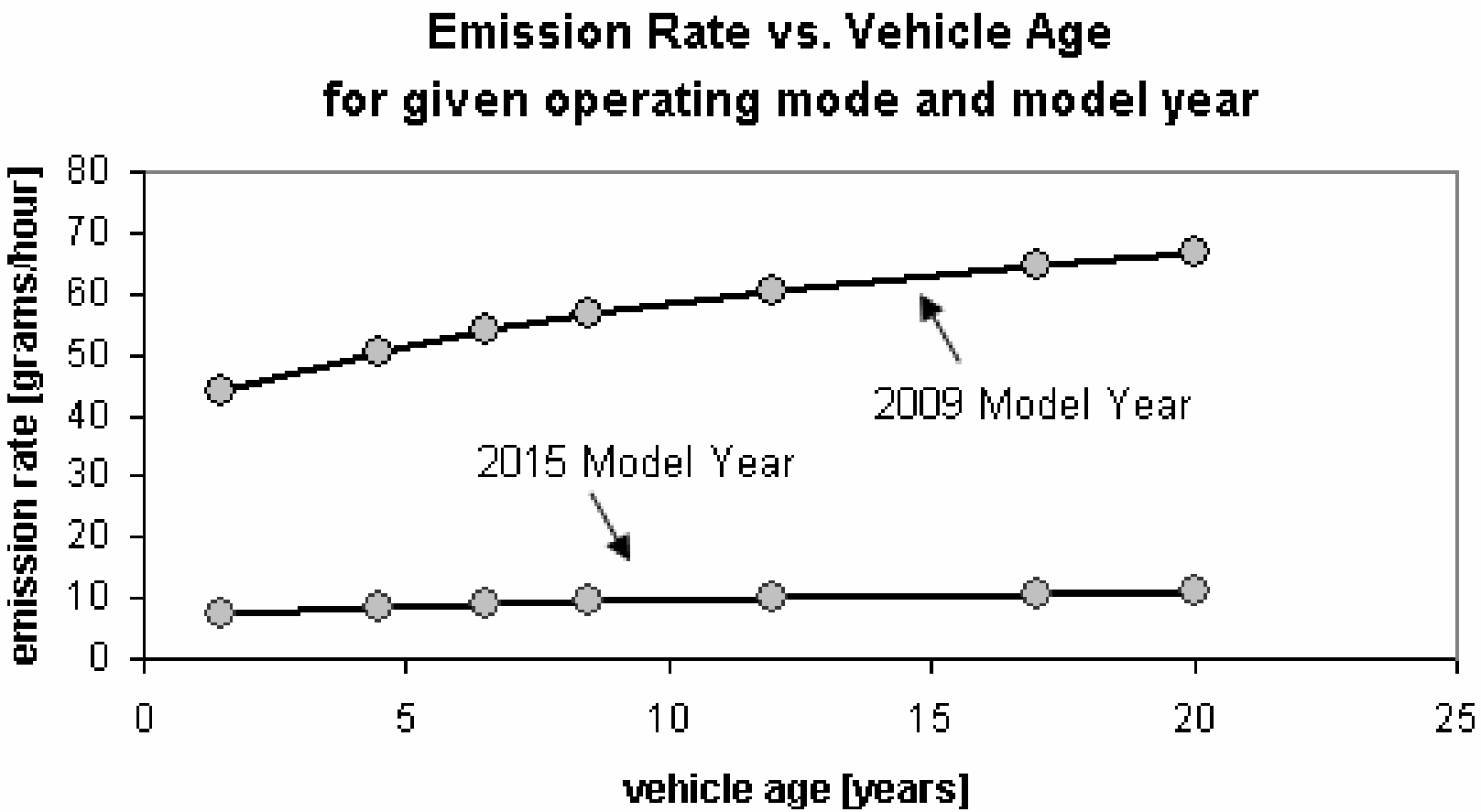
Mean Vehicle Weight (source VIUS)

- LHDD ~ 15000 lbs
- MHDD ~ 30000 lbs
- HDDD ~ 60000 lbs
- Buses ~ 30000 lbs

PM2.5 and EC/OC Relationships

- **PM2.5 Fraction = 0.92**
  - Literature review
- **PM2.5 = PM10 x PM2.5 Fraction**
- **EC/OC Fractions vary by operating mode**
  - From CRC E55
- **Non-idle Modes**
  - EC = 0.64
  - OC = 0.32
- **Idle Modes**
  - EC = 0.34
  - OC = 0.59
- **Rates subject to change**

Emission Rate Trends



Conclusions

- **LD and HD future rates based on emission standards**
- **Currently assume relatively conservative compliance rates and mild deterioration rates**
- **Future considerations**
  - Tampering and malmaintenance?
  - Retrofit model