MOBILE6
On-Road Motor Vehicle Emissions Model
5-Day Training Course

Presented in Seattle
the week of September 10, 2001

U.S. Environmental Protection Agency

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Course Outline

- Day 1 (Basic Course - Lecture)
  - Course Introduction
  - Motor Vehicle Emission Modeling Basics
  - Differences Between MOBILE5 and MOBILE6
  - MOBILE6 Operation
- Day 2 (Basic Course - Hands-On)
  - Review of MOBILE6 Operation
  - Input File Development Basics
  - Summary of MOBILE6 Commands and Inputs
- Day 3 (Advanced Course - Lecture + Hands-On)
  - Advanced Topics in MOBILE6 Development
  - SIP-Based Inventory Preparation
- Day 4 (Advanced Course - Hands-On)
  - More Advanced Use of DATABASE Output
  - Control Measure Analysis
- Day 5 (Advanced Course - Hands-On)

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Course Objectives

- Day 1 – This lecture course is intended for individuals who do not have extensive knowledge of how emissions models are formulated and would benefit from an introduction to basic terminology and a general introduction to how MOBILE6 is run and how it differs from MOBILE5.

- Day 2 – This hands-on course is intended for individuals who have minimal knowledge of how MOBILE6 inputs are generated. Every MOBILE6 command will be addressed, but detailed coverage of all commands will not be possible.

- Days 3 to 5 – This section of the course, consisting of both lecture and hands-on components, is intended for more advanced MOBILE users. Detailed treatment of model inputs/outputs will be covered as well as "off-model" approaches to estimating on-road motor vehicle emissions impacts.

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What is MOBILE6?

- MOBILE6 is a computer model developed by EPA used to predict emissions from on-road motor vehicles.

  - MOBILE6.0 (this course) – HC, CO, and Nox
  - MOBILE6.1 – Add particulates
  - MOBILE6.2 – Add toxics
  - M6.3/NGM1 – Add greenhouse gases

- All on-highway vehicle types are included in MOBILE6, including light-duty cars and trucks, heavy-duty trucks, motorcycles, and buses.

- The model is used to generate SIP inventories, for conformity determinations, emissions TRENDS reports, environmental impact statements, inputs for hot-spot analyses, and in EPA rulemakings.

- MOBILE6 is a replacement for MOBILE5.

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A Brief MOBILE History

- MOBILE1 (1978) – Calculated HC, CO, and NOx for calendar years 1970 through 1999 for six vehicle types (Diesel cars and light trucks were not included).
- MOBILE2 (1981) – Updated with new data on emission-controlled vehicles at higher mileages.
- MOBILE3 (1984) – Updated with additional data; California emission rates were eliminated.
- MOBILE4 (1989) – Significant changes to evap algorithms (running losses included for the first time). Higher deterioration rates for mileages above 50,000.
- MOBILE4.1 (1991) – Impact of oxygenated gasoline was included, evap resting losses were added, the effects of Tier 1 and Cold CO standards were incorporated.
- MOBILE5 (1992) and MOBILE5a (1993) – Basic emission rates derived from IM240 data; impacts of new standards and RFG incorporated.
- MOBILE5b (1996) – Additional I/M options, impacts of new standards.
- MOBILE6 (2001?) – Significant changes to nearly every aspect of the model.

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Scope of MOBILE6

- Vehicle Types – Traditional eight vehicle classes with an option for expanded output covering 28 classes
- Vehicle Standards – Pre-control, Tier 0, Tier 1, Tier 2, and LEVs; impacts of HDDV "defeat devices" and MY2007 standards included
- Gasoline Parameters – RVP, RFG, oxygenates, sulfur
- Vehicle Operating Parameters – speed, off-cycle effects, air conditioning, soak time
- Environmental Parameters – Temperature, humidity, cloud cover, altitude
- State Programs – Inspection and maintenance (I/M), anti-tampering inspections, Stage II refueling controls
- Calendar Years – 1952 to 2051
- Inputs/Outputs – More user-friendly input file format and more detailed outputs available as a user option

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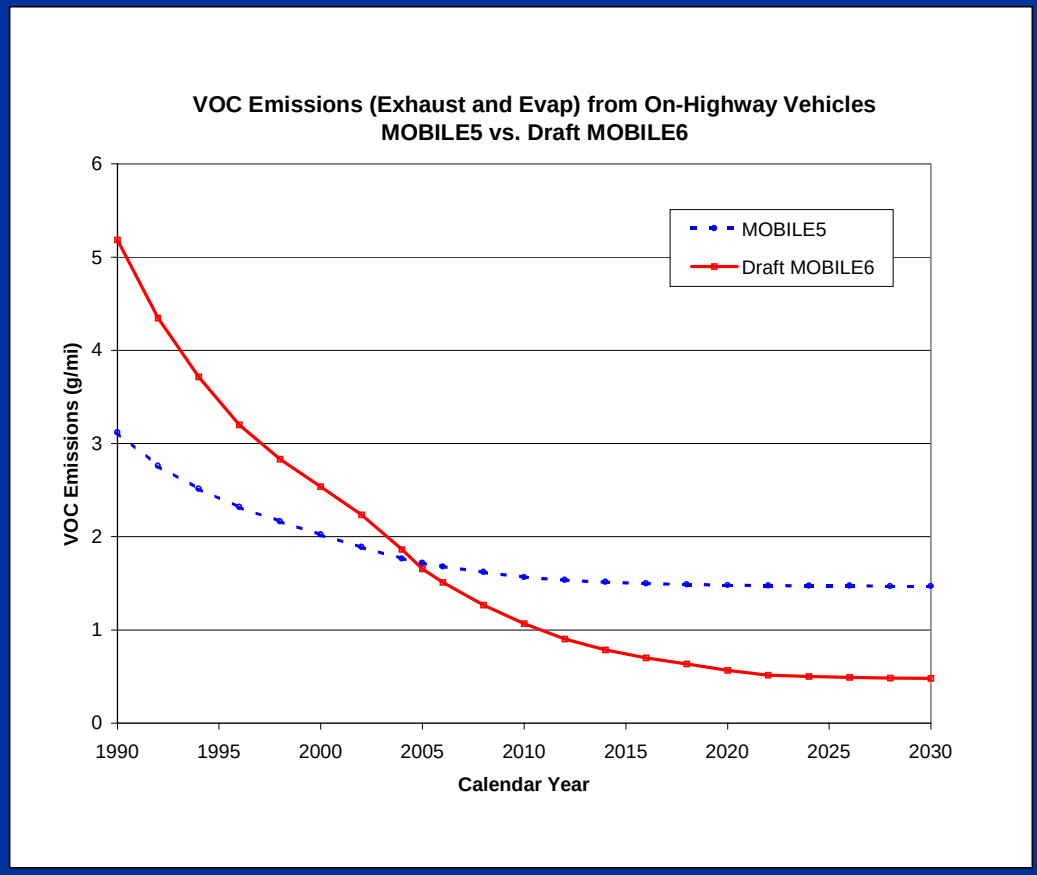

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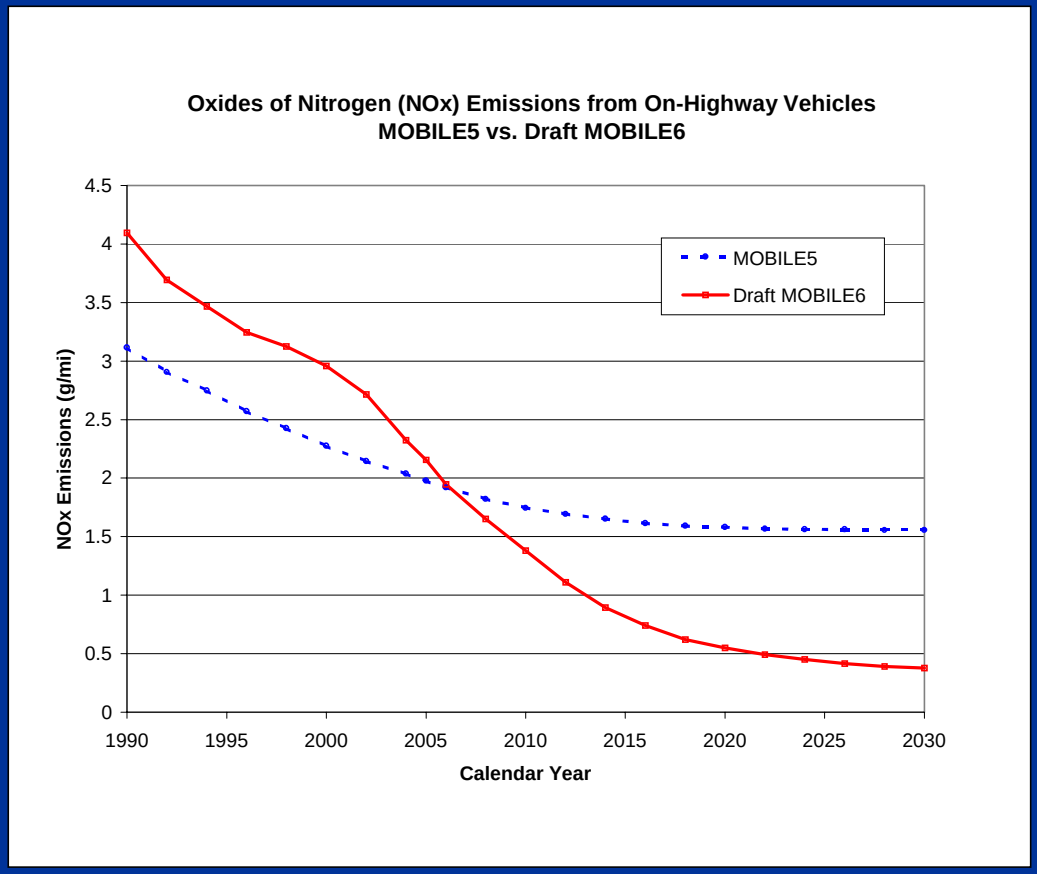

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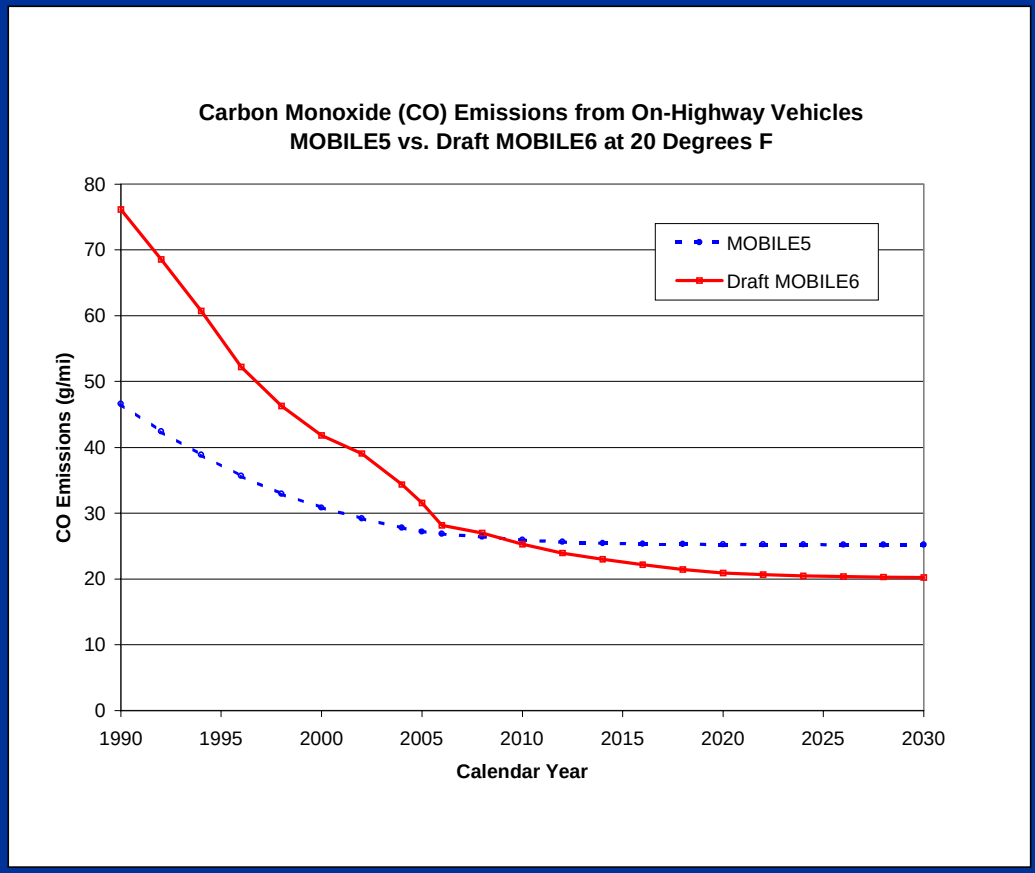
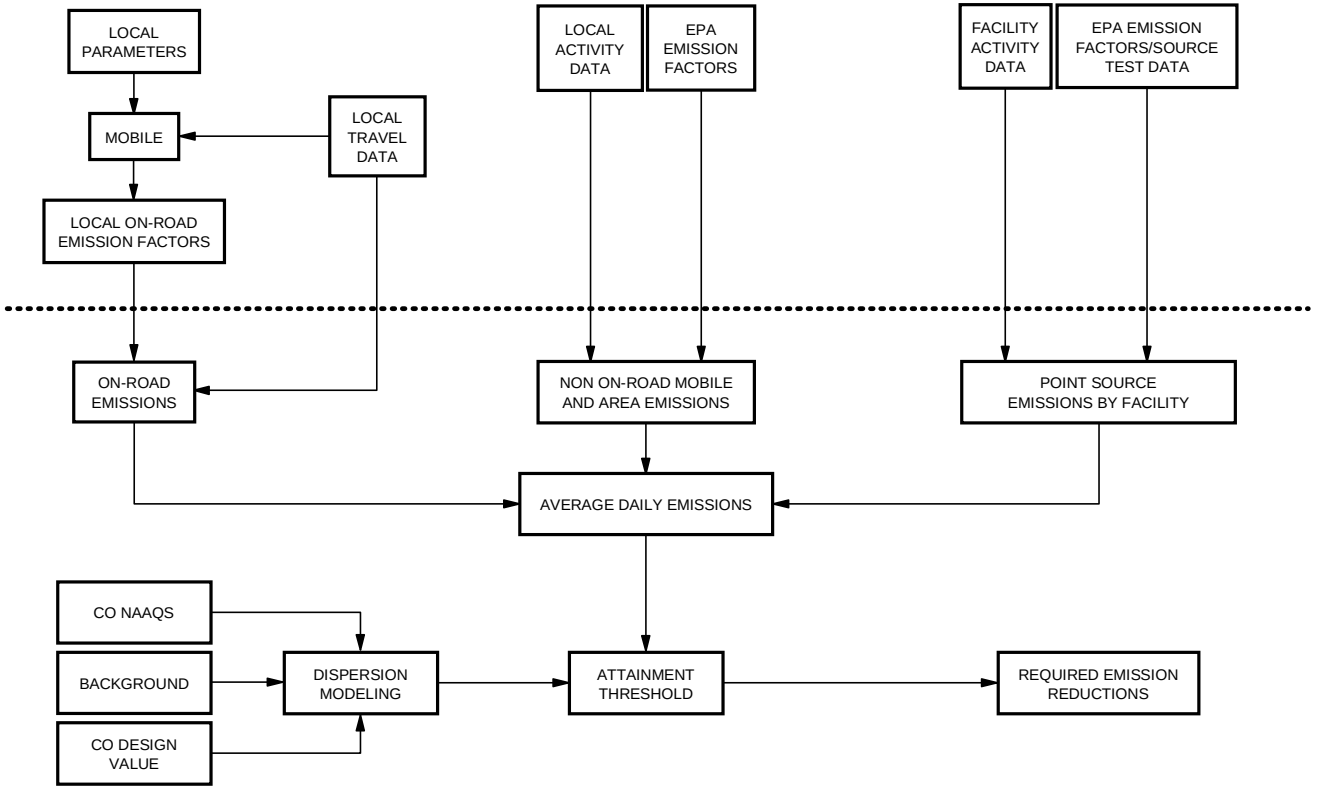


Overview of Carbon Monoxide SIP Emissions Modeling



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Definition of Terms and Acronyms

ALVW - Alternative Loaded Vehicle Weight: the numerical average of the vehicle curb weight and the GVWR.

AP-42 - U.S. EPA Compilation of Air Pollutant Emission Factors

APTI - Air Pollution Training Institute

Area Sources - Stationary emission sources that are too small to be inventoried individually, such as gasoline stations.

ASM - Acceleration Simulation Mode: a steady-state loaded-mode emissions test cycle developed to simulate acceleration without having to put the vehicle under varying load. The two most well-known ASM cycles are ASM2525 (in which the vehicle is driven at 25 mph at a load equal to 25% of the maximum acceleration on the FTP) and ASM5015 (15 mph at 50% of the maximum FTP acceleration).

ATP - Anti-Tampering Program

Bags 1, 2, and 3 - Portions of the FTP: Bag 1 = cold start; Bag 2 = stabilized operation; and Bag 3 = hot start.

BAR90 - An acronym used to refer to a computerized emissions analyzer or test analyzer system, originally developed by the California Bureau of Automotive Repair (BAR) in 1990. BAR90 emission analyzers are currently being used in a number of state I/M programs.

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Definition of Terms and Acronyms
(continued)

Baseline Inventory - An emissions inventory developed for a base or current year to estimate existing emissions conditions and that serves as the basis for future emissions projections.

Basic I/M Program - An I/M program that, when modeled using MOBILE5, achieves emissions reductions equivalent to or better than a basic performance standard established by EPA.

BER - Base emission rate equation, consisting of a zero-mile level (ZM) and one or more deterioration rates (DRs).

CAA - Clean Air Act

CAAA - Clean Air Act Amendments (1990)

Canister - Part of the evaporative control system, the evaporative canister contains activated carbon that traps HC vapors released from the vehicle fuel tank (e.g., during a diurnal heat build). The stored vapors are later released and burned in the engine as fresh air is drawn through the canister and into the intake manifold.

CARB - California Air Resources Board

Centralized I/M Program - A program in which emissions testing is conducted in centrally located, specially constructed facilities in which no emissions-related repairs are performed; also known as a test-only program.

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Definition of Terms and Acronyms
(continued)

Chassis Dynamometer - A treadmill-like piece of equipment on which a vehicle is driven and a load placed on the engine during loaded-mode testing.

CNG - Compressed natural gas

CO - Carbon monoxide

Cold Start - Vehicle start-up after extended engine-off period.

Decentralized I/M Program - A program in which vehicle emissions testing and repairs can be conducted in the same facility; also known as a test-and-repair program.

Diurnal Breathing Emissions - Evaporative HC or VOC emissions that are caused by the change in ambient temperature over the course of a day, independent of vehicle use.

DOT - U.S. Department of Transportation

DR - Deterioration rate: the rate at which vehicle emission rates are assumed to increase with increasing mileage. Typically reported in units of g/mi per 10,000 miles or g/bhp-hr per 10,000 miles.

ECOS - Environmental Council of the States

EF - Emission factor

EGR - Exhaust Gas Recirculation

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Definition of Terms and Acronyms
(continued)

EMFAC - Similar to MOBILE, EMFAC is CARB's on-road motor vehicle emissions model specific to California.

Emissions Inventory - The total emissions produced by all sources within the area being inventoried, which is normally estimated on a design day basis.

Enhanced I/M Program - An I/M program that, when modeled using MOBILE, achieves equivalent or better emissions reductions to an enhanced performance standard established by EPA; the enhanced performance standard includes IM240 vehicle testing.

EPA - U.S. Environmental Protection Agency

Evaporative Hot Soak Emissions - HC or VOC emissions that are produced immediately after a vehicle is stopped and the engine is turned off.

Evaporative Resting Loss Emissions - HC or VOC emissions that result from leaks or permeation of gasoline vapors through various parts of the evaporative control system.

Evaporative Running Loss Emissions - HC or VOC emissions that are produced due to heat build-up in the fuel during vehicle operation.

FHWA - the Federal Highway Administration, a division of the DOT.

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Definition of Terms and Acronyms
(continued)

FID - Flame Ionization Detector; used to measure HC emissions.

FTP - Federal Test Procedure: a standardized test procedure that is used to test and certify new vehicles for emissions compliance using a transient loaded-mode drive cycle (the LA4) designed to represent a typical vehicle trip.

g/bhp-hr - Grams per brake-horsepower-hour: a unit of emissions measurement when testing is conducted on an engine dynamometer.

g/mi - Grams per mile: a unit of emissions measurement when testing is conducted on a chassis dynamometer.

GVWR - Gross Vehicle Weight Rating

HC - Hydrocarbons

HDDV - Heavy-Duty Diesel Vehicle

HDGV - Heavy-Duty Gasoline Vehicle

HDV - Heavy-Duty Vehicle

HPMS - Highway Performance Monitoring System: a system established by U.S. DOT used to track changes in VMT in urban areas nationwide.

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Definition of Terms and Acronyms
(continued)

Hybrid I/M Program - A program that combines elements of both test-and-repair and test-only programs.

Idle Test - A no-load emissions test procedure conducted in an I/M program during which the engine is allowed to idle.

IM147 - The last 147 seconds of the IM240 cycle (see below).

IM240 - A transient loaded-mode emissions test performed on a dynamometer over a 4-minute standardized drive cycle that mimics a portion of the FTP.

I/M Program - Vehicle emissions inspection and maintenance program.

I/M Credit - The amount of emissions credit claimed for an I/M program in the SIP.

LA4 - The speed-time trace used for the FTP, developed from data collected in Los Angeles during the late 1960s.

LA92 - Also known as the "Unified Cycle," the LA92 drive trace was developed from chase car data collected in Los Angeles in 1992. It is the basis of CARB's emission inventory model, EMFAC2000.

LDDT - Light-Duty Diesel Truck

LDDV - Light-Duty Diesel Vehicle

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Definition of Terms and Acronyms
(continued)

LDGT - Light-Duty Gasoline Truck

LDGV - Light-Duty Gasoline Vehicle

LDT - Light-Duty Truck

LDV - Light-Duty Vehicle

LEV - Low-Emission Vehicle

Loaded-Mode Testing - Emissions testing in which either a steady or varying load is placed on the vehicle engine using a chassis dynamometer.

MC - Motorcycles

MIL - Malfunction indicator light located on the instrument panel of OBD-equipped vehicles. The MIL illuminates in the event of an emission control system malfunction.

MOBILE - EPA on-road mobile source emission factor model.

MOBILE6.0 - MOBILE model used to predict HC, CO and NOx emissions from motor vehicles.

MOBILE6.1 - Future update for MOBILE6.0 which will include estimates for particulate emissions from motor vehicles.

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Definition of Terms and Acronyms
(continued)

MOBILE6.2 - Future update for MOBILE6.1 which will include estimates for toxics emissions from motor vehicles.

MOBILE6.3 - Future update for MOBILE6.2 which will include estimates for greenhouse gases from motor vehicles. This model version may ultimately be released as the 'New Generation Model 1' (NGM1).

NAA - Acronym for nonattainment area, which is an area designated by formal EPA action as being in nonattainment of one or more of the NAAQS (see below).

NAAQS - National Ambient Air Quality Standard

NESCAUM - Northeast States for Coordinated Air Use Management

NGM - New Generation Model

NGV - Natural gas vehicle

NMHC - Non-Methane Hydrocarbons

NMOG - Non-Methane Organic Gases

NOAA - National Oceanic and Atmospheric Administration

Nonroad Emissions - Emissions from sources other than on-road, area, or point sources (e.g., chain saws, outboard engines, etc.).

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Definition of Terms and Acronyms
(continued)

NOx - Oxides of nitrogen

OBD - On-board diagnostics. Second-generation OBD systems (OBD II) were required beginning with the 1994 model year, although MIL illumination was not required for all faults until 1996. All emissions-critical systems and components on the vehicle are monitored by the OBD II system. In the event of a malfunction, the MIL is illuminated and a fault code is stored.

On-Road Emissions - Emissions from motor vehicles traveling on the modeled roadway network in an area.

ORVR - On-board refueling vapor recovery. These systems, phased-in beginning with the 1998 model year, route HC vapors displaced during refueling to the on-board evaporative canister.

OTAQ - EPA's Office of Transportation and Air Quality

Oxygenated Fuel - Gasoline containing an oxygenate-based compound (e.g., ethanol or MTBE), which reduces emissions by enleaning the air/fuel combustion mixture.

Ozone - Air pollutant created by photochemical reaction between various emissions precursors, particularly HC and NOx.

PART5 - EPA on-road particulate emission factor model.

PCV - Positive Crankcase Ventilation

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Definition of Terms and Acronyms
(continued)

$PM_{2.5}$ - Particulates with diameter of 2.5 microns or less.

PM_{10} - Particulates with diameter of 10 microns or less.

Point Sources - Stationary sources that are of sufficient size to have their emissions estimated individually.

ppm - parts per million: the units normally used to express ambient CO concentrations and fuel sulfur levels.

Pressure Test - Part of an I/M check, the pressure test consists of pressurizing the vehicle fuel tank and vapor hoses from the gas cap to the evaporative canister and monitoring for a pressure loss over a 2-minute period.

Purge Test - Initially included as part of EPA's I/M rule, purge testing consists of monitoring the purge flow in the vapor line from the canister to the intake manifold. Because of its intrusive nature, purge testing has not been successfully implemented in any high-volume I/M program and is not even modeled in MOBILE6.

Reasonable Further Progress - A term used by EPA to denote acceptable progress by a nonattainment area toward attaining the NAAQS by the required deadline.

RFG - Reformulated Gasoline

ROP - Rate of Progress plans

Running Emissions - Vehicle emissions that are a function of the length of

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Definition of Terms and Acronyms
(continued)

RVP - Reid Vapor Pressure; a measure of gasoline volatility.

SC03 - Part of the SFTP (see below), the SC03 test cycle is performed after a 10-minute soak and was designed to address emissions following start-up and air conditioning usage.

SFTP - Supplemental Federal Test Procedure. Implemented beginning with the 2000 model year, the SFTP requires compliance with two additional test cycles during certification–the US06 (to control emissions during aggressive driving) and the SC03 (to control emissions during start-up and air conditioning usage).

SHED - Sealed Housing for Evaporative Determination: an enclosure used to house a vehicle for measuring evaporative emissions.

SIP - State Implementation Plan

Soak Period - Time during which a vehicle is left non-operational and subjected to constant or variable SHED or ambient temperatures.

Stage II Vapor Recovery - Implemented at gasoline stations, Stage II vapor recovery systems route the HC vapor in the vehicle fuel tank that is displaced during refueling into the underground storage tank.

STAPPA/ALAPCO - State and Territorial Air Pollution Program Administrators/Association of Local Air Pollution Control Officials

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Definition of Terms and Acronyms
(continued)

Starting Emissions - Vehicle emissions that are a function of the number of daily vehicle starts.

Steady-State Loaded Mode Testing - Testing in which the vehicle is subjected to a steady load.

SULEV - Super Ultra-Low Emission Vehicle

SURFRAD - NOAA's Surface Radiation Monitoring System

TCM - Transportation control measure

TECH5 - EPA model that functions as a preprocessor model to MOBILE5; used to generate base emission rate equations and I/M credits for MOBILE5.

THC - Total Hydrocarbons

TLEV - Transitional Low Emission Vehicle

TOG - Total Organic Gases

Transient Loaded-Mode Testing - Testing in which the vehicle is subjected to a varying load to better represent actual in-use driving conditions.

TTC - An acronym for Technician Training and Certification, a training program for I/M technicians designed to increase program effectiveness by improving technician performance.

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Definition of Terms and Acronyms
(continued)

Two-Speed Idle Test - A two-mode, no-load emissions test procedure conducted in an I/M program during which emissions are checked while the vehicle engine is operated at curb idle and approximately 2500 rpm.

ULEV - Ultra-Low Emission Vehicle

US06 - Part of the SFTP, the US06 is a high-speed, high-acceleration test cycle designed to reflect aggressive driving behavior.

Vehicle Scrappage - Emission control program aimed at removing older, high-emitting vehicles from the in-use fleet.

VOC - Volatile organic compound: reactive HC emissions

VMT - Vehicle miles traveled

WESTAR - Western States Air Resources Council

ZEV - Zero-Emission Vehicle

ZM or ZML - Zero mile level. Part of the BER equation, the ZM reflects emissions at zero miles (i.e., when new). Units are typically g/mi (light-duty vehicles) or g/bhp-hr (heavy-duty vehicles).

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II. BACKGROUND

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Background
Motor Vehicle Emissions Modeling

- Emission Modes (cold and hot start, stabilized)
- Federal Test Procedure (FTP)
- Standard Modeling Approach
- Fleet Characteristics
- Exhaust Base Emission Rate Equations
- Correction Factors (temperature, speed, etc.)
- Idle Emission Rates
- Heavy-Duty Vehicles
- Evaporative Emissions
- Inspection and Maintenance (I/M) Programs
- Low-Emission Vehicles and Tier 2
- On-Board Diagnostics (OBD)

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Summary of MOBILE Components

- Emission Factors - Also known as "base emission rates," these have historically been represented by a zero-mile level and a deterioration rate (function of mileage).
- Test Conditions - Standardized procedures include specific driving cycles, temperatures, vehicle load, and starting conditions.
- Fleet Characteristics - Fleet-average emission rates incorporate the contribution of all model years and vehicle classes.
- Fuel Characteristics - FTP is conducted with Indolene; in-use fuels will differ in terms of RVP, oxygen content, sulfur content, etc.
- Emission Control Programs - Base emission rates do not include the effects of local control programs (e.g., I/M) and must be adjusted accordingly.

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Motor Vehicle Emission Modes

Exhaust Emissions

- Cold Start
- Hot Start
- Hot Stabilized
- Idle Emissions

Evaporative (or Non-Exhaust) Emissions

- Diurnal
- Hot Soak
- Running Losses
- Resting Losses
- Refueling Losses
- Crankcase Emissions

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Measurement Units

- All emissions estimates are ultimately reported by MOBILE in terms of grams per mile (g/mi)
- However, many of the evaporative processes are based on different measurement units that are converted to a g/mi basis:
  - Diurnal
    g/day ÷ mi/day = g/mi
  - Hot soak
    (g/trip × trips/day) ÷ mi/day = g/mi
  - Resting losses
    (g/hr × hr/day) ÷ mi/day = g/mi
  - Refueling losses
    g/gal ÷ mi/gal = g/mi
- For MOBILE6, start emissions are now reported on a per trip basis:
  - (g/trip × trips/day) ÷ mi/day = g/mi

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Pollutants

- MOBILE6.0 calculates emission rates for:
  - hydrocarbons (HC)
  - carbon monoxide (CO)
  - oxides of nitrogen (NOx)
- Hydrocarbon emission rates can be reported as:
  - total hydrocarbons (THC)
  - non-methane hydrocarbons (NMHC)
  - volatile organic compounds (VOC)
  - total organic gases (TOG)
  - non-methane organic gases (NMOG)

Option	FID HC	Methane	Ethane	Aldehydes
THC	yes	yes	yes	no
NMHC	yes	no	yes	no
VOC	yes	no	no	yes
TOG	yes	yes	yes	yes
NMOG	yes	no	yes	yes

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Federal Test Procedure (FTP)

- The FTP has been the basis of light-duty vehicle certification for 25 years.
- The FTP's chassis dynamometer driving cycle (the "LA4") simulates "average" urban driving in Los Angeles in the late 1960s.
- The test procedure consists of three parts:
  - Cold start ("Bag 1"): 3.6 miles; 25.6 mph
  - Stabilized ("Bag 2"): 3.9 miles; 16.2 mph
  - Hot Start ("Bag 3"): 3.6 miles; 25.6 mph
- Prior to testing, the vehicle is preconditioned and "soaked" in a controlled environment (68 to 86°F) overnight.
- Composite FTP calculation (with bag results reported as total grams for each test portion):

$$\frac{[(0.43 \times Bag1) + (0.57 \times Bag3)] + Bag2}{7.5 miles} = grams / mile$$

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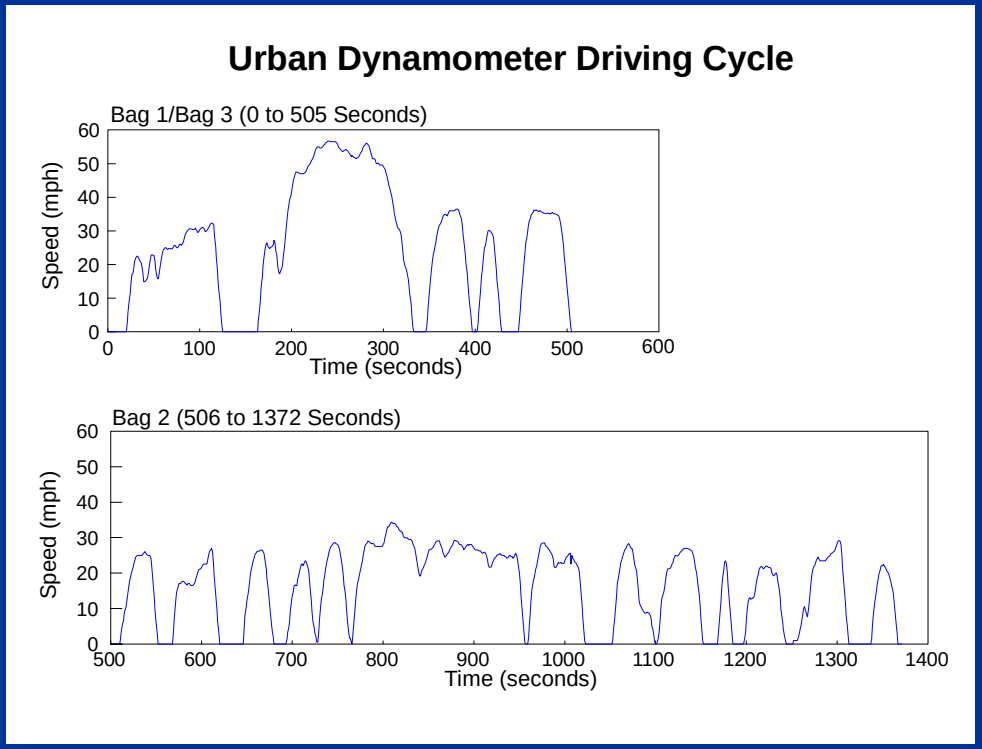
FTP (Continued)

- Standard Conditions:
  - 75°F temperature
  - 19.6 mph average speed
  - Indolene fuel (9.0 RVP)
- LA4 Speed-Time Trace:



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LDGV Exhaust Standards Summary and Predominant Emission Control Technology (Represent 50,000-mile Standards)

Model Year	Test Procedure	Standards HC	CO	NOx	Predominant Emission Control Technology
Pre-1968	CVS-75	8.8 g/mi	87.0 g/mi	3.6 g/mi	Positive crankcase ventilation.
1968-69	7-mode	350 ppm[a]	2.0%[a]	--	Leaner carburetor settings. Some air pumps.
1970-71	7-mode	2.2 g/mi	23 g/mi	--	
1972	CVS-72[b]	3.4 g/mi	39 g/mi	--	Higher percentage of air pumps.
1973-74	CVS-72	3.4 g/mi	39 g/mi	3.0 g/mi	Richer mixtures and EGR for NOx control. Air pumps for HC and CO.
1975-76	CVS-75	1.5 g/mi	15 g/mi	3.1 g/mi	Oxidation catalysts for HC and CO. EGR for NOx.
1977-79	CVS-75	1.5 g/mi	15 g/mi	2.0 g/mi	
1980	CVS-75	0.41 g/mi	7.0 g/mi	2.0 g/mi	
1981-93 (Tier 0)	CVS-75	0.41 g/mi	3.4 g/mi	1.0 g/mi	Improved fuel delivery systems coupled with three-way catalysts and closed-loop fuel control. Air pumps to reduce cold start HC and CO. EGR for NOx control.
1994+ (Tier 1)	CVS-75	0.25 g/mi	3.4 g/mi	0.4 g/mi	Close-coupled catalysts for improved cold-start HC control. Improved fuel control for better three-way catalyst efficiency.
NLEV[c]					
TLEV	CVS-75	0.125 g/mi	3.4 g/mi	0.4 g/mi	Above with improved catalyst wash coat technology and more sophisticated cold start fuel control.
LEV	CVS-75	0.075 g/mi	3.4 g/mi	0.2 g/mi	
ULEV	CVS-75	0.040 g/mi	1.7 g/mi	0.2 g/mi	
Tier 2/LEV II[c]					
LEV	CVS-75	0.075 g/mi	3.4 g/mi	0.05 g/mi	Optimization of above technologies.
ULEV	CVS-75	0.040 g/mi	1.7 g/mi	0.05 g/mi	
SULEV[d]	CVS-75	0.010 g/mi	1.0 g/mi	0.02 g/mi	

[a] These standards applied to vehicles with displacements of 101-140 cubic inches. Other numerical standards applied to other displacements.

[b] "CVS" refers to Constant Volume Sampler, the method of sample collection for vehicles tested according to the current Federal Test Procedure. CVS-72 refers to the 2-bag test procedure and CVS-75 refers to the 3-bag test procedure.

[c] HC standards are in terms of NMOG. Fleet-average standards are established based on NMOG for NLEV and CARB LEV programs; NOx for federal Tier 2 standards.

[d] Reflects 120,000-mile standards.

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Exhaust Emission Control Components

- Fuel induction system
  - carburetion
  - throttle-body fuel injection
  - multi-point fuel injection
- Catalyst
  - oxidation catalyst (HC/CO control)
  - three-way catalyst (HC/CO/NOx control)
  - close-coupled and heated catalysts
- Oxygen sensor – helps maintain stoichiometric combustion mixture
- Air injection system – injects air into the exhaust manifold during vehicle start-up to complete combustion (HC/CO control)
- Exhaust gas recirculation (EGR) – injects “inert” exhaust gases into the intake manifold to lower combustion temperatures (NOx control)

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Tier 0, Tier 1, Tier 2
Explanation of Terms

- Tier 0 Vehicles
  - Light-duty vehicles produced in the 1981 to 1993 model years
  - LDGV standards of 0.41 g/mi HC, 3.4 g/mi CO, and 1.0 g/mi NOx
- Tier 1 Vehicles
  - Light-duty vehicles first produced in MY 1994
  - LDGV standards of 0.25 g/mi NMHC, 3.4 g/mi CO, and 0.4 g/mi NOx
- Tier 2 Vehicles
  - Light-duty vehicles first produced in MY 2004
  - Fleet-average standards based on complying with 0.07 g/mi NOx with up to eight “bins”

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Supplemental Federal Test Procedure (SFTP)

- Effective with 2001+ model year LDV/LDT
- Designed to address:
  - aggressive/off-cycle driving behavior
  - rapid speed fluctuations
  - driving behavior following start-up
  - use of air conditioning
- New driving cycles:
  - US06 (aggressive driving)
  - SC03 (starts/speed fluctuation + A/C)
- US06 is a hot stabilized test; SC03 occurs after a 10-minute soak and is conducted at high temp.
- Weightings - 35% FTP, 37% SC03, 28% US06
- Specific numerical standards for the composite SFTP were established for NMHC+NOx; separate CO standards were set for the US06 and SC03 (but a composite option is allowed).

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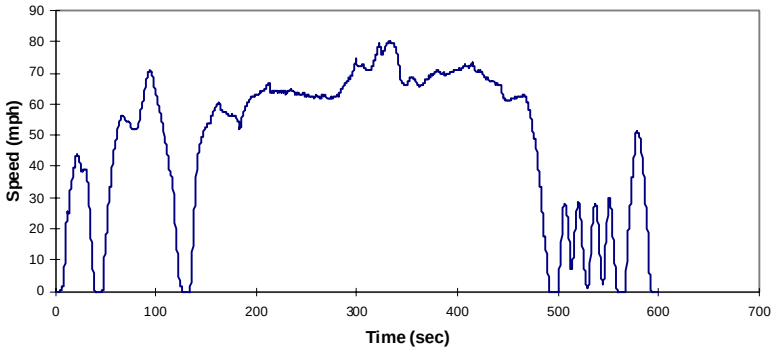
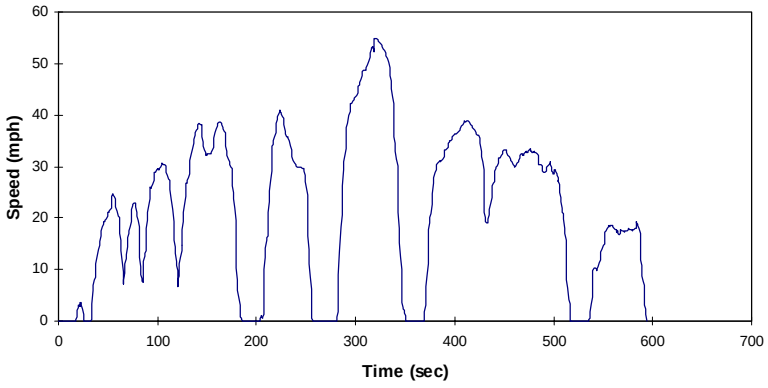
SFTP Driving Cycles

SFTP US06 Drive Trace
(Aggressive Driving Cycle)



SFTP SC03 Drive Trace
(Start, Speed Fluctuation, and Air Conditioning Cycle)



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MOBILE6 Light-Duty Vehicle Exhaust Emission Modeling Approach

Treatment of Start vs. Running Emissions

- Previous versions of MOBILE accounted for vehicle start emissions by virtue of how the bag weightings were specified; typically FTP weightings were used.
- MOBILE6 calculates running exhaust separately from vehicle start emissions.
- Running emissions are corrected for speed; start emissions are corrected for soak time.
- Start emissions (calculated as an **offset** in g/trip) are converted to a g/mi basis as follows:

$$Start_{g/mi} = (Start_{g/trip} \times Trips/day) / (Miles/day)$$

- MOBILE6 reports a total g/mi value, but the user can specify an output option that separates running and starting emissions.

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Running Exhaust Emissions Modeling Methodology

$$\left[\begin{array}{c}\text{Fleet-Ave}\\ \text{Emission}\\ \text{Rate}\end{array}\right]_{\text{Veh Class}} = \sum_{Age=1}^{25} \left[\text{Travel Fraction}\right] \times \left\{\left[\begin{array}{c}\text{LA4}\\ \text{Emission}\\ \text{Rate}\end{array}\right] + \text{Tampering Offset} + \left[\begin{array}{c}\text{Aggressive}\\ \text{Driving}\end{array}\right] + \left[\begin{array}{c}\text{Air}\\ \text{Conditioning}\end{array}\right]\right] \times \left[\begin{array}{c}\text{Temperature}\\ \text{Adjustment}\end{array}\right] \times \left[\begin{array}{c}\text{Speed}\\ \text{Adjustment}\end{array}\right] \times \left[\begin{array}{c}\text{Fuel}\\ \text{Adjustment}\end{array}\right] \right\}$$

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Running Exhaust Emissions Modeling Methodology

$$\left[\begin{array}{c}\text{Fleet-Ave}\\ \text{Emission}\\ \text{Rate}\end{array}\right]_{\text{Veh Class}} = \sum_{Age=1}^{25} \left[\frac{\text{Travel}}{\text{Fraction}}\right] \times \left\{\left[\begin{array}{c}\text{LA4}\\ \text{Emission}\\ \text{Rate}\end{array}\right] + \left[\begin{array}{c}\text{Tampering}\\ \text{Offset}\end{array}\right] + \left[\begin{array}{c}\text{Aggressive}\\ \text{Driving}\end{array}\right] + \left[\begin{array}{c}\text{Air}\\ \text{Conditioning}\end{array}\right]\right] \times \left[\begin{array}{c}\text{Temperature}\\ \text{Adjustment}\end{array}\right] \times \left[\begin{array}{c}\text{Speed}\\ \text{Adjustment}\end{array}\right] \times \left[\begin{array}{c}\text{Fuel}\\ \text{Adjustment}\end{array}\right]\right\}$$

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Travel Parameters – Fleet Characterization

- Registration distribution
  - MOBILE5 and MOBILE6 include 25 years
  - Based on Polk data
  - MOBILE5 focused on 1990 inventory year
  - MOBILE6 uses curve-fit of 1996 data
- Diesel Fractions
  - Registrations are for combined gasoline/Diesel fleet
  - Need to separate gas/Diesel for analysis (see spreadsheet that follows)
- Mileage accumulation rates
  - MOBILE4/4.1 based on NPD data; MOBILE5 increased these estimates by 9.7%
  - MOBILE6 based on 1995 NPTS data (DOT)
- VMT distribution (travel fraction)
  - Calculated from above parameters
  - MOBILE5: higher fraction of VMT attributed to newer vehicles

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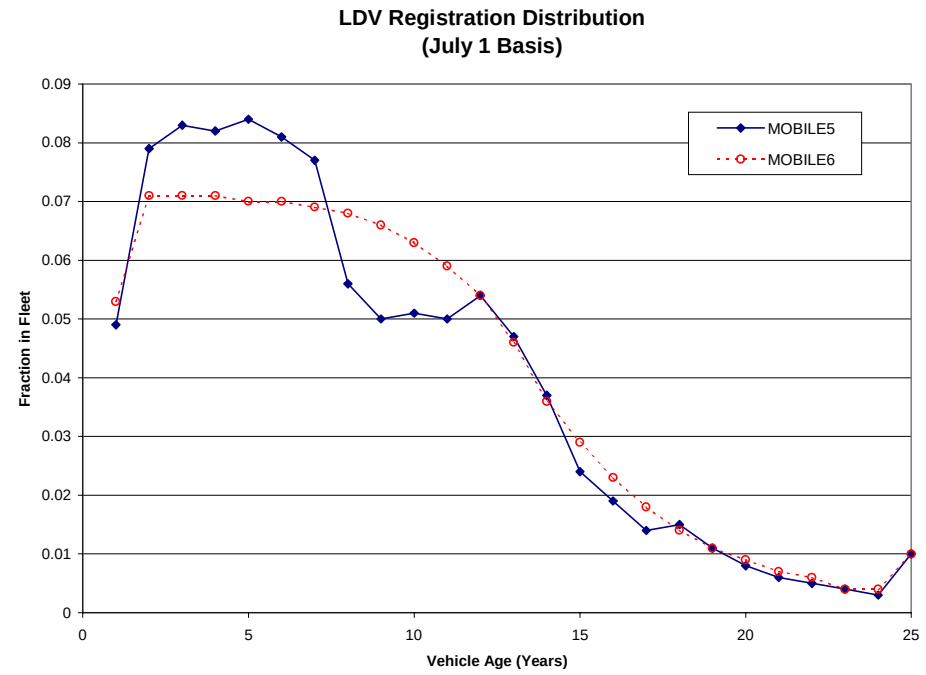

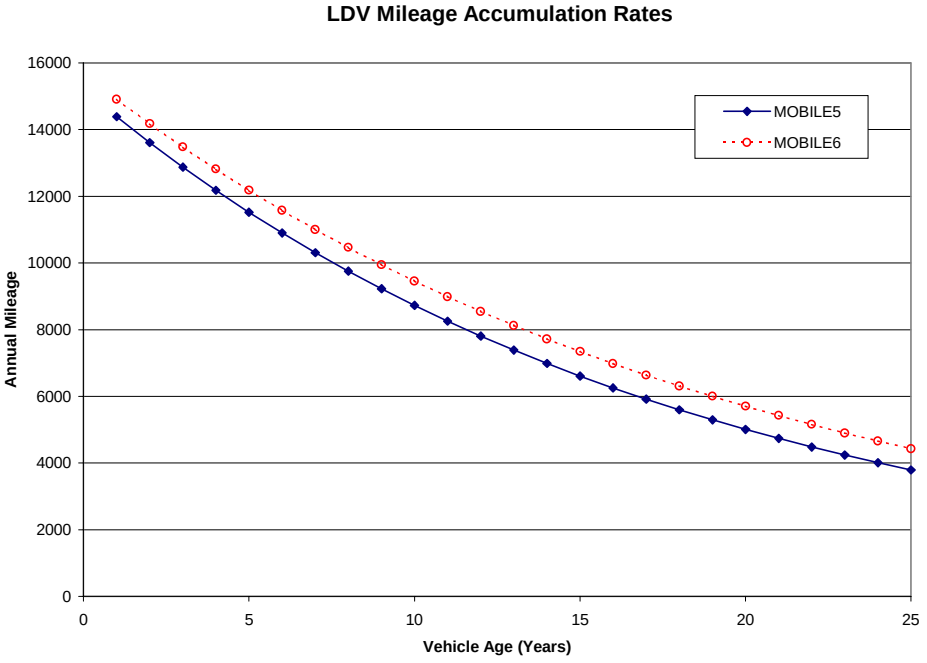

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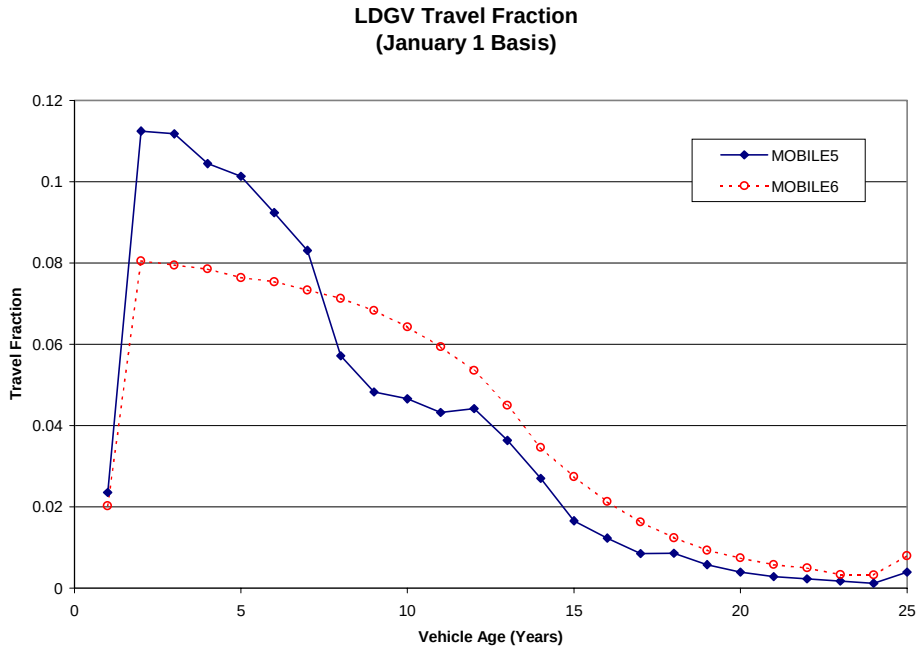

MOBILE5b-Based Calculation of Model-Year-Specific Travel Parameters for Light-Duty Vehicles
Calendar Year 2000

Model Year	Annual Miles (AMAR)	Jan 1 Fleet Miles (TFMYM)	Miles per Day (BMYMPD)	Trips per Day (BMYTPD)	Miles per Trip	Jul 1 Reg (JULMYR)	Gas Fraction (GSFIDX)	Gas Jul 1 Reg	Normlzd Jul 1 Reg	Jan 1 Reg (JANMYR)	Jan 1 Wtd Mi	Travel Fraction (TF)	TPD Fraction (BMTPDF)	Fleet Mi Accm (CUM)
2000	14,390	14,390	39.4	4.66	8.46	0.049	0.998	0.049	0.04911	0.017	244	0.0236	0.0187	1,799
1999	13,612	14,196	38.9	4.60	8.45	0.079	0.998	0.079	0.07918	0.082	1,162	0.1125	0.0891	10,768
1998	12,875	13,428	36.8	4.54	8.10	0.083	0.998	0.083	0.08319	0.086	1,155	0.1118	0.0924	24,576
1997	12,180	12,701	34.8	4.48	7.76	0.082	0.998	0.082	0.08219	0.085	1,079	0.1045	0.0901	37,637
1996	11,522	12,016	32.9	4.43	7.44	0.084	0.999	0.084	0.08428	0.087	1,047	0.1013	0.0912	49,991
1995	10,899	11,366	31.1	4.37	7.13	0.081	0.999	0.081	0.08127	0.084	955	0.0924	0.0868	61,679
1994	10,310	10,752	29.5	4.31	6.84	0.077	0.999	0.077	0.07726	0.080	859	0.0831	0.0814	72,735
1993	9,751	10,170	27.9	4.25	6.56	0.056	0.999	0.056	0.05619	0.058	591	0.0572	0.0584	83,193
1992	9,225	9,620	26.4	4.19	6.29	0.050	0.999	0.050	0.05017	0.052	499	0.0483	0.0514	93,085
1991	8,726	9,100	24.9	4.13	6.03	0.051	0.999	0.051	0.05117	0.053	481	0.0466	0.0517	102,442
1990	8,254	8,608	23.6	4.08	5.79	0.050	1	0.050	0.05022	0.052	447	0.0433	0.0500	111,294
1989	7,807	8,142	22.3	4.02	5.55	0.054	1	0.054	0.05423	0.056	457	0.0442	0.0533	119,667
1988	7,386	7,702	21.1	3.96	5.33	0.047	1	0.047	0.04720	0.049	376	0.0364	0.0457	127,586
1987	6,987	7,286	20.0	3.90	5.12	0.037	0.997	0.037	0.03705	0.038	279	0.0270	0.0353	135,078
1986	6,608	6,892	18.9	3.84	4.92	0.024	0.997	0.024	0.02403	0.025	171	0.0166	0.0226	142,165
1985	6,251	6,519	17.9	3.78	4.72	0.019	0.991	0.019	0.01891	0.020	127	0.0123	0.0175	148,869
1984	5,913	6,167	16.9	3.72	4.54	0.014	0.983	0.014	0.01382	0.014	88	0.0085	0.0126	155,210
1983	5,594	5,833	16.0	3.67	4.36	0.015	0.979	0.015	0.01475	0.015	89	0.0086	0.0132	161,208
1982	5,291	5,518	15.1	3.61	4.19	0.011	0.953	0.010	0.01053	0.011	60	0.0058	0.0093	166,882
1981	5,005	5,220	14.3	3.55	4.03	0.008	0.941	0.008	0.00756	0.008	41	0.0039	0.0066	172,249
1980	4,735	4,938	13.5	3.49	3.88	0.006	0.956	0.006	0.00576	0.006	29	0.0028	0.0049	177,326
1979	4,478	4,671	12.8	3.43	3.73	0.005	0.979	0.005	0.00492	0.005	24	0.0023	0.0041	182,129
1978	4,237	4,418	12.1	3.37	3.59	0.004	0.991	0.004	0.00398	0.004	18	0.0018	0.0033	186,672
1977	4,007	4,180	11.5	3.31	3.45	0.003	0.995	0.003	0.00300	0.003	13	0.0013	0.0024	190,970
1976	3,790	3,953	10.8	3.26	3.33	0.010	0.997	0.010	0.01001	0.010	41	0.0040	0.0080	195,034
						0.9990		0.9957	1.0000	1.0000	10332	1	1	

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Running Exhaust Emissions Modeling Methodology

$$\left[\begin{array}{c}\text{Fleet-Ave}\\ \text{Emission}\\ \text{Rate}\end{array}\right]_{\text{Veh Class}} = \sum_{Age=1}^{25} \left[\begin{array}{c}\text{Travel}\\ \text{Fraction}\end{array}\right] \times \left\{\left[\left[\begin{array}{c}\overline{\text{LA4}}\\ \text{Emission}\\ \text{Rate}\end{array}\right] + \begin{array}{c}\text{Tampering}\\ \text{Offset}\end{array} + \begin{array}{c}\text{Aggressive}\\ \text{Driving}\end{array} + \begin{array}{c}\text{Air}\\ \text{Conditioning}\end{array}\right] \times \left[\begin{array}{c}\text{Temperature}\\ \text{Adjustment}\end{array}\right] \times \left[\begin{array}{c}\text{Speed}\\ \text{Adjustment}\end{array}\right] \times \left[\begin{array}{c}\text{Fuel}\\ \text{Adjustment}\end{array}\right]\right\}$$

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Basic Emission Rates

- Units: grams/mile (or grams/bhp-hr for heavy-duty vehicles) for running emissions; grams per start for start emissions. Developed from FTP test data.
- Historically, the basic emission rate has been modeled as a linear function increasing with vehicle mileage. It is represented by two components:
  - Zero-mile level (intercept) with units of g/mi
  - Deterioration rate (slope) with units of g/mi/10,000 mi.
- The basic emission rate is a function of vehicle type, model year, and technology type.
- Developed from emissions test data:
  - LDV/LDT: Chassis dynamometer
  - HDV: Engine dynamometer
  - MC: Motorcycle dynamometer

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Basic Emission Rates
(MOBILE6 Basis)

- Similar methodology to MOBILE5, but there is no pre-processor program such as TECH5.
- Two emitter categories are defined in MOBILE6 for non-OBD vehicles – normals and highs.
- The high-emitter cutpoints are 2×HC, 3×CO, or 2×NOx FTP standards.
- As vehicles age, there is movement from the normal to high categories that results in deterioration.
- Only FTP data were used for these rates, but an "in-use" adjustment was applied to the FTP data to account for potential sampling bias.
- Overall, deterioration rates for newer model year vehicles (i.e., 1988+) are much lower in MOBILE6 relative to MOBILE5.

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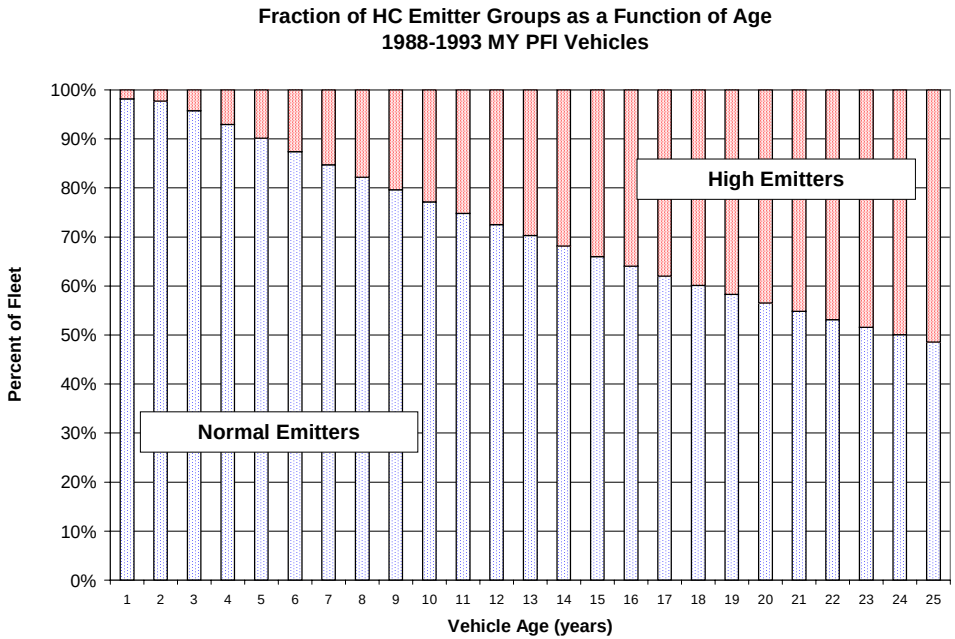

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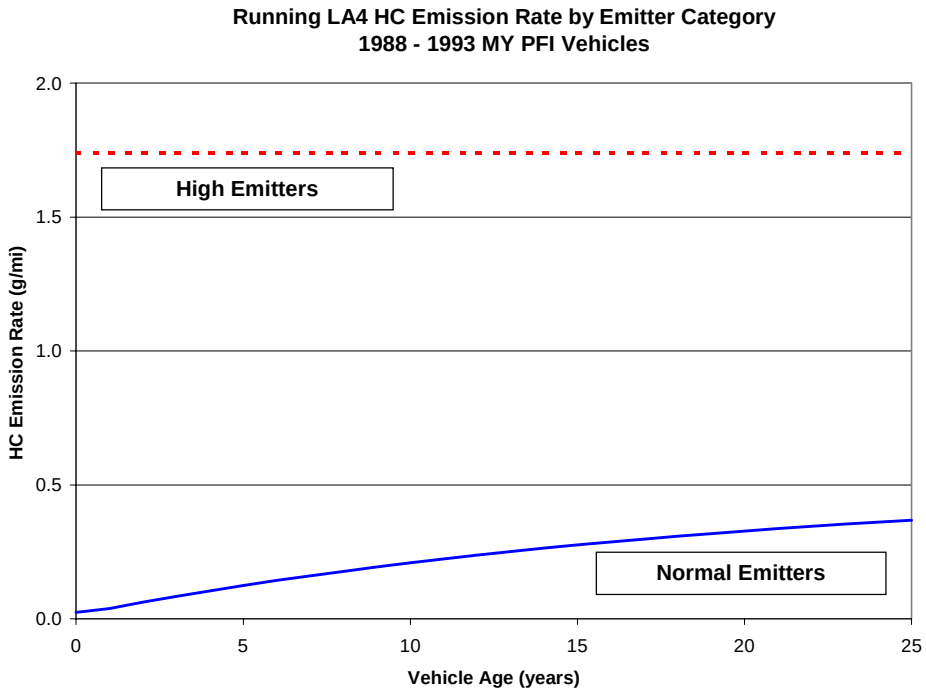

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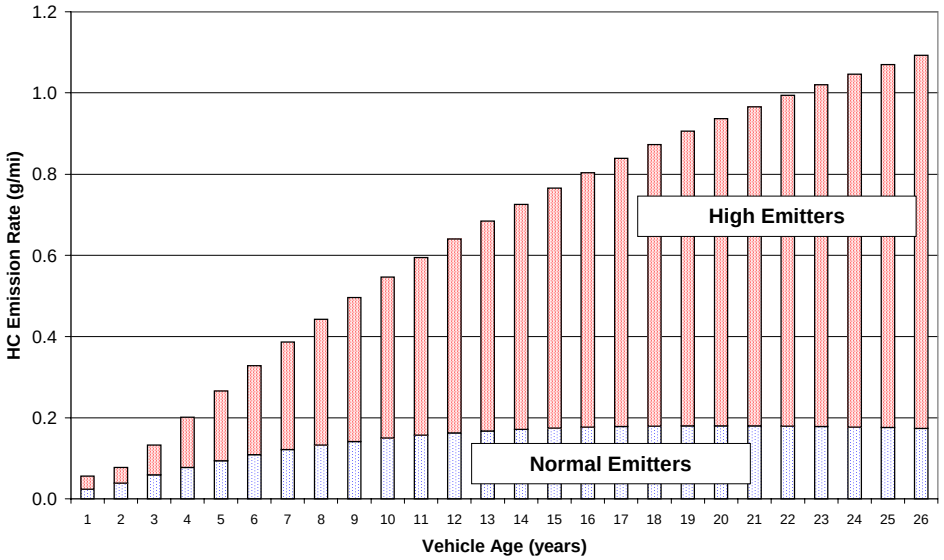
Contribution of Emitter Groups to Baseline Running LA4 HC Emissions
1988-1993 MY PFI Vehicles



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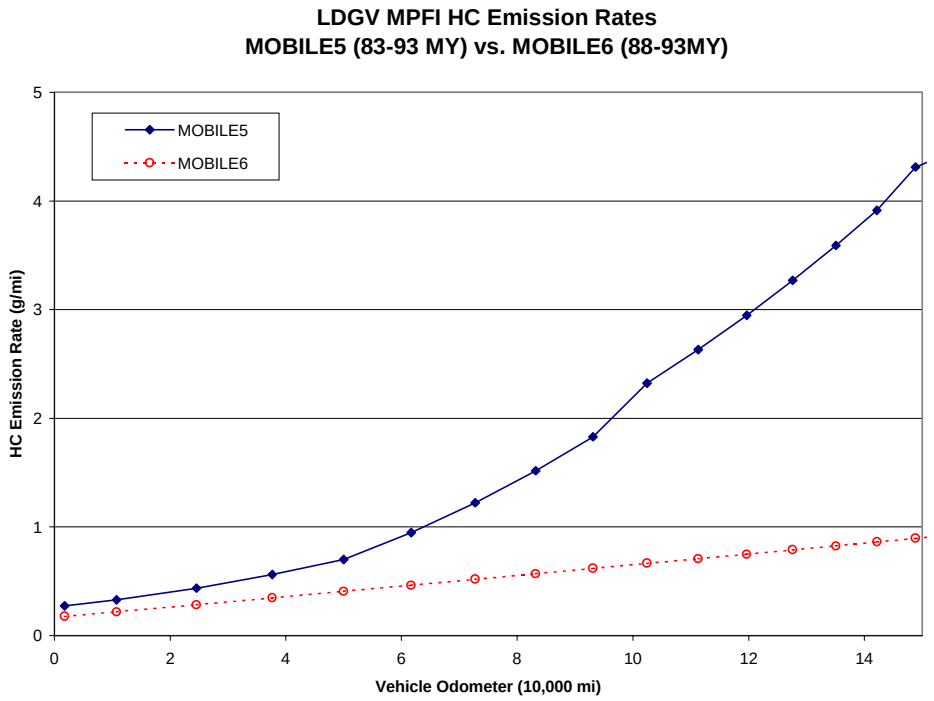

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Running Exhaust Emissions Modeling Methodology

$$\left[\begin{array}{c}\text{Fleet-Ave}\\ \text{Emission}\\ \text{Rate}\end{array}\right]_{\text{Class}}^{\text{Veh}} = \sum_{Age=1}^{25} \left[\text{Travel Fraction}\right] \times \left\{\left[\text{LA4 Emission Rate} + \overline{\text{Tampering Offset}} + \text{Aggressive Driving} + \text{Air Conditioning}\right] \times \left[\text{Temperature Adjustment}\right] \times \left[\text{Speed Adjustment}\right] \times \left[\text{Fuel Adjustment}\right]\right\}$$

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Tampering Offset (MOBILE6)

- Pre-1981 MY vehicles treated the same as MOBILE5.
- 1981 to 1995 MY (i.e., non-OBD II vehicles) emission rates are assumed to have tampering included in them (based on the "in-use" adjustment applied to the FTP data).
- 1996 and newer MY vehicles are assumed to have no (or negligible) tampering because:
  - Anecdotal evidence suggests that deliberate tampering of emission control devices is an action that is mostly historical.
  - The reasons for tampering with such vehicles (i.e., ability to misfuel, improved performance, perceived cost savings) do not exist anymore.
  - The OBD system should immediately detect tampering and may serve as a deterrent.

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Running Exhaust Emissions Modeling Methodology

$$\left[\begin{array}{c}\text{Fleet-Ave}\\ \text{Emission}\\ \text{Rate}\end{array}\right]_{\text{Veh Class}} = \sum_{Age=1}^{25} \left[\begin{array}{c}\text{Travel}\\ \text{Fraction}\end{array}\right] \times \left\{ \left[\left[\begin{array}{c}\text{LA4}\\ \text{Emission}\\ \text{Rate}\end{array}\right] + \left[\begin{array}{c}\text{Tampering}\\ \text{Offset}\end{array}\right] + \left[\begin{array}{c}\text{Aggressive}\\ \text{Driving}\end{array}\right] + \left[\begin{array}{c}\text{Air}\\ \text{Conditioning}\end{array}\right] \right] \times \left[\begin{array}{c}\text{Temperature}\\ \text{Adjustment}\end{array}\right] \times \left[\begin{array}{c}\text{Speed}\\ \text{Adjustment}\end{array}\right] \times \left[\begin{array}{c}\text{Fuel}\\ \text{Adjustment}\end{array}\right] \right\}$$

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Aggressive Driving Effects

- The LA4 driving cycle has a maximum acceleration rate of 3.3 mph/s because of dynamometer limitations in the late 1960s.
- Investigations of “real-world” driving patterns were conducted in the early 1990s.
- Those investigations revealed that the FTP was not capturing acceleration rates observed in customer service.
- As a result, MOBILE6 accounts for “off-cycle” emissions.
- This off-cycle increment is reduced for vehicles subject to SFTP requirements.

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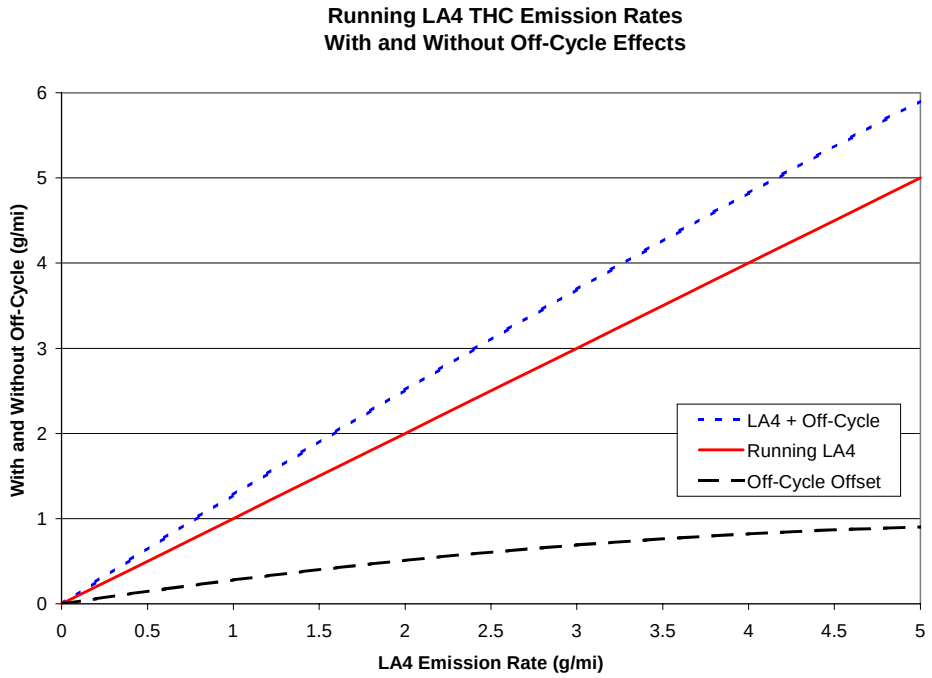

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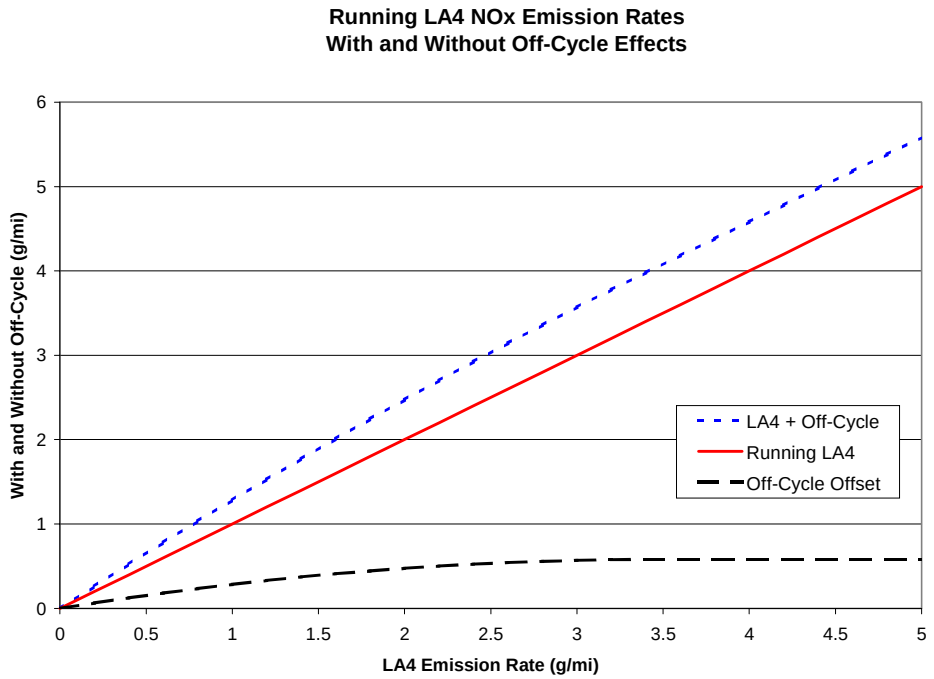

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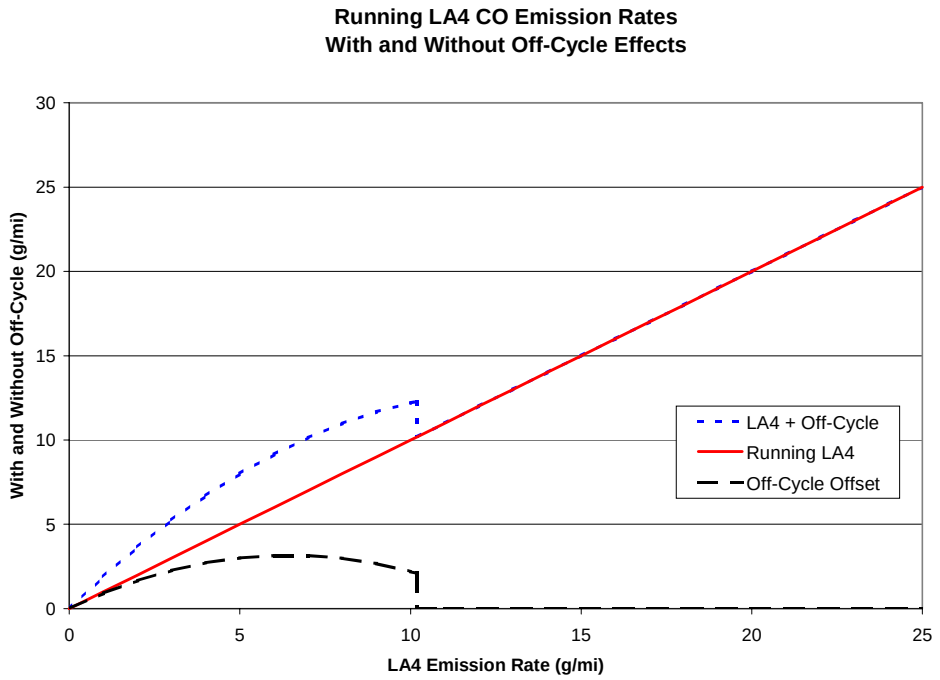

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Running Exhaust Emissions Modeling Methodology

$$\left[\begin{array}{c}\text{Fleet-Ave}\\ \text{Emission}\\ \text{Rate}\end{array}\right]_{\text{Veh Class}} = \sum_{Age=1}^{25} \left[\begin{array}{c}\text{Travel}\\ \text{Fraction}\end{array}\right] \times \left\{ \left[\begin{array}{c}\text{LA4}\\ \text{Emission}\\ \text{Rate}\end{array}\right] + \left[\begin{array}{c}\text{Tampering}\\ \text{Offset}\end{array}\right] + \left[\begin{array}{c}\text{Aggressive}\\ \text{Driving}\end{array}\right] + \left[\begin{array}{c}\overline{\text{Air}}\\ \underline{\text{Conditioning}}\end{array}\right] \right\} \times \left[\begin{array}{c}\text{Temperature}\\ \text{Adjustment}\end{array}\right] \times \left[\begin{array}{c}\text{Speed}\\ \text{Adjustment}\end{array}\right] \times \left[\begin{array}{c}\text{Fuel}\\ \text{Adjustment}\end{array}\right]$$

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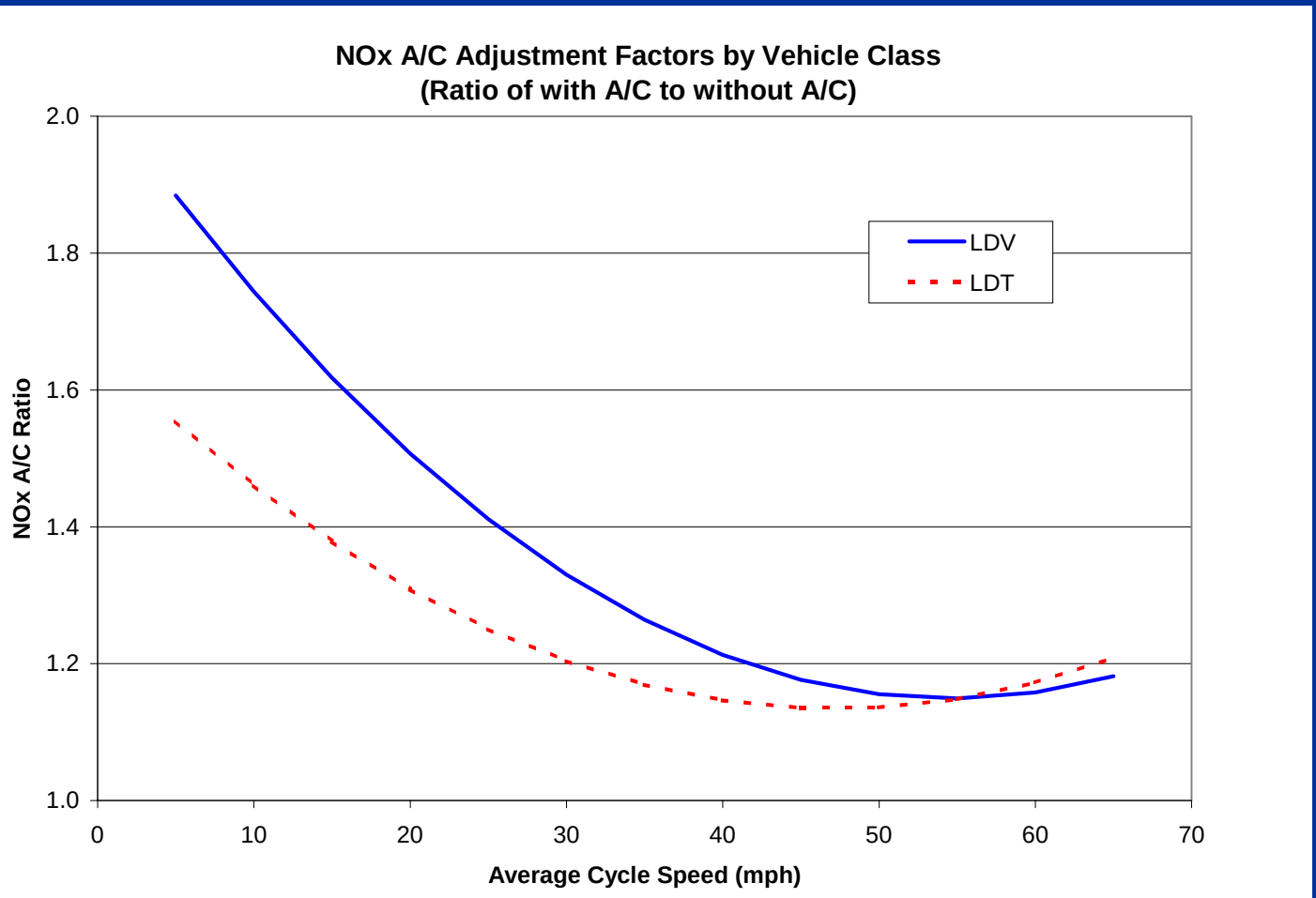
Air Conditioning Effects

- Although MOBILE5 contained a user option to include A/C effects, the data and algorithms were outdated.
- Based on data collected during the development of the SFTP, the A/C adjustment was significantly revised for MOBILE6.
- In MOBILE6, a "full-usage" A/C adjustment factor is developed first, which is then scaled by:
  - A/C demand factor (based on temperature and humidity)
  - Fraction of functioning A/C systems
- Based on modeling prepared for the Tier 2 rule, the air conditioning demand factor is 0.68 for a typical ozone season day.
- Depending on pollutant, the full-usage A/C adjustment factor is a function of speed, vehicle class, and/or emitter category.


NOx A/C Adjustment Factors by Vehicle Class
(Ratio of with A/C to without A/C)
NOx A/C Ratio
2.0
1.8
1.6
1.4
1.2
1.0
0
10
20
30
40
50
60
70
Average Cycle Speed (mph)
LDV
LDT

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Running Exhaust Emissions Modeling Methodology

$$\left[\begin{matrix}\text{Fleet-Ave}\\ \text{Emission}\\ \text{Rate}\end{matrix}\right]_{\text{Veh Class}} = \sum_{Age=1}^{25} \left[\begin{matrix}\text{Travel}\\ \text{Fraction}\end{matrix}\right] \times \left\{\left[\begin{matrix}\text{LA4}\\ \text{Emission}\\ \text{Rate}\end{matrix}\right] + \left[\begin{matrix}\text{Tampering}\\ \text{Offset}\end{matrix}\right] + \left[\begin{matrix}\text{Aggressive}\\ \text{Driving}\end{matrix}\right] + \left[\begin{matrix}\text{Air}\\ \text{Conditioning}\end{matrix}\right]\right] \times \left[\begin{matrix}\text{Temperature}\\ \text{Adjustment}\end{matrix}\right] \times \left[\begin{matrix}\text{Speed}\\ \text{Adjustment}\end{matrix}\right] \times \left[\begin{matrix}\text{Fuel}\\ \text{Adjustment}\end{matrix}\right]\right\}$$

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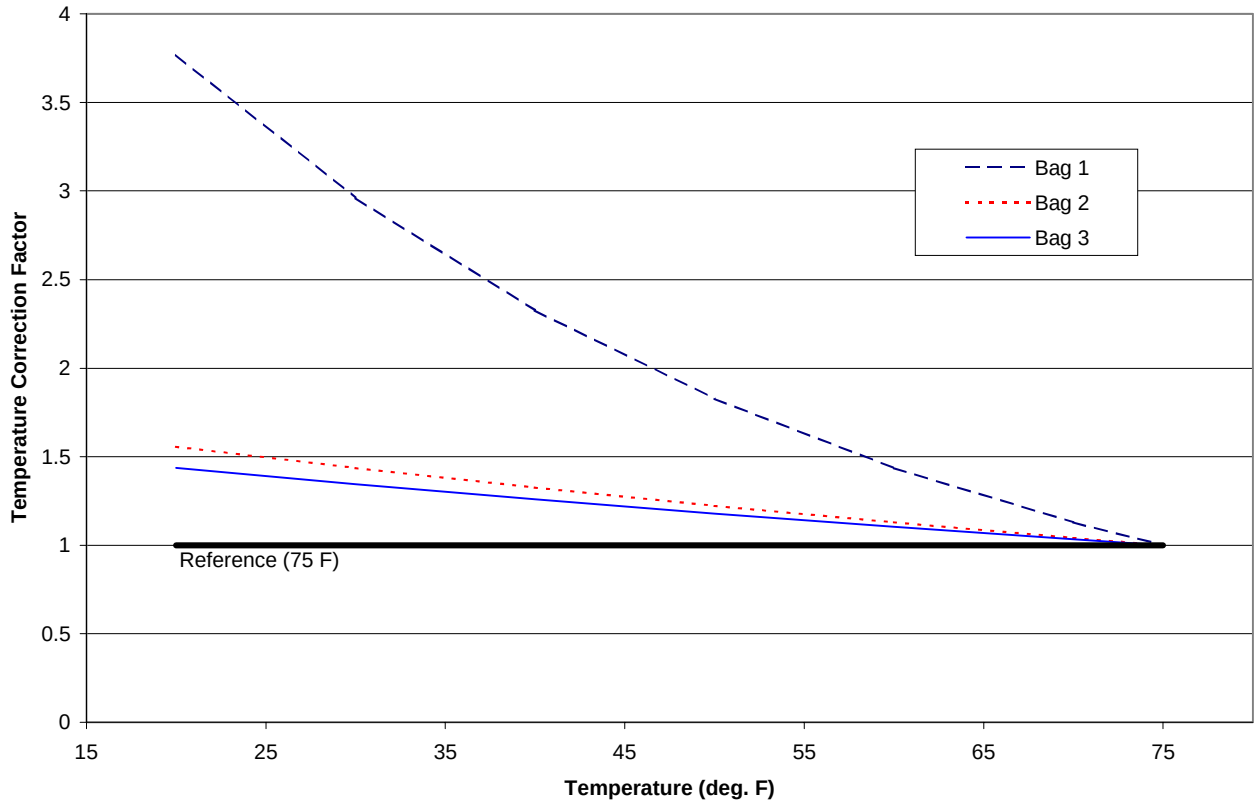
Temperature Adjustment ("Temperature Correction Factors")

- The basic emission rates are adjusted to account for temperatures outside of FTP conditions.
- Base emission factors are defined at 75°F.
- For low-temperature conditions, vehicles are tested at 20°, 50°, and 75°F.
- For high-temperature conditions, vehicles are tested at 70°, 82°, and 95°F.
- Temperature effects are a function of technology (e.g., carbureted versus fuel-injected).
- TCFs are multiplicative factors, except for cold start CO, which is an additive offset.
- MOBILE6 uses same TCFs as MOBILE5, but they are applied differently (i.e., bag 1 TCF is applied to start emissions with a 12-hour soak; a combination of bag 2 and 3 TCFs for running exhaust, etc.).
- MOBILE5 humidity corrections are also used in MOBILE6.

HC Temperature Correction Factors by Operating Mode (1983+ LDGVs)



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Running Exhaust Emissions Modeling Methodology

$$\left[\begin{matrix}\text{Fleet-Ave}\\ \text{Emission}\\ \text{Rate}\end{matrix}\right]_{\text{Veh Class}} = \sum_{Age=1}^{25} \left[\begin{matrix}\text{Travel}\\ \text{Fraction}\end{matrix}\right] \times \left\{\left[\begin{matrix}\text{LA4}\\ \text{Emission}\\ \text{Rate}\end{matrix}\right] + \left[\begin{matrix}\text{Tampering}\\ \text{Offset}\end{matrix}\right] + \left[\begin{matrix}\text{Aggressive}\\ \text{Driving}\end{matrix}\right] + \left[\begin{matrix}\text{Air}\\ \text{Conditioning}\end{matrix}\right]\right] \times \left[\begin{matrix}\text{Temperature}\\ \text{Adjustment}\end{matrix}\right] \times \left[\begin{matrix}\text{Speed}\\ \text{Adjustment}\end{matrix}\right] \times \left[\begin{matrix}\text{Fuel}\\ \text{Adjustment}\end{matrix}\right]\right\}$$

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MOBILE6 Speed Corrections

- Four roadway types are modeled:
  - Freeway (function of speed)
  - Ramp (single speed)
  - Arterial (function of speed)
  - Local (single speed)

- Test cycles used for developing SCFs:

- FWY High Speed	63.2 mph
- FWY, LOS A-C	59.7 mph
- FWY, LOS D	52.9 mph
- FWY, LOS E	30.5 mph
- FWY, LOS F	18.6 mph
- FWY, LOS "G"	13.1 mph
- FWY, Ramp	34.6 mph
- ART, LOS A-B	24.8 mph
- ART, LOS C-D	19.2 mph
- ART, LOS E-F	11.6 mph
- Local Roadways	12.9 mph

- SCFs were developed as a function of emission level, with lower-emitting vehicles typically being more sensitive to speed.

- Arterial and freeway SCFs converge above 30 mph and below 7.1 mph.

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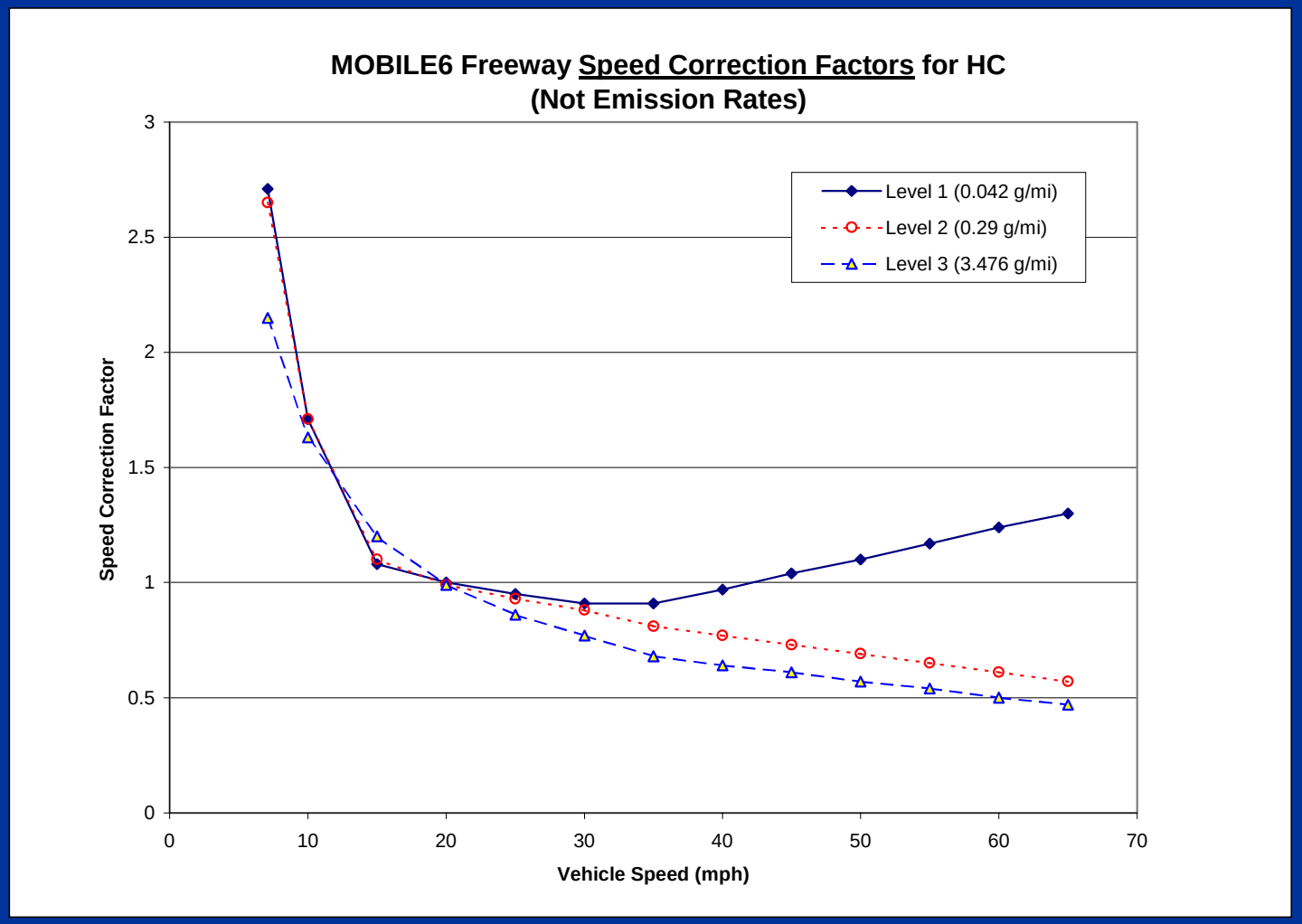
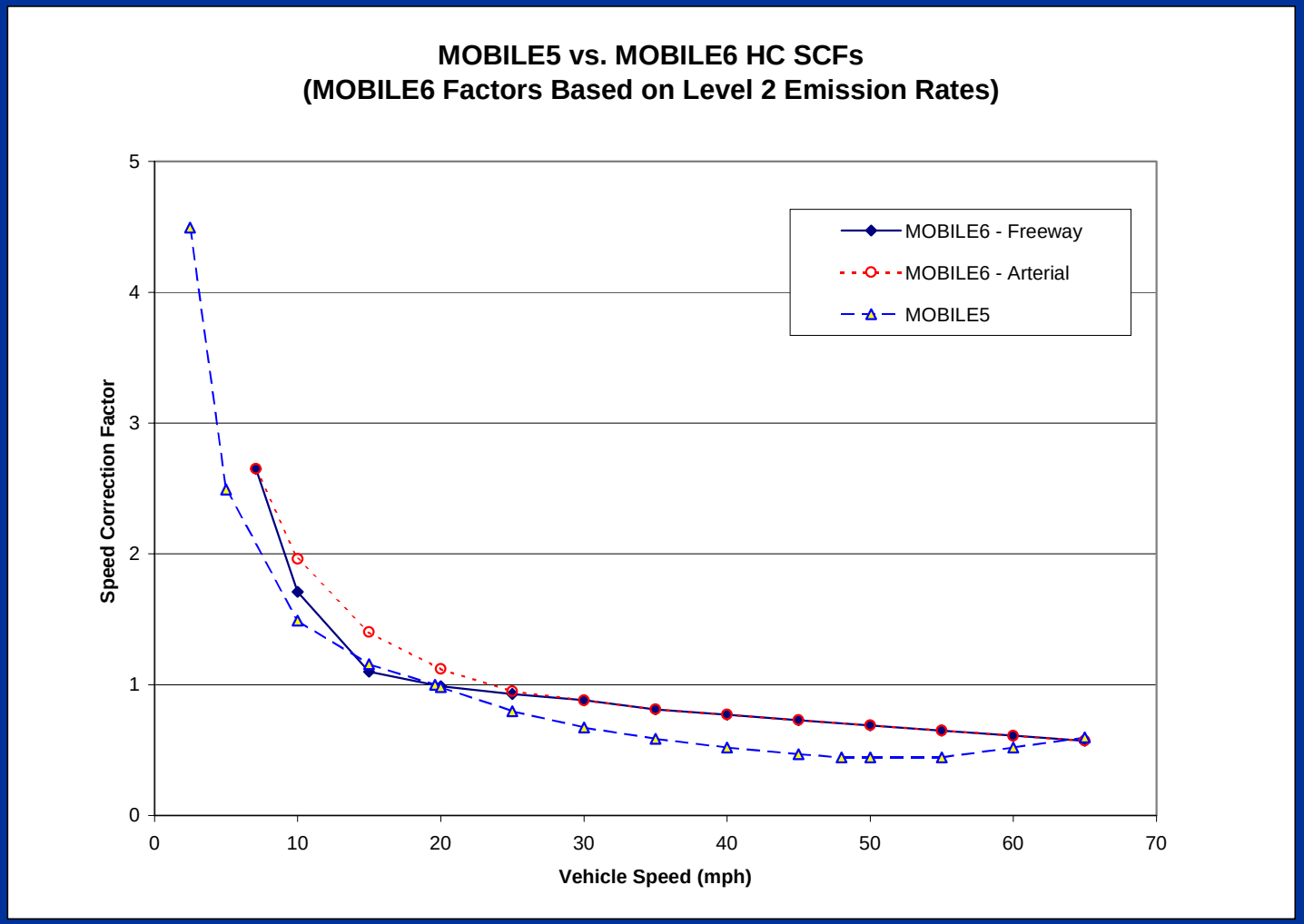
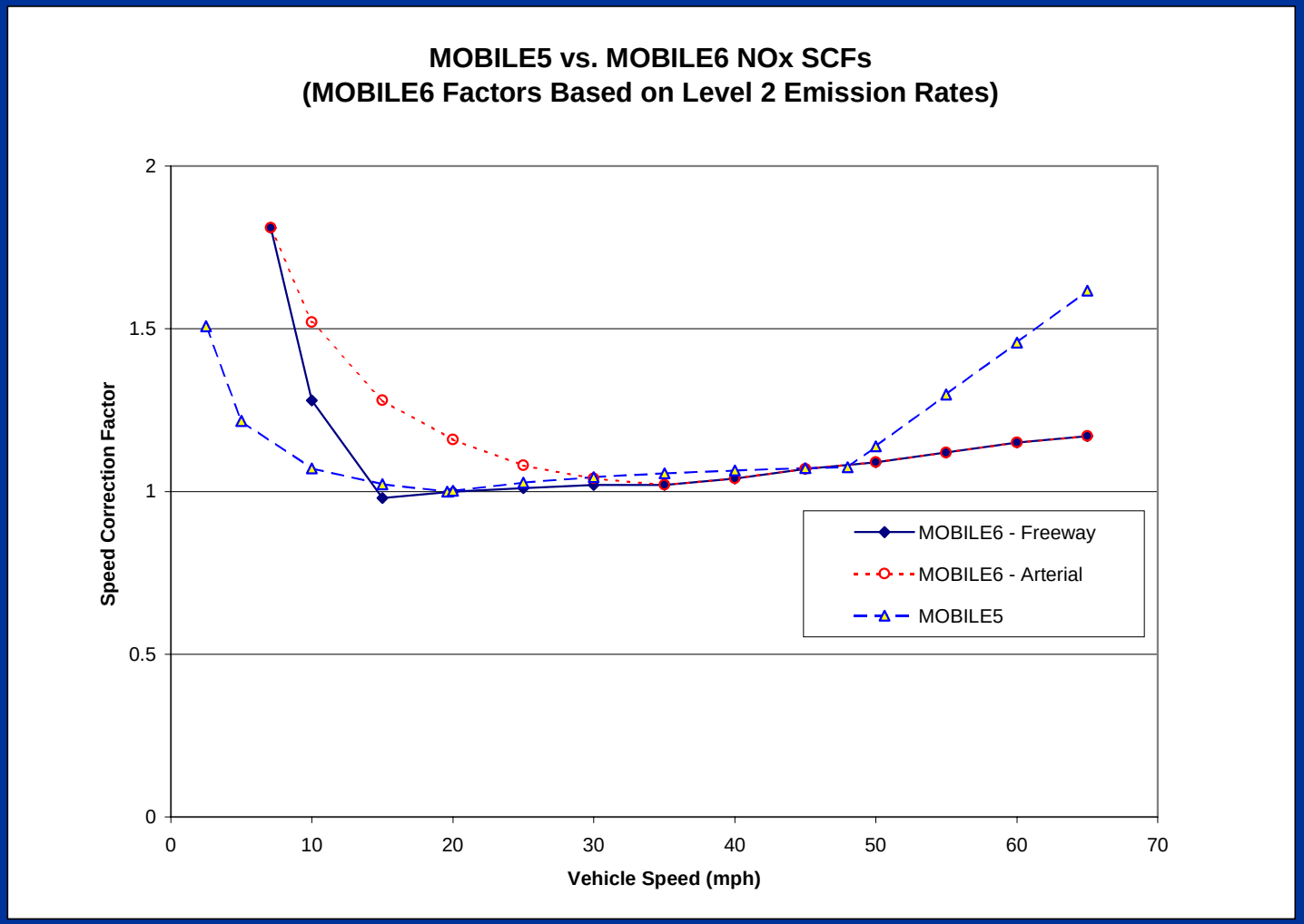
MOBILE6 LDGV NOx Running Exhaust Emission Rates as a Function of Speed (Calendar Year 2000)

Roadway Type	NOx Emissions (g/mi) by Speed			
	10 mph	25 mph	40 mph	55 mph
Freeway	1.39	1.03	1.01	1.05
Arterial	1.63	1.10	1.01	1.05
Local	1.04 (Ave Speed = 12.9 mph)			
Ramp	1.24 (Ave Speed=34.6 mph)			


MOBILE6 Freeway Speed Correction Factors for HC
(Not Emission Rates)
Speed Correction Factor
Vehicle Speed (mph)
Level 1 (0.042 g/mi)
Level 2 (0.29 g/mi)
Level 3 (3.476 g/mi)
0
0.5
1
1.5
2
2.5
3
0
10
20
30
40
50
60
70


MOBILE5 vs. MOBILE6 HC SCFs
(MOBILE6 Factors Based on Level 2 Emission Rates)
Speed Correction Factor
0
1
2
3
4
5
0
10
20
30
40
50
60
70
Vehicle Speed (mph)
MOBILE6 - Freeway
MOBILE6 - Arterial
MOBILE5


MOBILE5 vs. MOBILE6 NOx SCFs
(MOBILE6 Factors Based on Level 2 Emission Rates)
Speed Correction Factor
2
1.5
1
0.5
0
0
10
20
30
40
50
60
70
Vehicle Speed (mph)
MOBILE6 - Freeway
MOBILE6 - Arterial
MOBILE5

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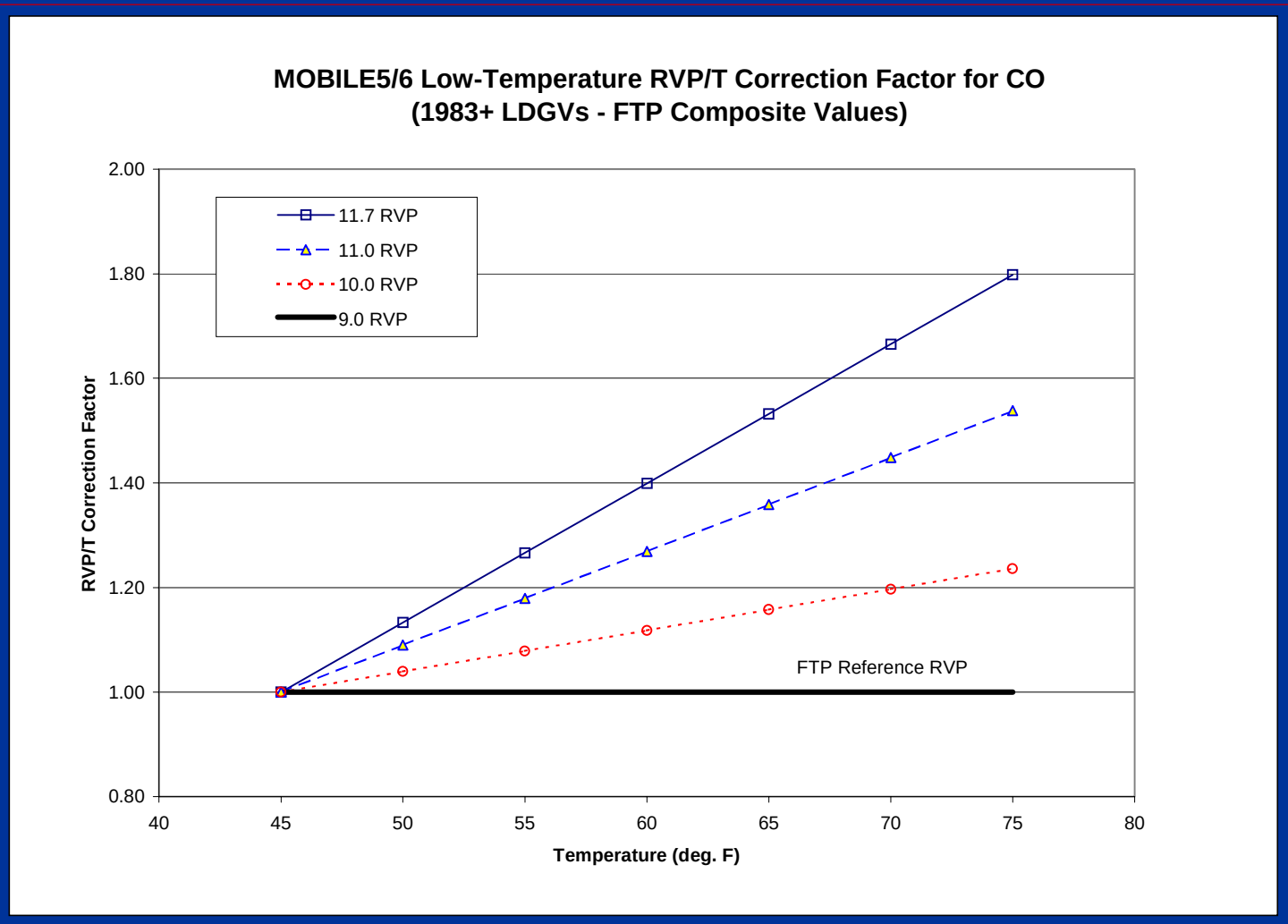
Running Exhaust Emissions Modeling Methodology

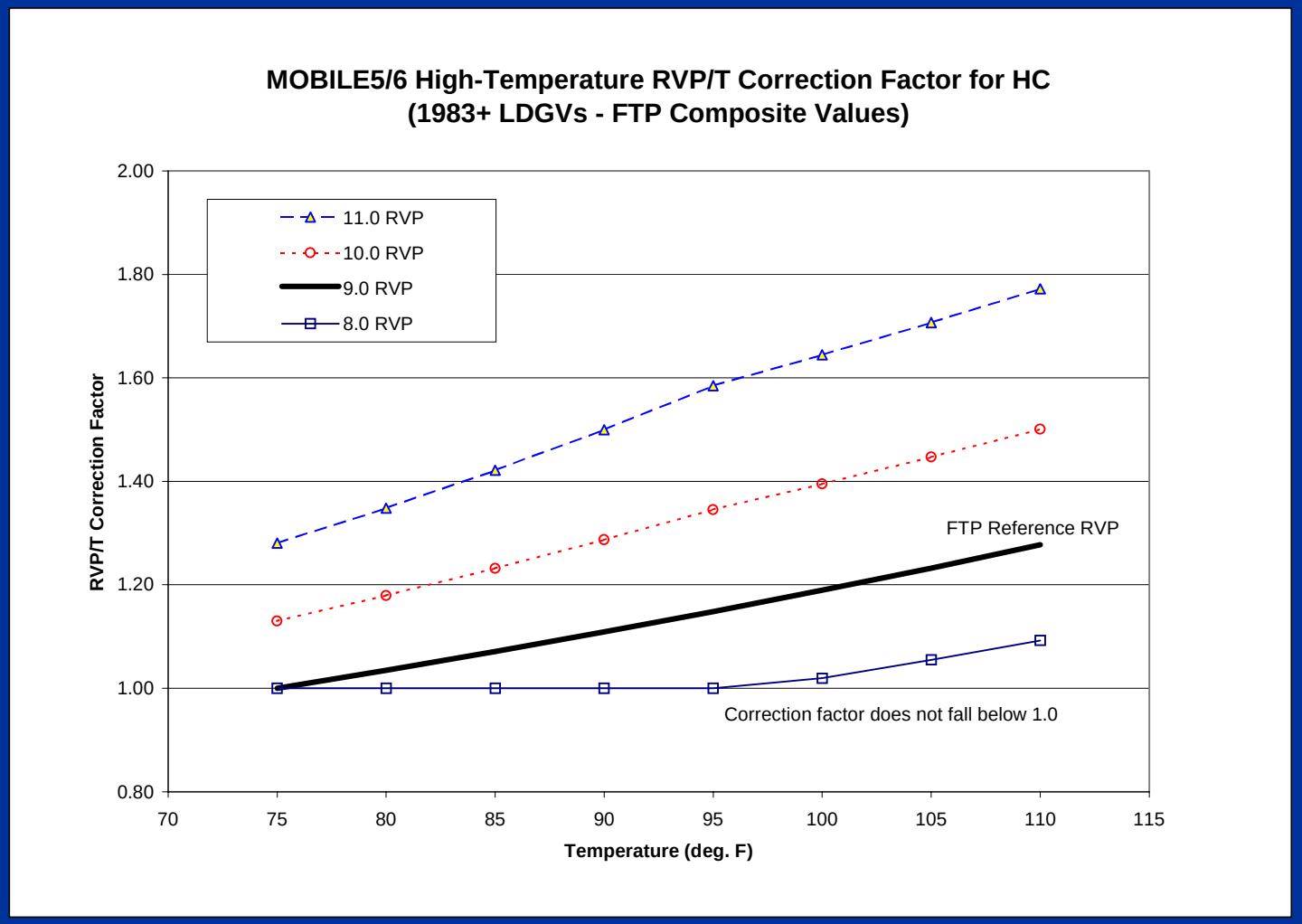
$$\left[\begin{array}{c}\text{Fleet-Ave}\\ \text{Emission}\\ \text{Rate}\end{array}\right]_{\text{Veh Class}} = \sum_{Age=1} \left[\text{Travel Fraction}\right] \times \left\{\left[\begin{array}{c}\text{LA4}\\ \text{Emission}\\ \text{Rate}\end{array}\right] + \text{Tampering Offset} + \left[\text{Aggressive Driving} + \text{Air Conditioning}\right]\right\} \times \left[\text{Temperature Adjustment}\right] \times \left[\text{Speed Adjustment}\right] \times \left[\frac{\text{Fuel}}{\text{Adjustment}}\right]$$

No video available in this version of presentation

MOBILE6 Fuel Corrections

- FTP data are based on Indolene fuel (i.e., non-oxygenated, 9.0 psi RVP, relatively low sulfur).
- First fuel adjustment performed is to account for "industry average" fuel.
- RVP exhaust corrections applied at both low temperature (down to 45°F) and high temperature (75°F to 110°F).
- Oxygenated fuel adjustment calculated for fuels with up to 3.5% oxygen for CO and 2.7% oxygen for HC (no impact on NOx).
- Reformulated gasoline modeled by assuming an RVP level based on volatility class; exhaust reductions based on requirements of the rule.
- MOBILE6 includes explicit estimates of the impact of gasoline sulfur level on exhaust emissions.


MOBILE5/6 Low-Temperature RVP/T Correction Factor for CO
(1983+ LDGVs - FTP Composite Values)
RVP/T Correction Factor
2.00
1.80
1.60
1.40
1.20
1.00
0.80
11.7 RVP
11.0 RVP
10.0 RVP
9.0 RVP
FTP Reference RVP
40
45
50
55
60
65
70
75
80
Temperature (deg. F)


MOBILE5/6 High-Temperature RVP/T Correction Factor for HC
(1983+ LDGVs - FTP Composite Values)
RVP/T Correction Factor
2.00
1.80
1.60
1.40
1.20
1.00
0.80
11.0 RVP
10.0 RVP
9.0 RVP
8.0 RVP
FTP Reference RVP
Correction factor does not fall below 1.0
70
75
80
85
90
95
100
105
110
115
Temperature (deg. F)

No video available in this version of presentation

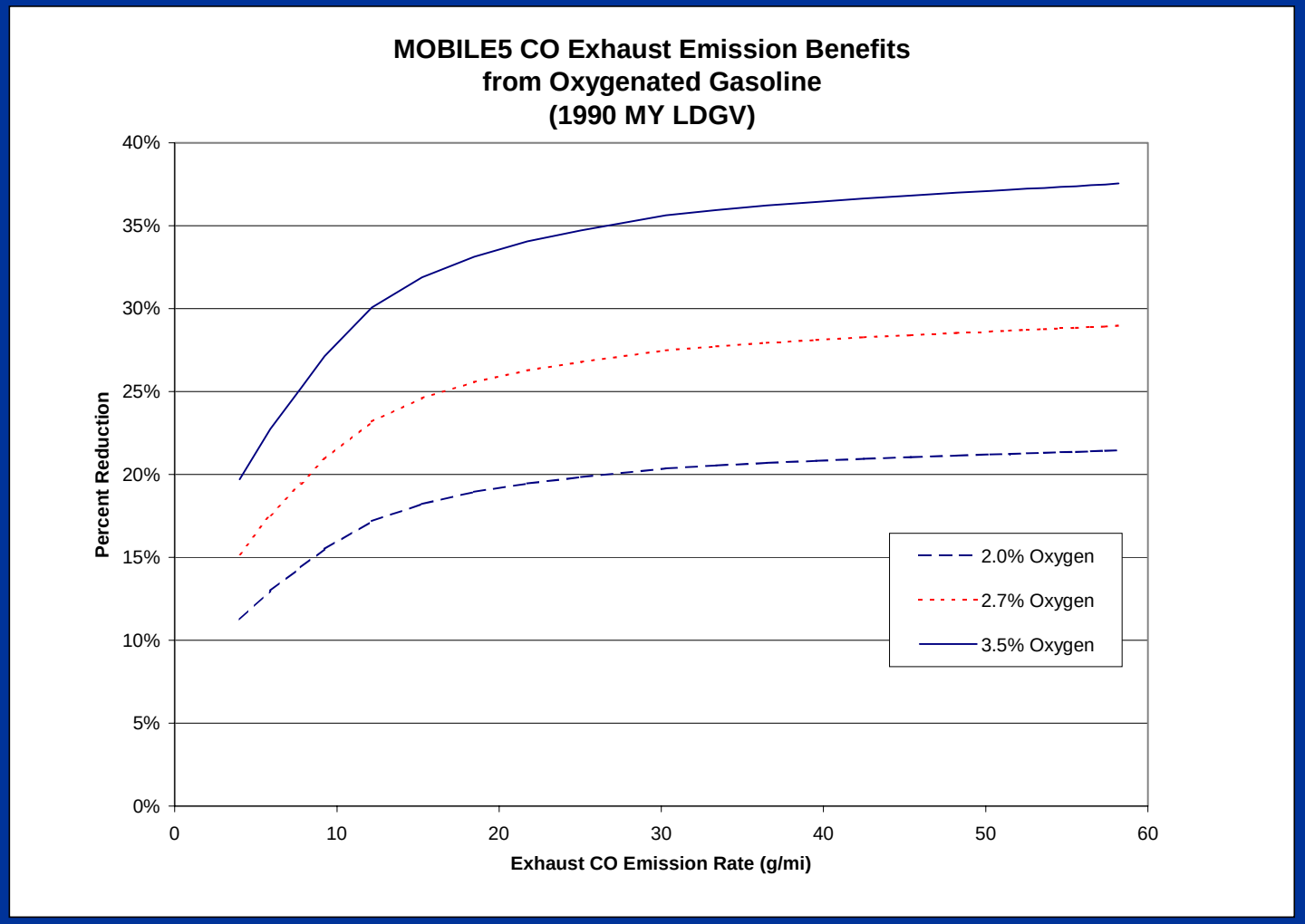
MOBILE6 Fuel Corrections
Oxygenated Gasoline

- Fuel corrections for oxygenated gasoline are significantly different in MOBILE6, with no impact ascribed to normal emitting Tier 1 and newer vehicles.

CO Effects From the Use of Oxygenated Fuels in Light-Duty Gasoline Vehicles

Emitter Category	Technology	CO Impact Per Wt% Oxygen	Typical MTBE Blend (2.7 wt% O)	Typical Ethanol Blend (3.5 wt% O)
Normal	Tier 1/Adv. Tech.	0.0%	0.0%	0.0%
	1988+ TWC/ADL	-3.1% (n=133)[a]	-8.4%	-10.9%
	1986-87 TWC/ADL	-4.8% (n=104)	-13.0%	-16.8%
	1986+ TWC/No ADL	-5.7% (n=151)	-15.4%	-20.0%
	1981-85 TWC/CL	-4.0% (n=73)	-10.8%	-14.0%
	OX/OL[b]	-9.4%	-25.4%	-32.9%
	Non-Catalyst[b]	-6.6%	-17.8%	-23.1%
High	Tier 1/Adv. Tech	-5.3%	-14.3%	-18.6%
	1981+ TWC/CL	-5.3% (n=134)[a]	-14.3%	-18.6%
	OX/OL[b]	-9.4%	-25.4%	-32.9%
	Non-Catalyst[b]	-6.6%	-17.8%	-23.1%

[a] Sample size shown in parentheses.
[b] CO impacts for these technologies are based on MOBILE5.


MOBILE5 CO Exhaust Emission Benefits
from Oxygenated Gasoline
(1990 MY LDGV)
Percent Reduction
40%
35%
30%
25%
20%
15%
10%
5%
0%
0
10
20
30
40
50
60
Exhaust CO Emission Rate (g/mi)
2.0% Oxygen
2.7% Oxygen
3.5% Oxygen

No video available in this version of presentation

MOBILE6 Fuel Corrections
Gasoline Sulfur Level

- MOBILE6 also includes specific accounting for gasoline sulfur content, which is a new feature in the model.
- The impact of sulfur on exhaust emissions is more severe for more advanced technology vehicles.
- Separate regression equations were developed for normal versus high emitters.

Emissions Impacts from Varying Sulfur Levels in Gasoline
(Draft MOBILE6 Estimates -- FTP Basis)

Vehicle Category	Pollutant	% Increase when Sulfur is Increased from 30 ppm to:			
		75	150	330	600
Tier 0 Normals	HC	5.8	10.4	15.8	20.1
	CO	7.2	13.0	20.0	25.6
	NOx	2.9	5.1	7.7	9.7
Tier 1 Normals	HC	3.7	10.1	27.3	34.8
	CO	2.9	7.9	20.8	26.6
	NOx	1.4	3.9	10.0	12.6
LEV and ULEV Normals	HC	16.7	31.1	49.8	65.6
	CO	24.3	46.5	76.7	103.6
	NOx	38.3	76.8	133.6	188.7
High Emitters	HC	0.2	0.5	1.1	2.2
	CO	0.0	0.1	0.2	0.4
	NOx[a]	1.4	3.7	9.6	19.0

[a] EPA has suggested a larger NOx impact be ascribed to high-emitting LEVs.

No video available in this version of presentation

Combining Vehicle-Class Emission Rates (With VMT Mix)

$$\left[\begin{array}{c}\text{Fleet-Ave}\\ \text{Emission}\\ \text{Rate}\end{array}\right] = \sum_{\text{Veh}=1} \left[\begin{array}{c}\text{VMT}\\ \text{Mix}\end{array}\right]_{\text{Veh Class}} \times \left[\begin{array}{c}\text{Fleet-Ave}\\ \text{Emission}\\ \text{Rate}\end{array}\right]_{\text{Veh Class}}$$

No video available in this version of presentation

VMT Mix

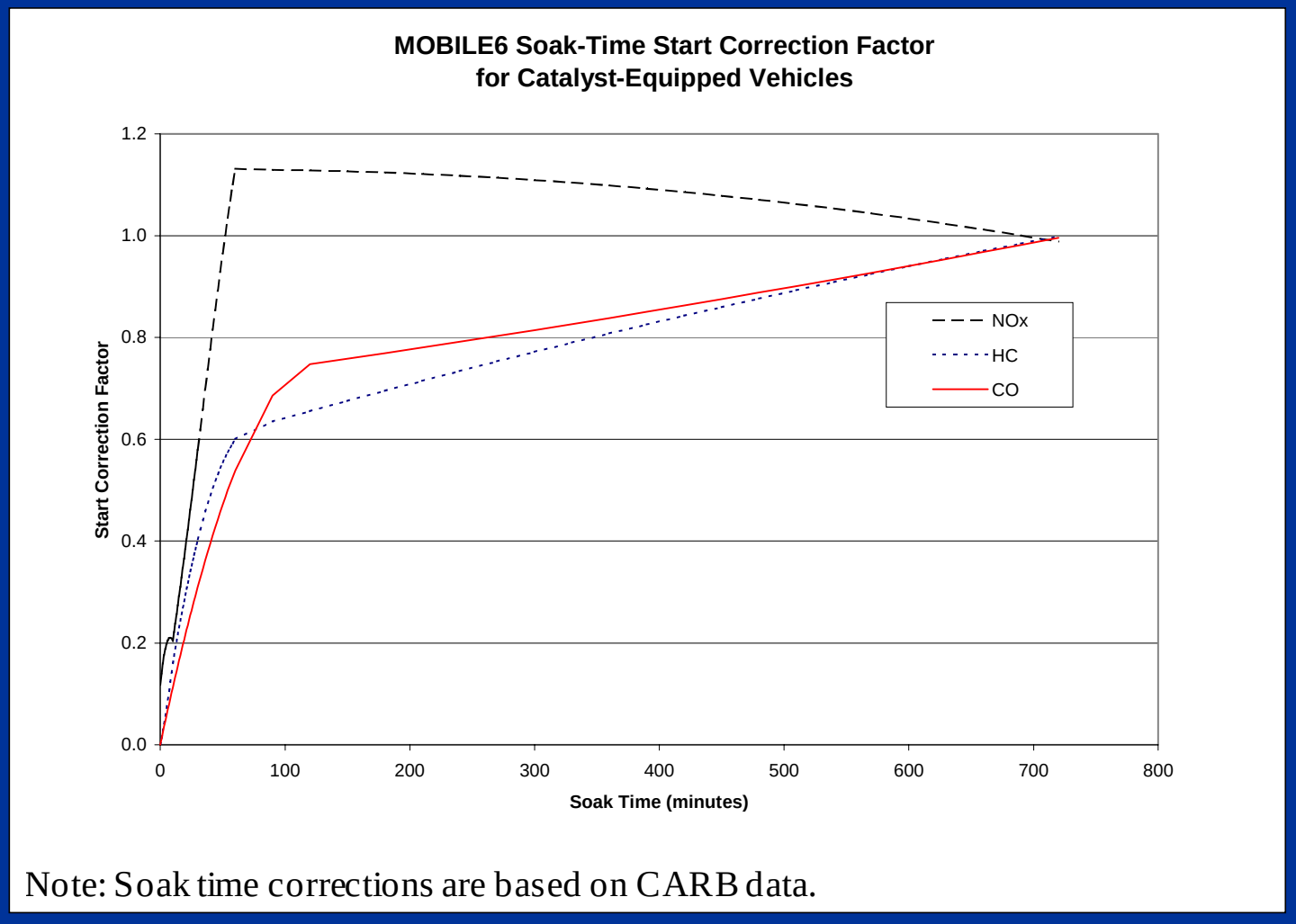
- VMT mix is calculated within MOBILE by applying average annual mileage accumulation rates for each vehicle class to population estimates for each vehicle class.
- MOBILE6 VMT mix estimates are significantly different from MOBILE5, particularly in terms of light-duty trucks.
- MOBILE5 projections were based on 1990 estimates that did not anticipate the growth in SUVs and mini-vans.
- Comparison for CY 2000 and 2010:

CY	Model	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC
2000	M5	.614	.191	.086	.031	.001	.001	.068	.006
	M6	.494	.283	.097	.036	.001	.002	.081	.006
2010	M5	.589	.201	.088	.032	.002	.003	.080	.005
	M6	.354	.386	.132	.036	.000	.002	.086	.005

No video available in this version of presentation

Start Emissions

- There is no operating mode adjustment in MOBILE6.
- Instead, emissions are calculated in terms of running exhaust ("Running LA4" in g/mi) and a start offset (in g/trip).
- The start offset is corrected for:
  - Soak time (data are collected based on a 12-hour soak)
  - Temperature effects
  - Fuel effects
- A g/mi start emission rate is calculated by multiplying the start offset by the number of trips per day and dividing by average daily mileage.
- MOBILE6 assumes a much larger number of trips per day than MOBILE5.



Note: Soak time corrections are based on CARB data.

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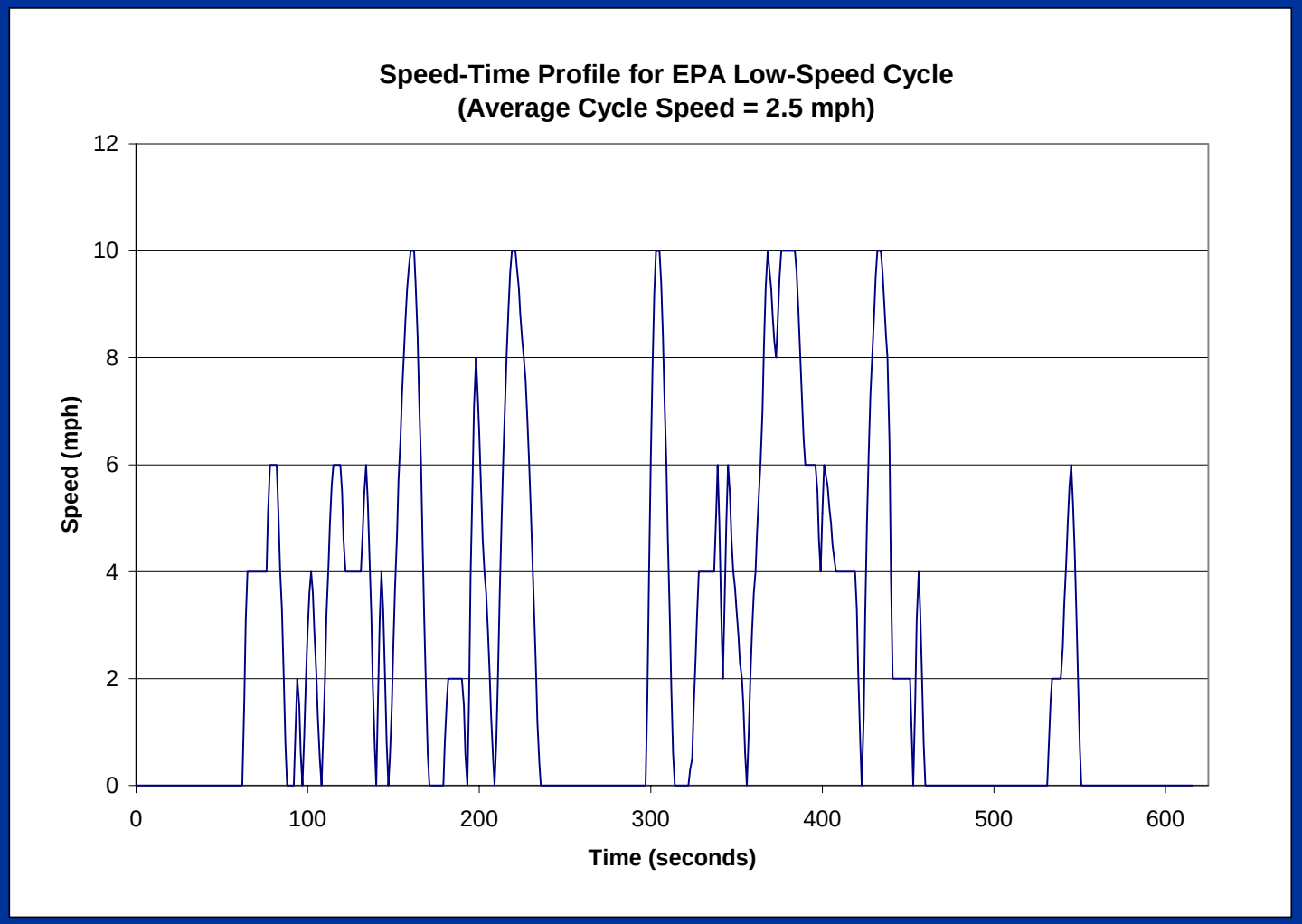
Idle Emission Rates

- Not calculated with MOBILE6.
- Current idle emission rates are not based on idle testing (but low-speed cycle has considerable idle time).
- The following calculation is used for idle rates:

$$Idle(g/hr) = FleetEF(g/mi)@2.5mph \times 2.5(mi/hr)$$

- The above methodology results in proportional reductions in idle rates relative to running exhaust emission rates as a result of I/M, oxygenated fuels, etc.

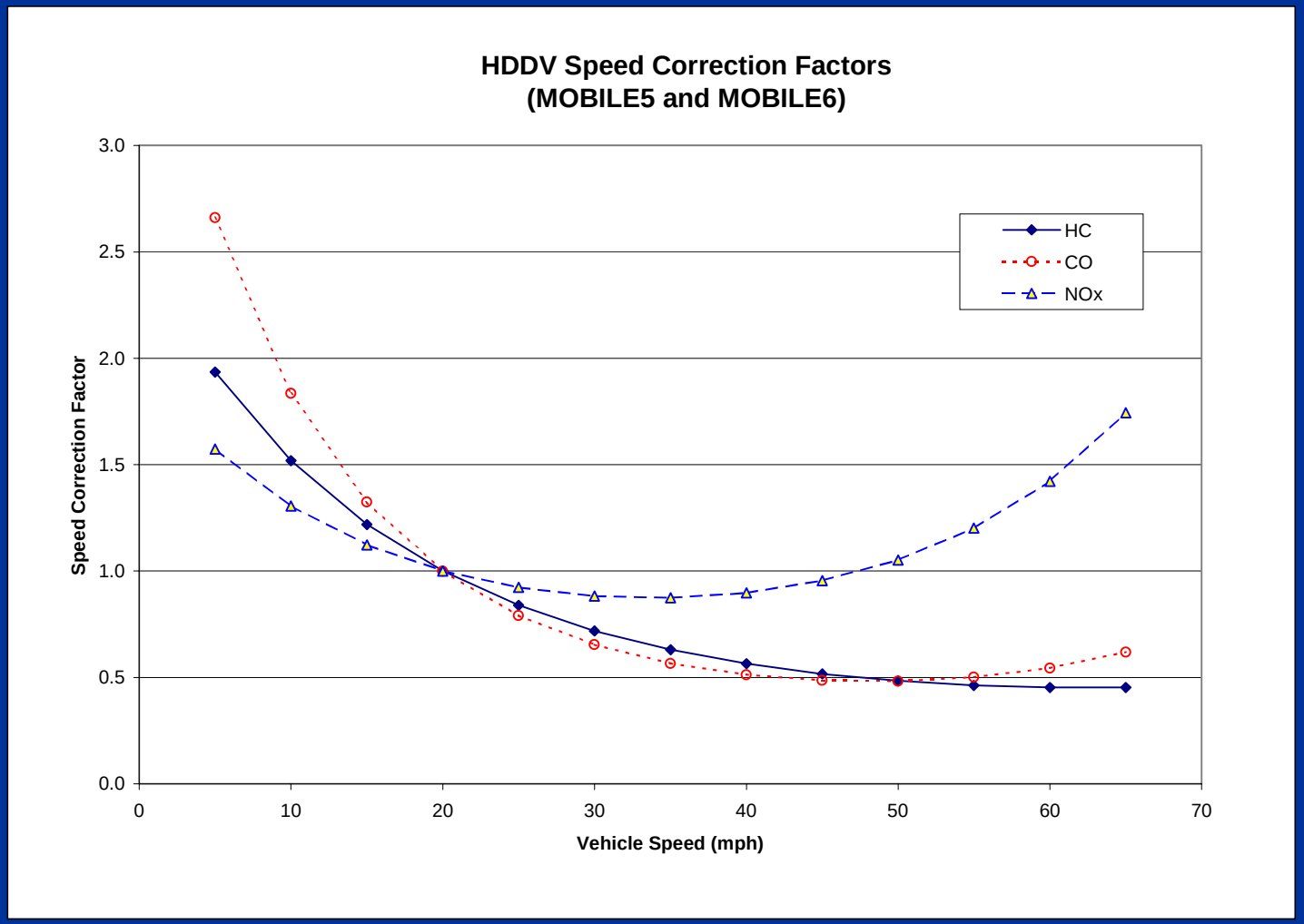

Speed-Time Profile for EPA Low-Speed Cycle
(Average Cycle Speed = 2.5 mph)
Speed (mph)
0
2
4
6
8
10
12
0
100
200
300
400
500
600
Time (seconds)

No video available in this version of presentation

Heavy-Duty Gas and Diesel Emission/Conversion Factors

- Heavy-duty engines are removed from the vehicle and tested on an engine dynamometer.
- Emission rates are specified in g/bhp-hr (i.e., mass per unit of work) units.
- The emission factors (in g/bhp-hr) are converted to g/mi units with "conversion factors."
- Conversion factors are a function of:
  - Brake specific fuel consumption
  - Fuel density
  - Fuel economy
- Temperature corrections are applied for gasoline vehicles.
- Speed corrections are applied for gasoline and Diesel.

NO
VIDEO

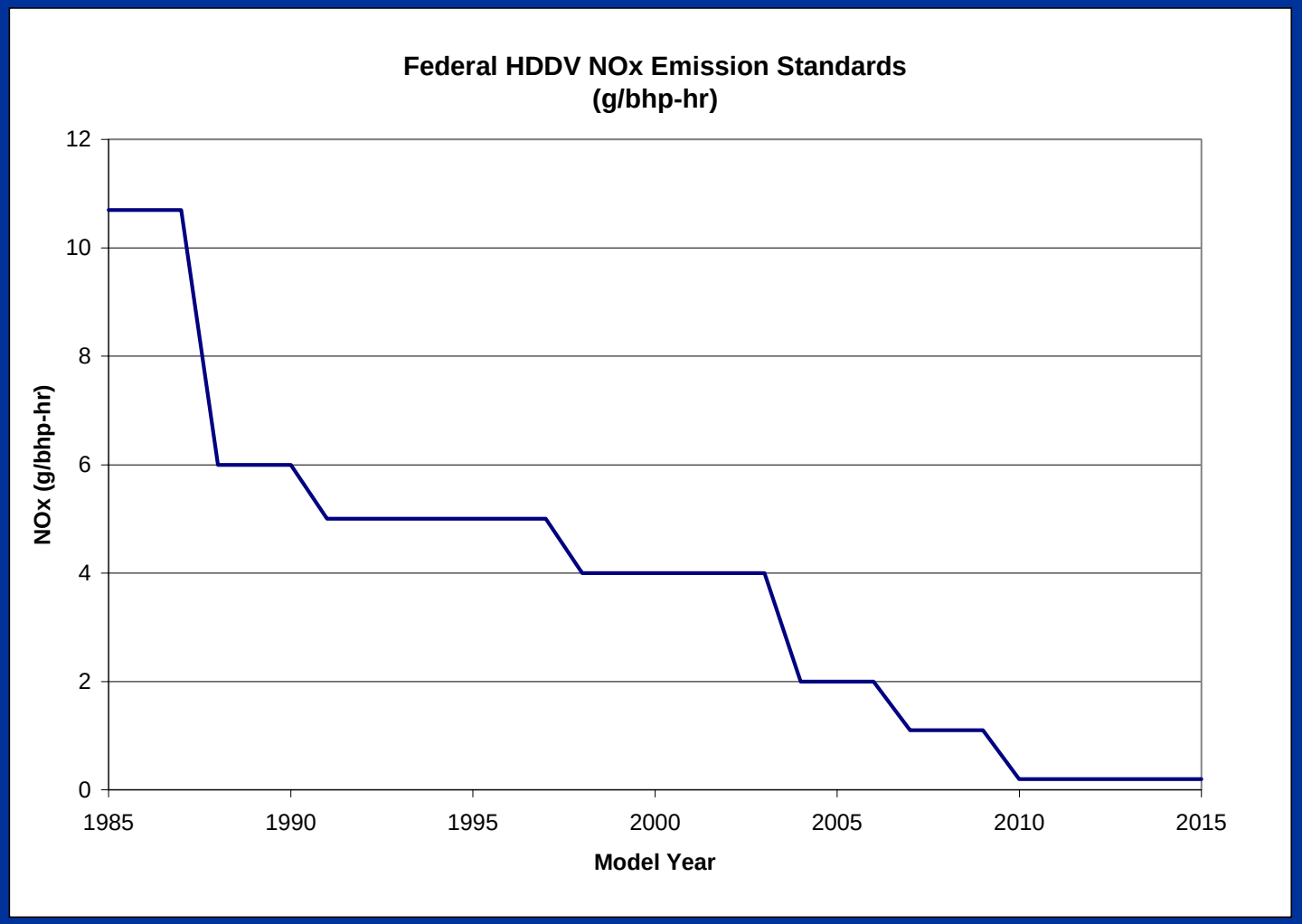

HDDV Speed Correction Factors
(MOBILE5 and MOBILE6)
Speed Correction Factor
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
70
Vehicle Speed (mph)
HC
CO
NOx

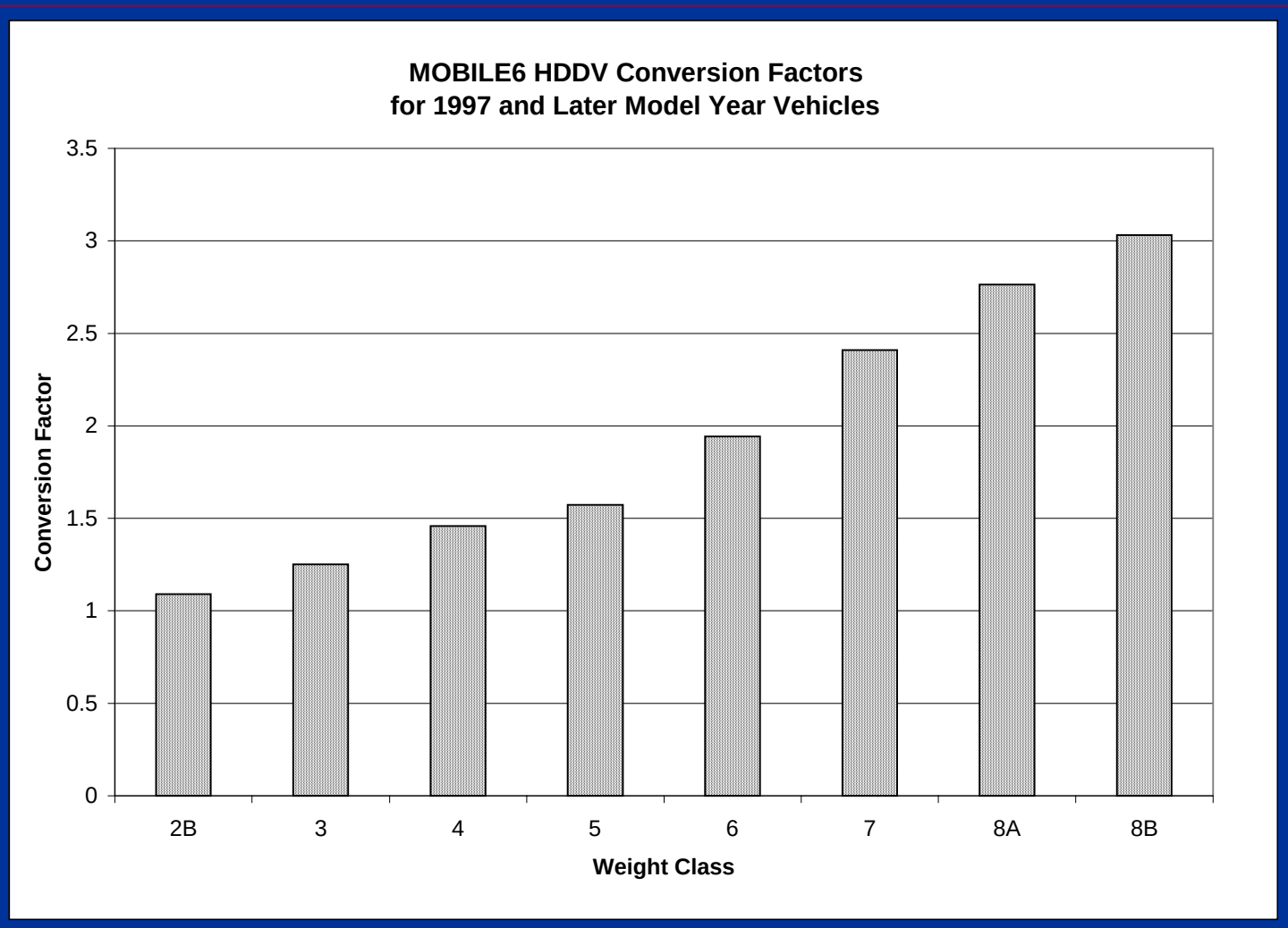
NO
VIDEO

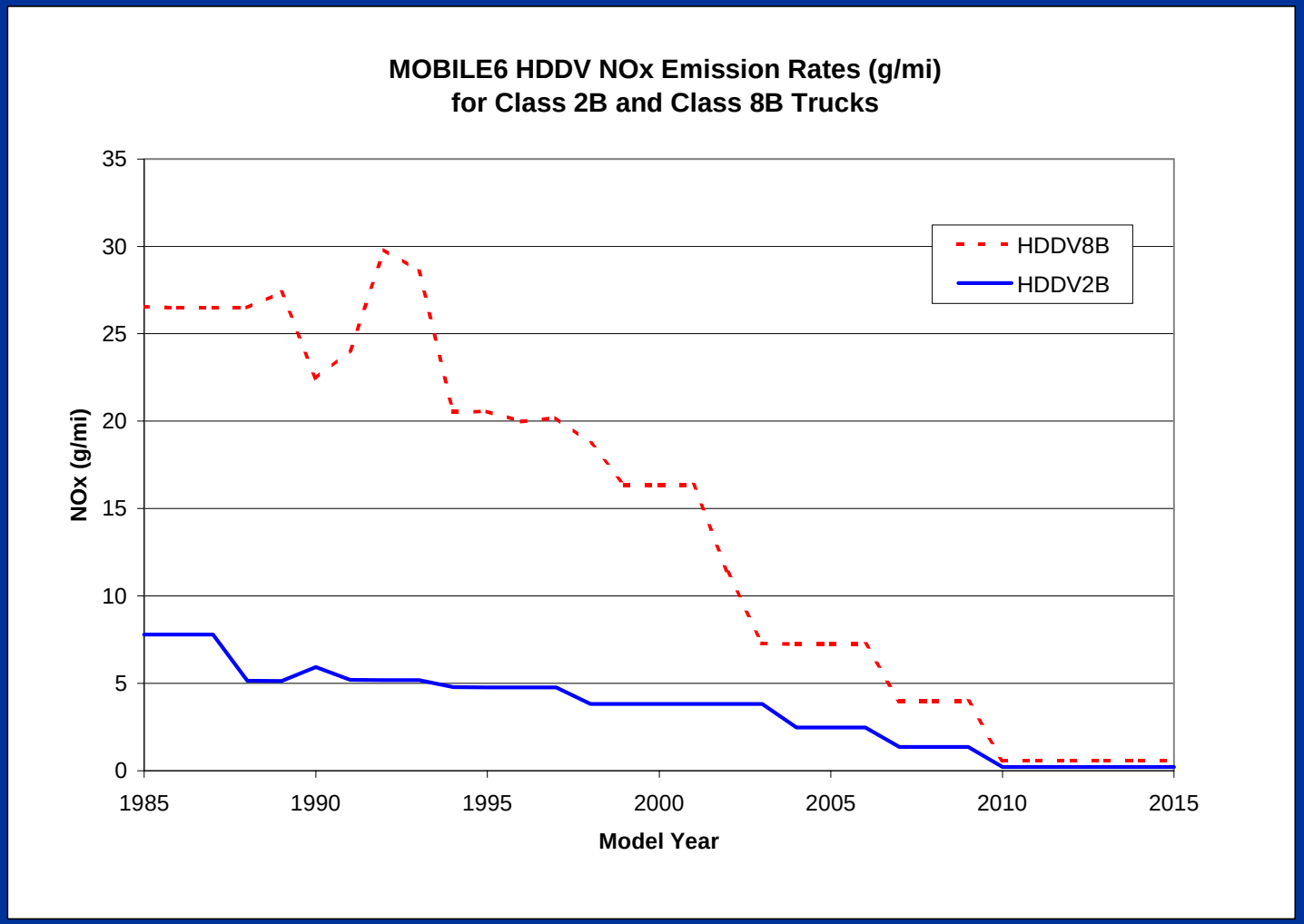
Heavy-Duty Vehicle Emission Factors Changes for MOBILE6

- Emission factors (g/bhp-hr) for 1988+ MY updated based on certification data and projected standards changes.
- Conversion factors revised based on updated estimates of fuel economy and fuel densities.
- Most significant addition to MOBILE6 was incorporation of NOx emissions impacts of built-in "defeat devices."

NO
VIDEO


Federal HDDV NOx Emission Standards
(g/bhp-hr)
NOx (g/bhp-hr)
12
10
8
6
4
2
0
1985
1990
1995
2000
2005
2010
2015
Model Year


MOBILE6 HDDV Conversion Factors
for 1997 and Later Model Year Vehicles
Conversion Factor
3.5
3
2.5
2
1.5
1
0.5
0
2B
3
4
5
6
7
8A
8B
Weight Class


MOBILE6 HDDV NOx Emission Rates (g/mi)
for Class 2B and Class 8B Trucks
NOx (g/mi)
35
30
25
20
15
10
5
0
1985
1990
1995
2000
2005
2010
2015
Model Year
HDDV8B
HDDV2B

Summary of NOx Increase (g/mi) as a Result of HDDVs Equipped with "Defeat Devices"

MYR	Defeat Device NOx Offset by Roadway Type				Class 8b 100% DD
	Interstate	Arterial	Urban	Composite	
1987	0.00	0.00	0.00	0.00	0.00
1988	1.99	0.73	0.00	1.26	29.11
1989	3.26	1.19	0.00	2.06	28.82
1990	5.25	1.53	0.20	3.29	25.28
1991	8.22	2.46	0.14	5.13	27.96
1992	16.17	3.83	0.16	9.85	24.34
1993	15.73	3.55	0.23	9.57	23.03
1994	6.12	1.32	0.12	3.72	8.76
1995	6.17	1.44	0.16	3.78	8.75
1996	5.95	1.20	0.04	3.58	8.63
1997	6.10	1.34	0.04	3.69	8.70
1998	8.45	2.09	0.11	5.17	11.56
1999	3.98	0.90	0.05	2.42	5.92
2000	2.95	0.67	0.04	1.79	4.39
2001	0.00	0.00	0.00	0.00	0.00
2002	-1.19	-0.94	-1.00	-1.09	-1.39
2003	-4.74	-3.76	-4.00	-4.37	-5.58
2004	0.00	0.00	0.00	0.00	0.00

Estimates based on M6.HDE.003

No video available in this version of presentation

Overall "Defeat Device" Impact on Fleet-Average HDDV NOx Emissions (g/mi)

Calendar Year	With DD (Default)	No DD	NOx Increase
1995	20.49	16.61	3.88
2000	18.05	13.41	4.64
2005	11.44	10.39	1.05
2010	6.83	6.42	0.41

No video available in this version of presentation

Evaporative/Non-Exhaust Emissions

- Diurnal breathing losses occur as the fuel tank heats up during the day.
- Resting losses result from vapor permeation and liquid leaks through various parts of the evaporative control system.
- Hot Soak losses occur after the vehicle has been turned off and result from evaporation of fuel in the engine and fuel delivery system.
- Running evaporative losses occur as the vehicle is being operated over the road.
- Refueling losses are a result of vapor space displacement and spillage.
- Crankcase losses are primarily the result of defective PCV systems.

No video available in this version of presentation

Evaporative Standards and Test Procedures

Procedure	Model Year	HS + DI Test	Running Loss	Refueling (ORVR)
Carbon Trap	1971 1972-77	6 g/test 2 g/test	None	None
1-Hour SHED	1978-80 1981-95	6 g/test 2 g/test	None	None
Enhanced Evap	1996+ (phase-in)	2 g/test or 2.5 g/test[a]	0.05 g/mi	0.2 g/gal[b]

[a] 2 g/test for the 3-day procedure; 2.5 g/test for the 2-day procedure. More stringent standards are required with Tier 2.
[b] ORVR standards are phased-in beginning in 1998.

- Carbon trap procedure vented air filter housing and filler neck/cap into carbon canisters.
- One-hour SHED test enclosed entire vehicle within a test cell; diurnal testing was performed by heating fuel from 60° to 84°F in one hour.
- Enhanced evap procedure requires 2- or 3-day real-time diurnal testing (72° to 96°F) and a running loss test (at 95°F).
- PCV required in 1963 in CA; federally required shortly thereafter.

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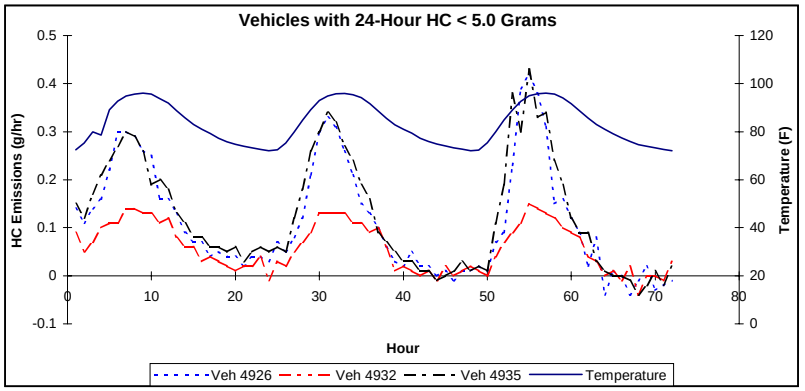
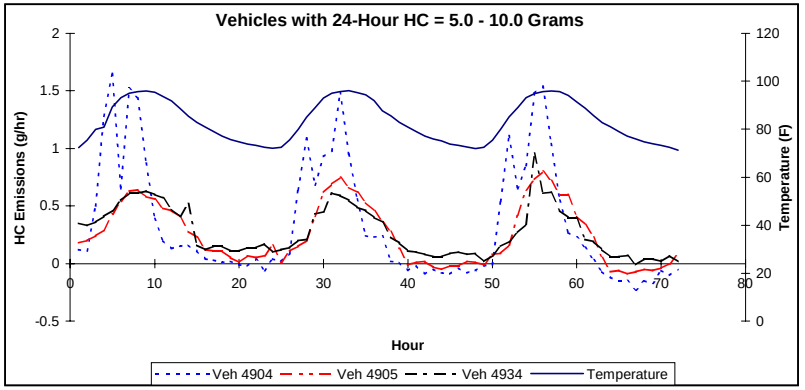
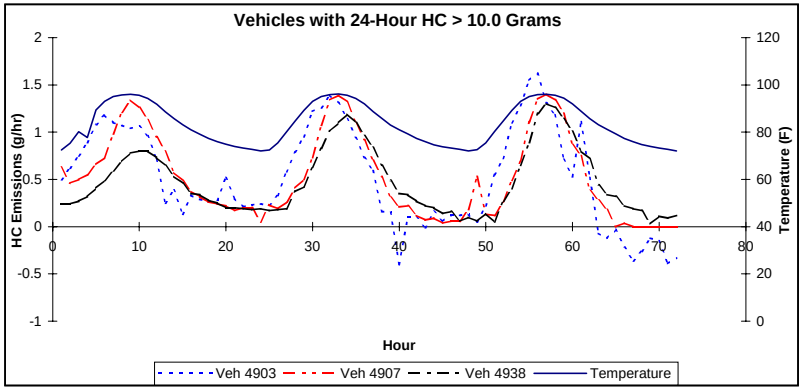
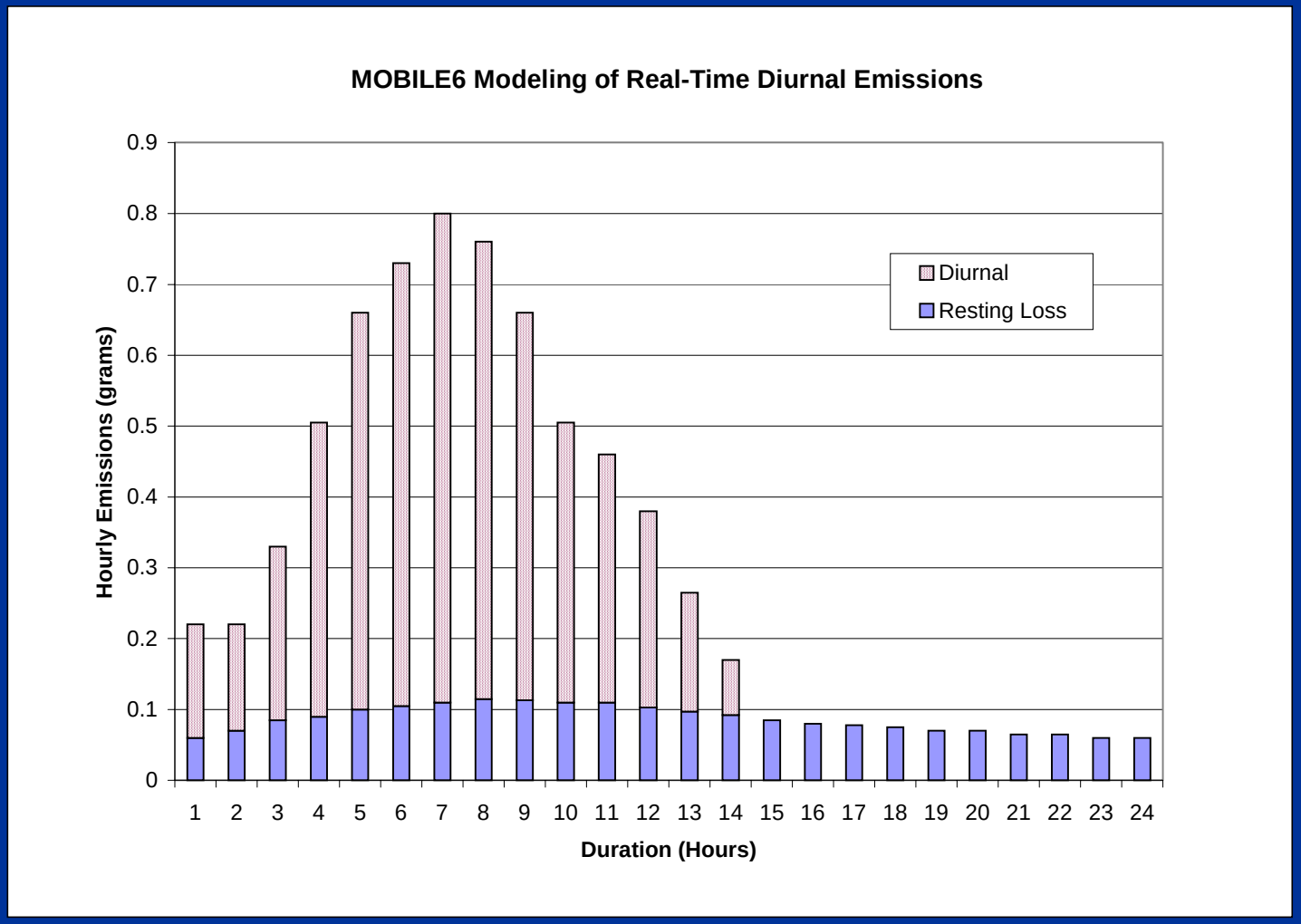
Baseline Hourly Diurnal Emissions for Vehicles in the IM92 Program
(6.7 psi RVP Fuel - 72° to 96° F Temperature Profile)








MOBILE6 Modeling of Real-Time Diurnal Emissions
Hourly Emissions (grams)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Duration (Hours)
Diurnal
Resting Loss

No video available in this version of presentation

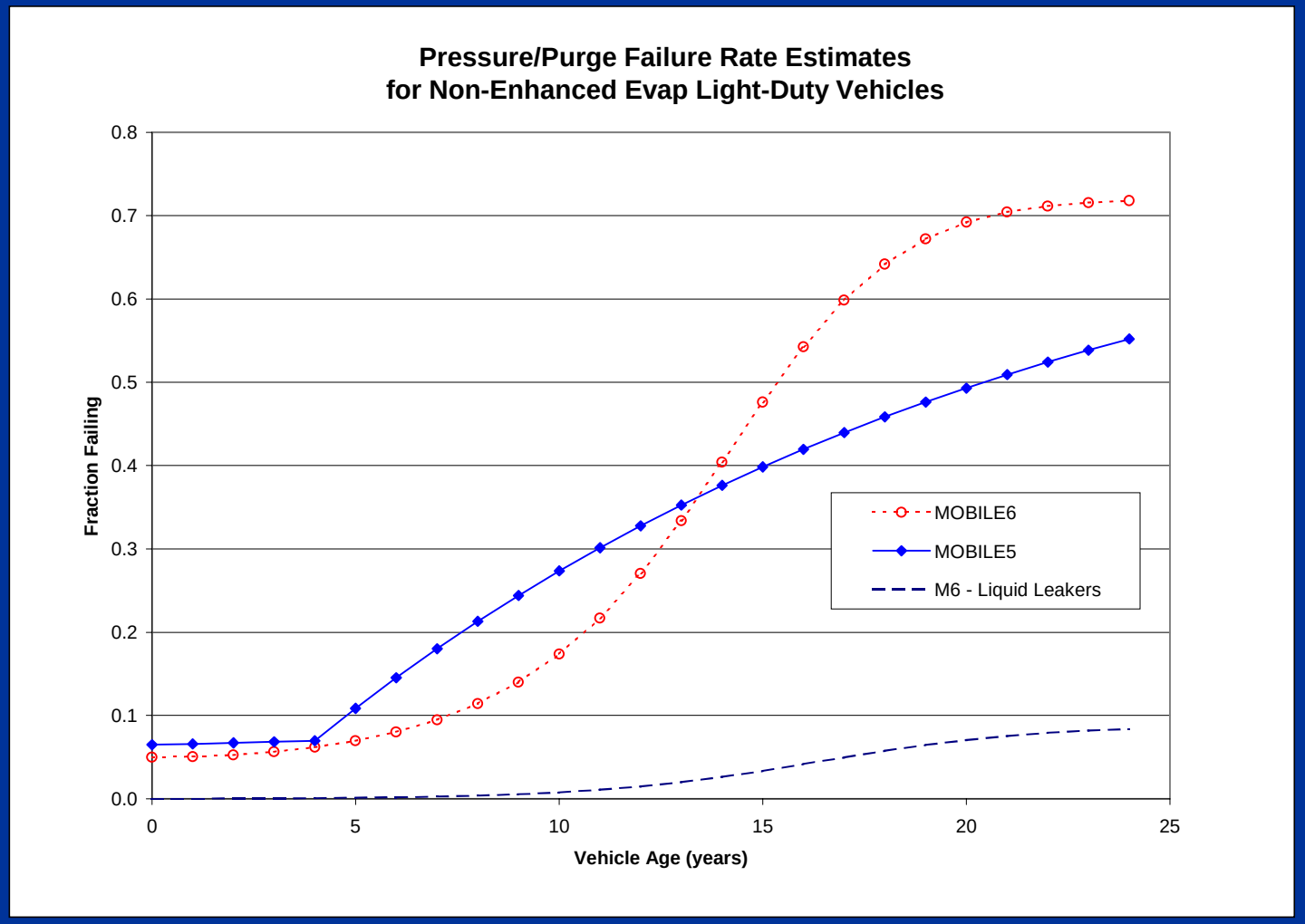
Modeling Evaporative Emissions

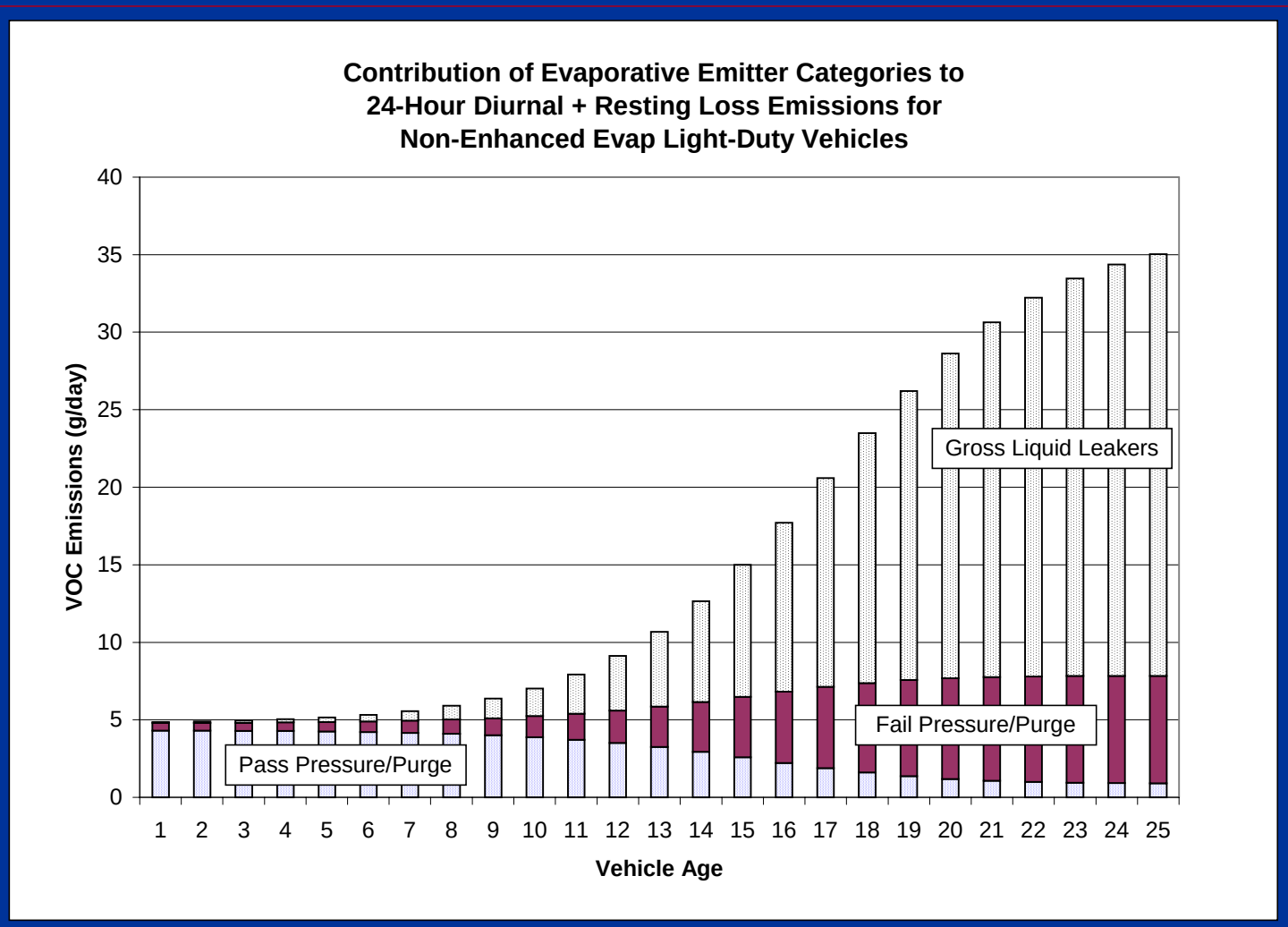
- Evaporative emissions are modeled by segregating the fleet by fuel delivery technology and by pressure/purge (P/P) passing and failing vehicles.
- In addition, MOBILE6 includes another emissions category for evap – Gross Liquid Leaker (GLL).
- Composite emission rate (by vehicle age) is determined by applying the fraction of passing and failing vehicles to the emission rates of passing and failing vehicles.
- MOBILE5 example – full-day diurnal rates from a 5-year old 1990 MY vehicle:

  - passing vehicle - 1.47 g/day
  - fail purge - 7.40 g/day
  - fail pressure - 14.28 g/day

  DI = 1.47*0.891 + 7.40*0.039 + 14.28*0.070
  = 2.60 g/day

- Emissions deterioration results from an increase in P/P failing vehicles as the fleet ages.


Pressure/Purge Failure Rate Estimates
for Non-Enhanced Evap Light-Duty Vehicles
Fraction Failing
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
5
10
15
20
25
Vehicle Age (years)
MOBILE6
MOBILE5
M6 - Liquid Leakers


Contribution of Evaporative Emitter Categories to
24-Hour Diurnal + Resting Loss Emissions for
Non-Enhanced Evap Light-Duty Vehicles
VOC Emissions (g/day)
0
5
10
15
20
25
30
35
40
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Vehicle Age
Gross Liquid Leakers
Fail Pressure/Purge
Pass Pressure/Purge

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Modeling Evaporative Emissions (Continued)

- Evaporative emissions estimates are adjusted to account for local RVP and ambient temperature.
- MOBILE5 corrects hot soaks for the fraction that run to completion; MOBILE6 includes a distribution of soak times and different HS emission estimates depending on soak time.
- Running losses are also corrected for speed and trip length – longer trips have more fuel heating and higher running losses; MOBILE6 will use MOBILE5-based factors except for GLLs.
- MOBILE5 calculated diurnal losses over three "partial-day" periods, a full-day period, and for multi-day events; MOBILE6 is much more detailed in its calculations.

No video available in this version of presentation

Comparison of Running Loss Emissions from MOBILE5a and the RL95 Test Program (95°F, 9.0 psi RVP, 19.6 mph)				
Trip Length (min)	P/P Passes (g/mi)		P/P Failures (g/mi)	
	MOBILE5a	RL95	MOBILE5a	RL95
≤10	0.14	0.07	1.19	1.14
11-20	0.30	0.09	2.94	3.35
21-30	0.35	0.09	3.88	4.04
31-40	0.51	0.09	5.03	4.69
41-50	0.61	0.09	5.50	4.99
>50	0.77	0.21	6.14	5.69

- MOBILE6 gross liquid leaker (GLL) running loss emission rate:
  - 17.65 g/mi (including resting losses)
  - GLL resting loss emission rate = 9.16 g/hr

No video available in this version of presentation

Comparison of Hot Soak Results from the Auto/Oil Test Program and the HS95 Test Program		
Parameter	A/O Fleet	HS95 Fleet
Sample Size	299	181
Mean Model Year/Age	1987.9 / 5.5 yrs	1988.0 / 7.5 yrs
Mean Temperature (°F)	100	98
Mean RVP (psi)	6.6	6.4
Mean HS Emissions (g)	1.53	1.76

- MOBILE6 GLL hot soak emission rate (including resting losses):

  - 16.95 g/hr for carbureted vehicles
  - 45.00 g/hr for TBI vehicles
  - 57.14 g/hr for MPFI vehicles

No video available in this version of presentation

Single-Day Real-Time Diurnal Results from the IM92 Test Program (Grams per Day)				
Pressure/ Purge Status	Fuel RVP (psi)	Temperature Range		
		60° to 84°F	72° to 96°F	82° to 106°F
All (n=21)[a]	9.0	6.23	10.07	--
	6.7	--	6.73	10.38
Pass (n=12)	9.0	4.00	6.83	--
	6.7	--	4.54	6.93
Fail (n=9)	9.0	9.21	14.21	--
	6.7	--	9.66	14.98

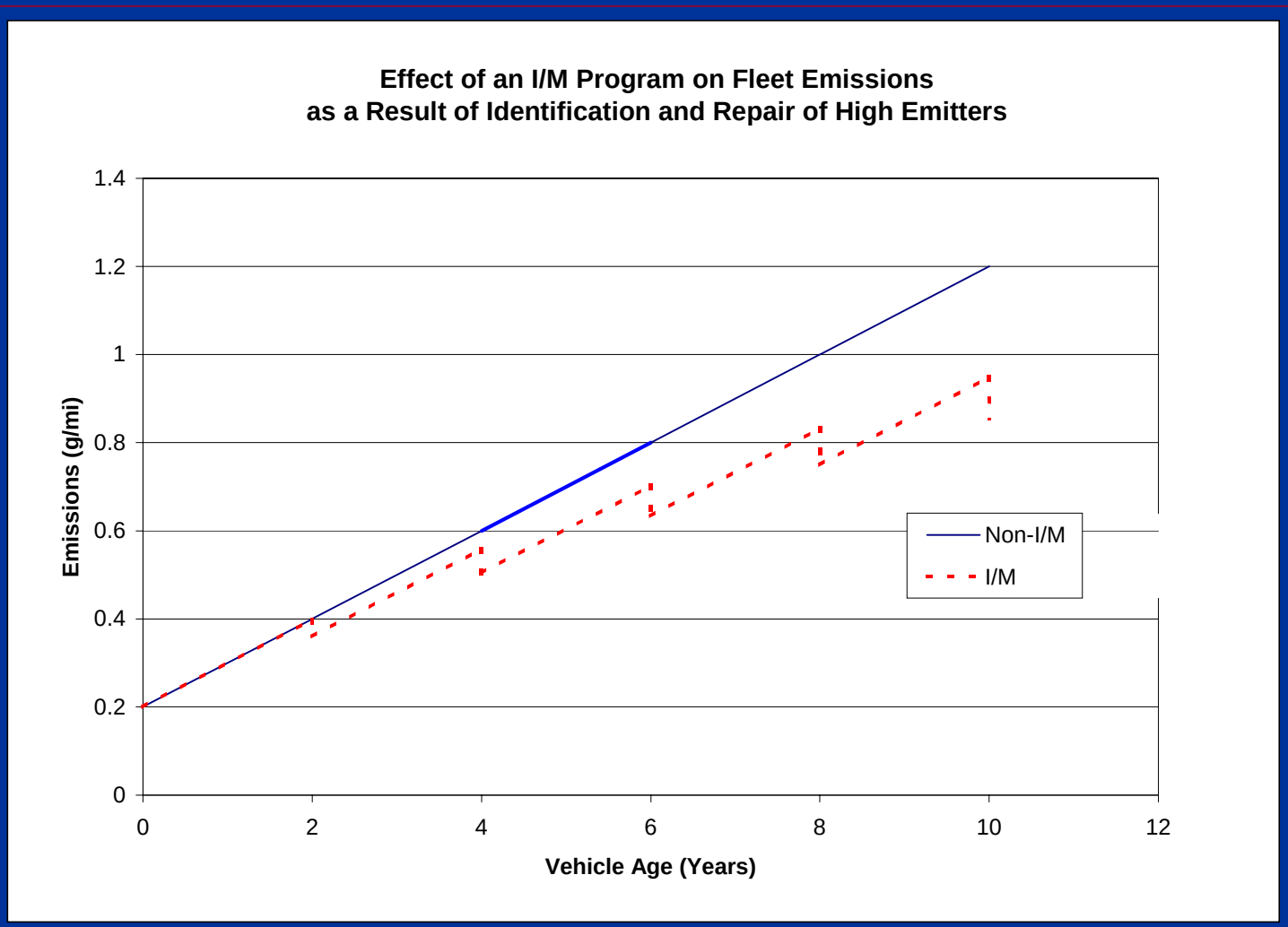
[a] Sample size is in parentheses.

- MOBILE6 GLL full-day diurnal emission rate (not including resting losses):
  - 104.36 g/day
  - GLL resting loss emission rate = 220 g/day

No video available in this version of presentation

MOBILE6 I/M Benefits Modeling

- The I/M benefits algorithm is built into MOBILE6 (no stand-alone model).
- The basic methodology is similar to MOBILE5 (i.e., high emitters are identified and repaired) but with only two emitter groups – normals and highs.
- Running LA4 and starting emissions are treated separately; I/M benefits are greater for running LA4 emissions.
- Credits are forecast in a sawtooth fashion representing repair and between-inspection deterioration.
- OBD II equipped vehicles are treated in I/M by assuming:
  - 85% of high emitters are identified;
  - 90% of them are repaired; and
  - after-repair level is equivalent to normal-emitter level, capped at 1.5 times the certification standard.


Effect of an I/M Program on Fleet Emissions
as a Result of Identification and Repair of High Emitters
Emissions (g/mi)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
Vehicle Age (Years)
Non-I/M
I/M

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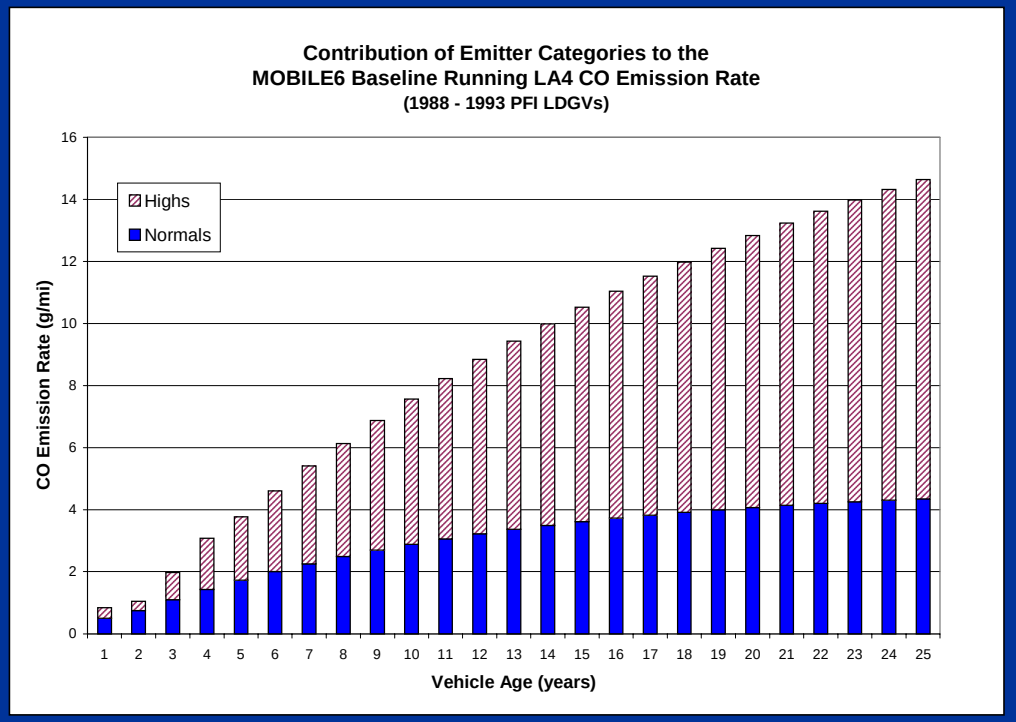
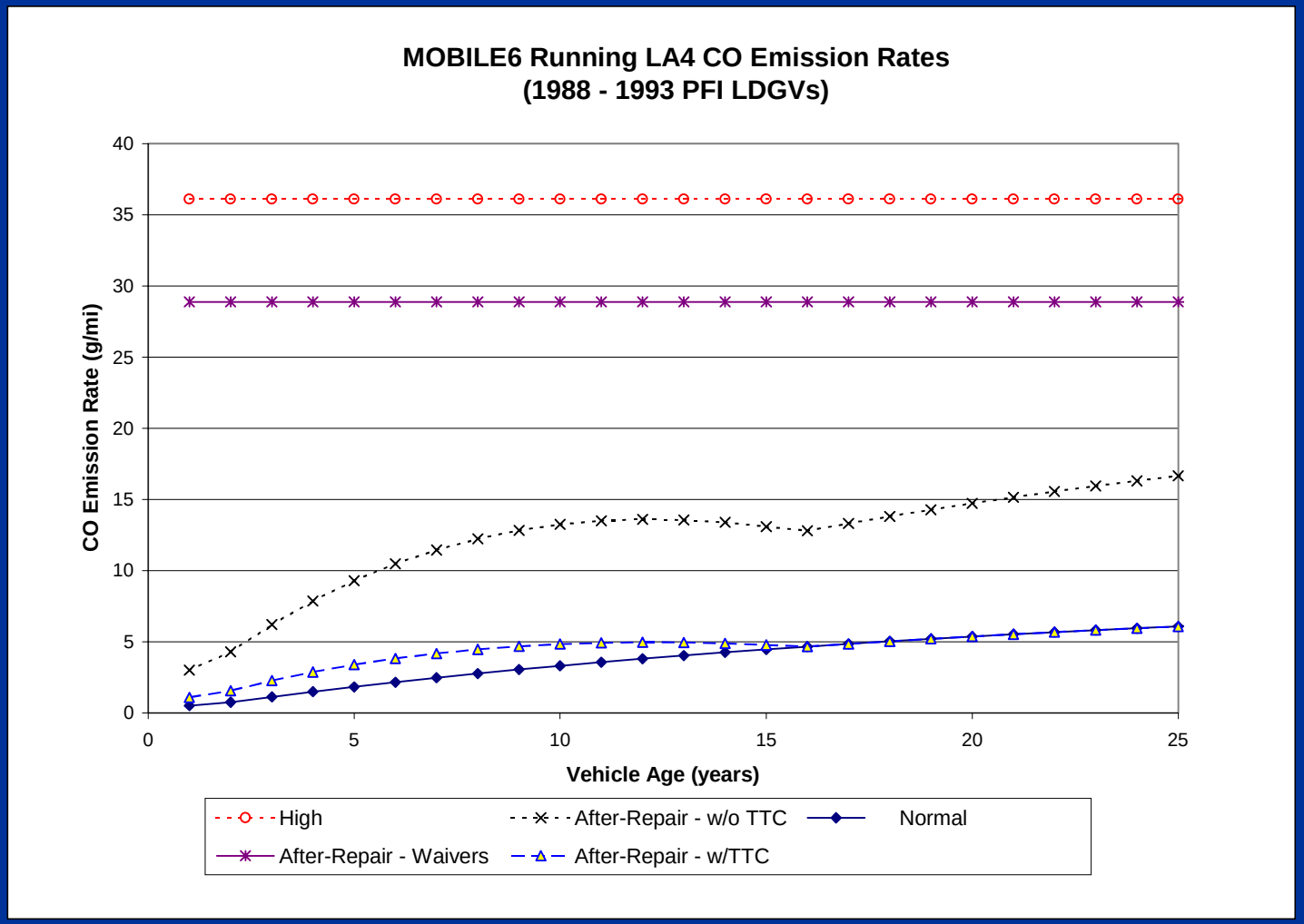
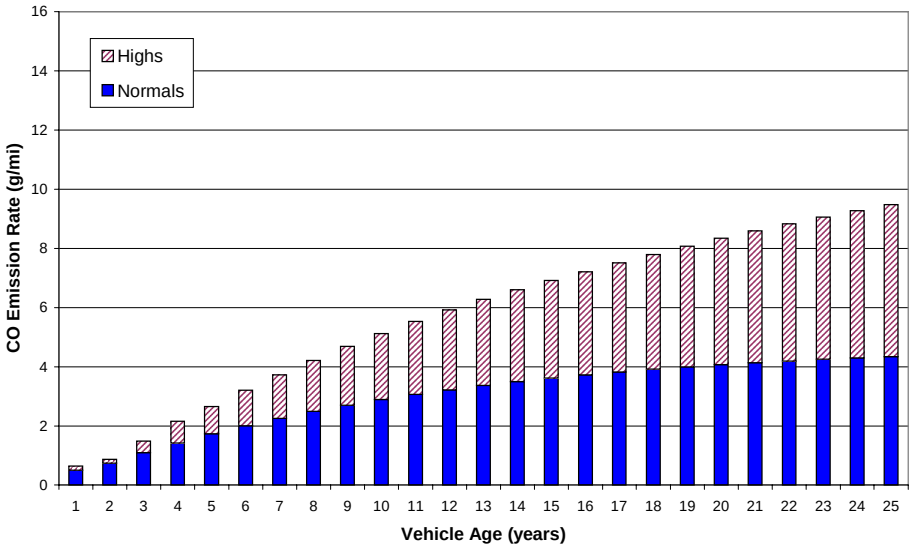


Fraction of LA4 High Emissions ID'd by IM240 Testing				
Pollutant	Cutpoint (g/mi)	Fraction ID'd	Cutpoint (g/mi)	Fraction ID'd
HC	1.2	0.80	0.8	0.89
CO	20	0.78	15	0.86
NOx	3	0.59	2	0.91

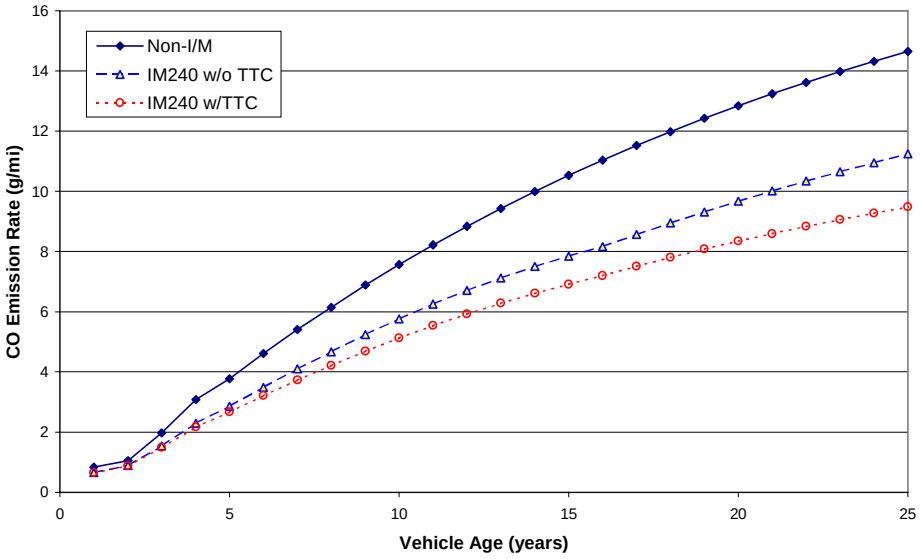

MOBILE6 Running LA4 CO Emission Rates
(1988 - 1993 PFI LDGVs)
CO Emission Rate (g/mi)
0
5
10
15
20
25
30
35
40
0
5
10
15
20
25
Vehicle Age (years)
High
After-Repair - w/o TTC
Normal
After-Repair - Waivers
After-Repair - w/TTC

No video available in this version of presentation

Contribution of Emitter Categories to the MOBILE6 After-I/M (with TTC) Running LA4 CO Emission Rate
(1988 - 1993 PFI LDGVs)



MOBILE6 Running LA4 CO Emissions
With and Without Technician Training and Certification Credits
(1988 - 1993 PFI LDGV)



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Evaporative Emissions I/M Modeling

- MOBILE5 and MOBILE6 are similar in treatment: pressure/purge failures are moved into the passing regime after repair.
- MOBILE5 has the following options:
  - visual cap check (part of ATP)
  - pressure testing
  - purge testing
- MOBILE6 has the following options:
  - visual cap check (part of ATP)
  - pressure testing
  - functional cap check
  - OBD II check
- MOBILE6 does not allow modeling of purge test benefits.

No video available in this version of presentation

EPA I/M Rule

- Required under the 1990 CAAA
- Finalized November 1992
- Established minimum performance standards for "basic" and "enhanced" areas
- Performance standards are based on a very specific set of MOBILE5 input parameters:

Input Parameter	Basic I/M	Enhanced I/M
Network:	Centralized	Centralized
Frequency:	Annual	Annual
Model Years:	1968+	1968+
Vehicle Types:	LDGV	LDGV,LDGT1,LDGT2
Emission Test(s):	Idle on 1968+	Idle on 1968-80 Idle/2500 on 81-85 IM240 on 1986+
Start Date:	1983/1994	1983/1995
Pressure Test:	None	1983+
Purge Test:	None	1986+
Visual Check:	None	Catalyst & Fuel Inlet
Pre-81 Stringency:	20%	20%
Pre-81 Waiver Rate:	0%	3%
Post-80 Waiver Rate:	0%	3%
Compliance Rate:	100%	96%

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EPA I/M Rule (Cont.)

- MOBILE5-based emission reductions from basic and enhanced performance standards (CY 2000):

I/M Scenario	Hydrocarbons[a]		Carbon Monoxide	
	g/mi	Reduction	g/mi	Reduction
No I/M	2.47	--	21.62	--
Basic I/M	2.28	8%	19.28	11%
Enhanced I/M	1.64	34%	13.83	36%

[a] Includes exhaust and all evaporative components except refueling losses.

- MOBILE6-based emission reductions from basic and enhanced performance standards (CY 2000):

I/M Scenario	Hydrocarbons[a]		Carbon Monoxide	
	g/mi	Reduction	g/mi	Reduction
No I/M	1.92	--	18.28	--
Basic I/M	1.84	4%	17.23	6%
Enhanced I/M	1.64	15%	15.30	16%

[a] Includes exhaust and all evaporative components except refueling losses.

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EPA I/M Rule (Cont.)

- I/M "flexibility" rule (September 1995) established "low-enhanced" and "high-enhanced" areas.
- Flexibility rule made it easier for enhanced areas to meet performance standard with decentralized testing.

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California Low-Emission Vehicle Program

- In 1990, CARB adopted the Low-Emission Vehicle (LEV) and Clean Fuel regulations.
- Established four levels of "low-emission" vehicles: TLEVs, LEVs, ULEVs, and ZEVs.

Category	NMOG (g/mi)	CO (g/mi)	NOx (g/mi)
1993 Conventional	0.25[a]	3.4	0.4
TLEV	0.125	3.4	0.4
LEV	0.075	3.4	0.2
ULEV	0.040	1.7	0.2
ZEV	0	0	0

[a] This is a non-methane hydrocarbon standard.

- By using a categorized fleet-average emissions approach, manufacturers were given some flexibility in meeting the standards.

No video available in this version of presentation

California LEVs (Cont.)

- Original California implementation schedule:

Model Year	Conventional (0.39)	Conventional (0.25)	TLEV (.125)	LEV (.075)	ULEV (.040)	ZEV[a] (0)	Fleet Ave. Std.
1994	10%	80%	10%				0.250
1995		85%	15%				0.231
1996		80%	20%				0.225
1997		73%		25%	2%		0.202
1998		48%		48%	2%	**2%**	0.157
1999		23%		73%	2%	**2%**	0.113
2000				96%	2%	**2%**	0.073
2001				90%	5%	**5%**	0.070
2002				85%	10%	**5%**	0.068
2003+				75%	15%	**10%**	0.062

[a] Percentage requirements for ZEVs are mandatory.

- A number of Northeast states have adopted California emission standards.
- The National LEV program was patterned after the California LEV program.

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National LEV Program (NLEV)

- Voluntary program in which CA LEVs are sold nationwide.
- Phase-in beginning in 1999 for Northeast states, nationwide in 2001.
- The following fleet-average NMOG standards were established for cars and light trucks under 6,000 lbs. GVWR:

MY	LDV	LDT
1999	0.148	0.190
2000	0.095	0.124
2001+	0.075	0.100

- EPA is preempted from requiring standards more stringent than Tier 1 until the 2004 model year.
- The NLEV program will be replaced by Tier 2 in 2004.

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Tier 2 Standards

- Fleet-average standard based on NOx; NMOG standards roughly equivalent to CA LEVs.
- Eight final and two interim standard "bins" were established, giving manufacters considerable flexibility in meeting the fleet-average NOx standard.
- All vehicles under 8,500 lbs. GVWR will eventually certify to the same fleet-average standards (as will "passenger vehicles" from 8,500 to 10,000 lbs.).
- Passenger cars and lighter light trucks (≤ 6,000 lbs. GVWR, LLDTs) are phased-in to meet a fleet-average 0.07 g/mi NOx level from 2004 - 2007.
- Heavier trucks (6,001 to 8,500 lbs., HLDTs) will meet 0.6 g/mi NOx in 2004; 0.2 g/mi NOx by 2007; and 0.07 g/mi NOx by 2009 (based on fleet-average).
- Evaporative standards are also reduced:

	3-Day DI+HS	2-Day DI+HS
LDVs+LLDTs	0.95 g/test	1.2 g/test
HLDTs	1.2 g/test	1.5 g/test

- Refiners must meet more stringent gasoline sulfur requirements that are phased-in between 2004 and 2007 (30 ppm nationwide required by 2007).

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On-Board Diagnostics

- Rudimentary systems were first implemented by GM on early1980s model year vehicles.
- OBD II regs were adopted by CARB in 1989; federal regulations were promulgated in 1993.
- Requires monitoring of all emissions-critical components on the vehicle; in the event of a malfunction, the malfunction indicator light (MIL) is illuminated and a fault code is stored.
- Phase-in began with the 1994 model year, but manufacturers did not have to enable the MIL for all faults until 1996.
- CARB requires a fault to be identified if the certification standard is exceeded by 1.5 times (1.75 for some LEV category vehicles).
- Federal rules include specific g/mi thresholds for certain components.
- As a practical matter, nearly all systems are certified to CARB's requirements (EPA accepts CARB certification).

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OBD II – Components Monitored

- Catalyst
- Misfire
- Evaporative control system
  - Purge flow
  - Leak check
- Secondary air system
- Fuel system
- Oxygen sensor
- EGR system
- PCV system (beginning in 2002)
- Thermostat monitoring (beginning in 2000)
- Comprehensive component monitoring – shall monitor any electronic powertrain component that provides input to or receives commands from the on-board computer and can affect emissions.

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III. MOBILE5 vs. MOBILE6

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Primary Revisions to MOBILE6

- LDV basic exhaust emission rates - Revised based on new data with different treatment of high emitters (no more emissions increase at 50,000 miles).
- Start emissions - Running exhaust and starting emissions for light-duty vehicles were separated, and a continuous start algorithm was incorporated.
- Speed/cycle corrections - New "inventory" cycles were developed based on chase car data collected over different roadway types and congestion levels.
- Inspection and maintenance - More I/M options are included in MOBILE6; TECH5 is no longer a stand-alone model.
- Gasoline fuel composition - Impact of variable sulfur level was included; oxy fuel effects were revised.
- Air conditioning - Emissions impact of air conditioner usage was incorporated.

No video available in this version of presentation

Primary Revisions to MOBILE6 (Cont.)

- Diurnal and resting losses - These evaporative rates were re-evaluated based on "real-time" test results.
- "Gross liquid leakers" - This class of emitters was added to the evap emissions algorithms.
- Heavy-duty vehicles - Emission and conversion factors were revised; impacts of "defeat devices" were incorporated.
- Fleet characterization - Default fleet characteristics were revised with more recent data (e.g., age dist, mileage accumulation, etc.).
- Trip characteristics - Defaults were revised based on instrumented vehicle data (e.g., trips per day, soak times, etc.).
- New emission standards - NLEV, Tier 2, and heavy-duty standards were built into MOBILE6.
- Idle emissions - Not explicitly calculated by MOBILE6.

NO
VIDEO

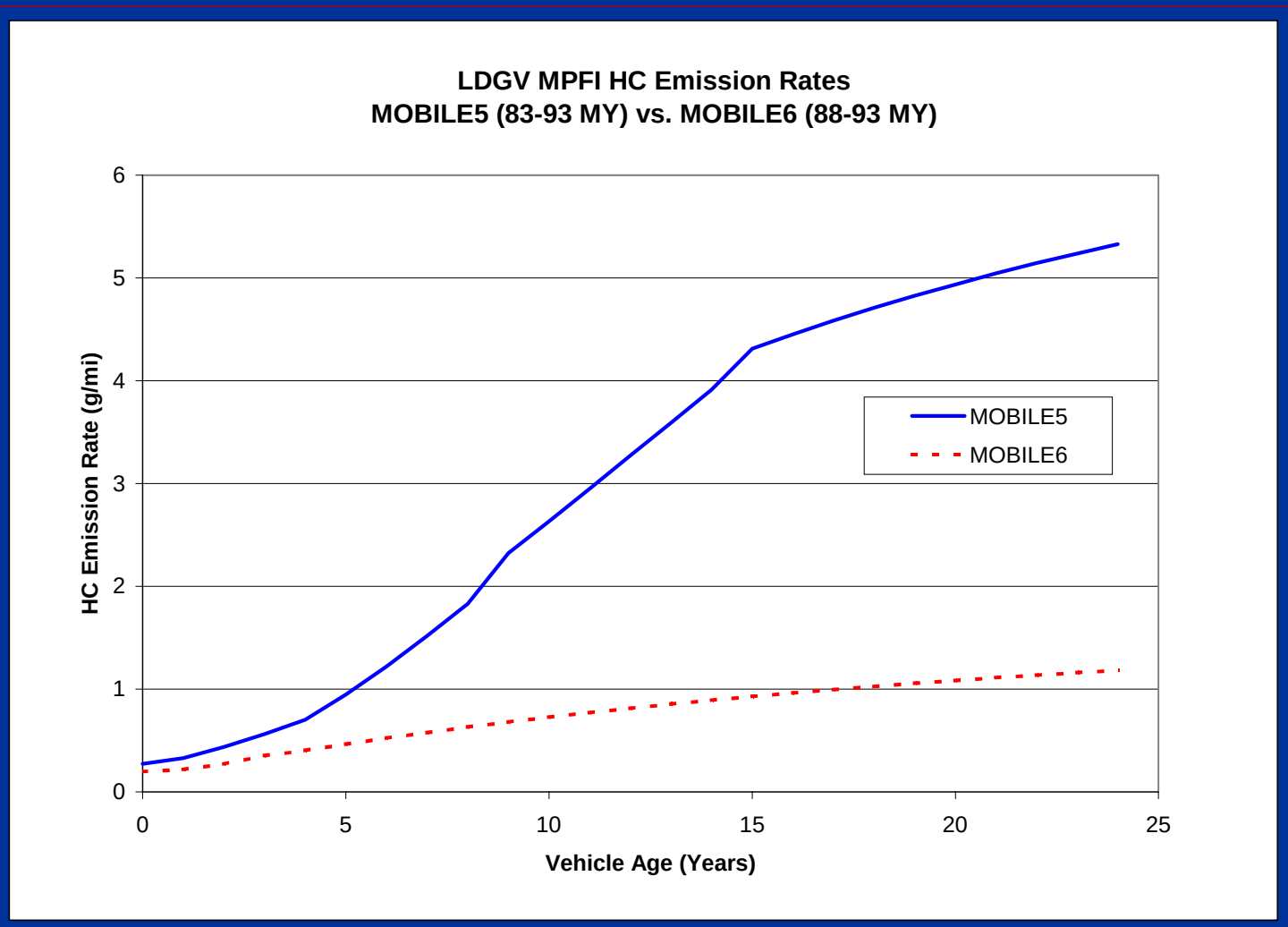
Differences Between MOBILE5 and MOBILE6

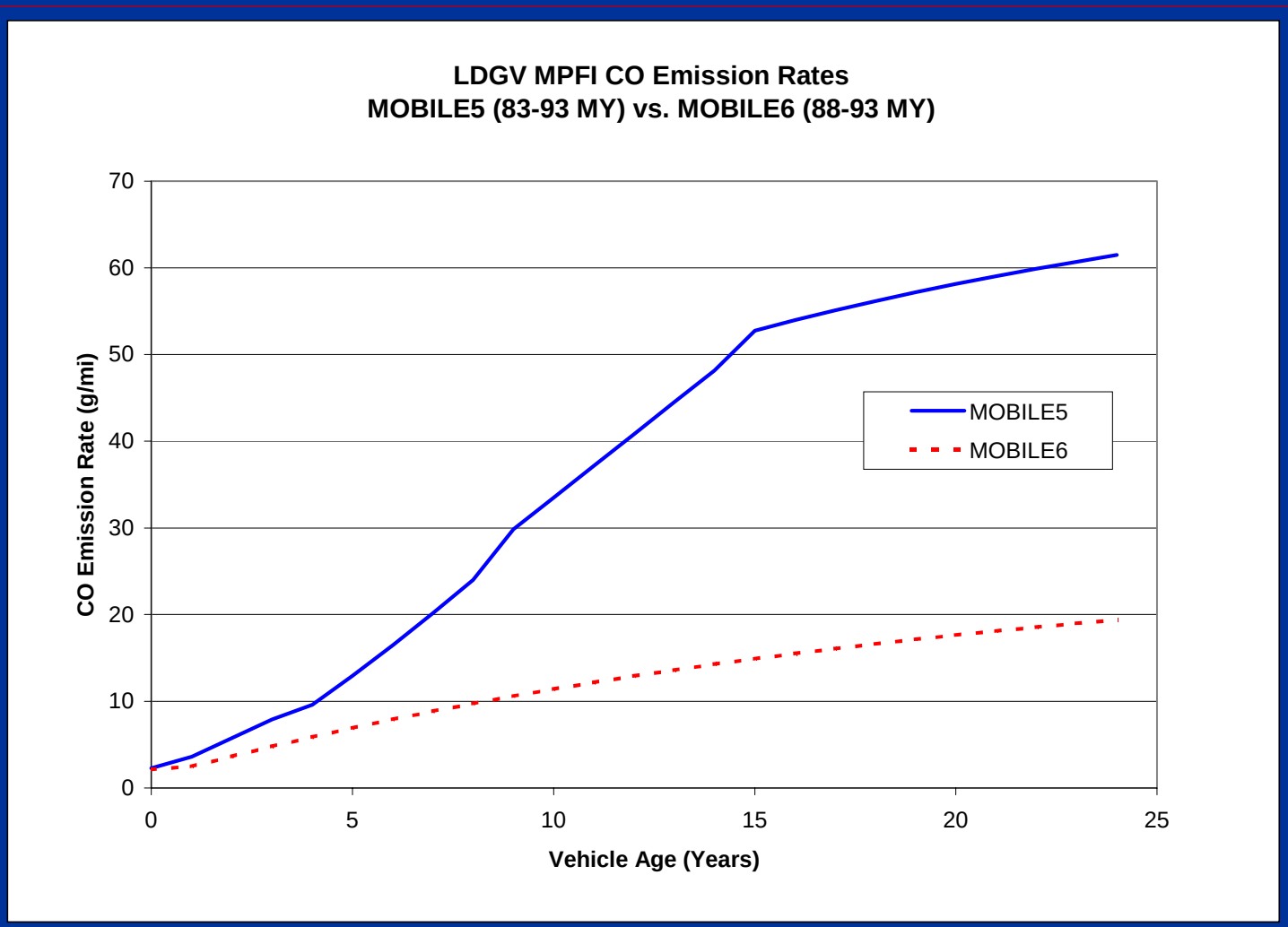
- Base Emission Rate Equations
- Treatment of Starting vs. Running Emissions
- Treatment of Vehicle Speed and Activity
- I/M Effects and Treatment of OBD
- Fuel Corrections
- Other Corrections

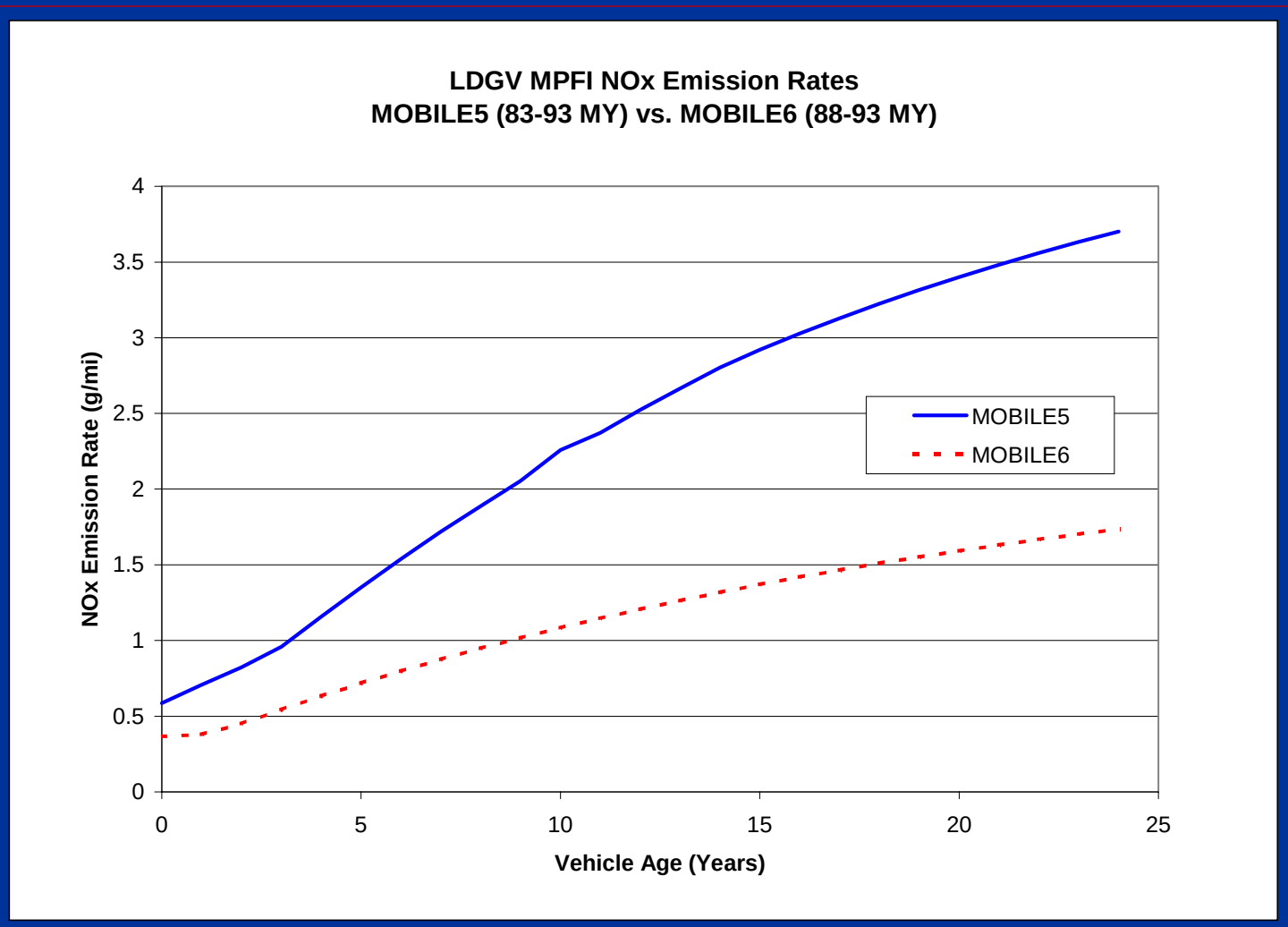
No video available in this version of presentation

Base Emission Rate Equations

- The base emission rate equations are substantially different in MOBILE6 relative to MOBILE5.
- Using new data and a different analysis methodology, emission control system deterioration is reduced in MOBILE6, particularly for 1988+ MY vehicles.
- Because of the lower baseline emission factors, the benefits of I/M (on a percentage basis) are much lower for MOBILE6 relative to MOBILE5.
- The revised BERs, coupled with some of the other new features of MOBILE6 (e.g., off-cycle impacts, which are controlled in the out-years), result in an increase in the rate at which emissions decrease over time relative to MOBILE5.


LDGV MPFI HC Emission Rates
MOBILE5 (83-93 MY) vs. MOBILE6 (88-93 MY)
HC Emission Rate (g/mi)
0
1
2
3
4
5
6
0
5
10
15
20
25
Vehicle Age (Years)
MOBILE5
MOBILE6


LDGV MPFI CO Emission Rates
MOBILE5 (83-93 MY) vs. MOBILE6 (88-93 MY)
CO Emission Rate (g/mi)
70
60
50
40
30
20
10
0
0
5
10
15
20
25
Vehicle Age (Years)
MOBILE5
MOBILE6


LDGV MPFI NOx Emission Rates
MOBILE5 (83-93 MY) vs. MOBILE6 (88-93 MY)
NOx Emission Rate (g/mi)
0
0.5
1
1.5
2
2.5
3
3.5
4
0
5
10
15
20
25
Vehicle Age (Years)
MOBILE5
MOBILE6

No video available in this version of presentation

Treatment of Start vs. Running Emissions

- MOBILE5 accounted for vehicle start emissions by virtue of how the bag weightings were specified; typically FTP weightings were used.
- MOBILE6 separates running exhaust from vehicle start emissions.
- Running emissions are corrected for speed; start emissions are corrected for soak time.
- Start emissions (calculated as an offset in g/trip) are converted to a g/mi basis as follows:

$$Start_{g/mi} = (Start_{g/trip} \times Trips/day) / (Miles/day)$$

- MOBILE6 reports a total g/mi value, but the user can specify an output option that separates running and starting emissions.
- Allows users more flexibility to model certain problems.

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Treatment of Vehicle Speed

- MOBILE5 included vehicle speed as a required user input.
- MOBILE5 did not distinguish among roadway types.
- MOBILE6 speed correction factors were developed for:
  - Freeways
  - Freeway ramps (single speed assumed)
  - Arterials
  - Local roads (single speed assumed)
- There is a default distribution of VMT by speed built into MOBILE6, but the user can specify an average speed or modify the distribution.
- Development of VMT by speed distribution estimates is likely to be one of the most difficult aspects of configuring MOBILE6 to reflect local conditions.

No video available in this version of presentation

MOBILE6 VMT Fractions

- As noted above, MOBILE6 does not require the user to enter an average speed.
- Instead, each MOBILE6 run calculates emission rates for:
  - 24 hourly periods
  - 4 roadway types
  - 14 speed bins (2.5, 5, 10, … 65 mph)
  - 28 vehicle classes (up from 8 in MOBILE5)
- For each hour, the model has default distributions of:
  - VMT fraction by roadway type (summing to 1 over the four roadway types for each hour and specified for each of the 28 vehicle classes)
  - VMT fraction by speed bin for freeways (summing to 1 for each hour)
  - VMT fraction by speed bin for arterials (summing to 1 for each hour).
- There is also a default distribution of VMT by hour (a 24-element array summing to 1) that is used to weight each of the hourly emissions estimates into a single value for the daily emission rate.

No video available in this version of presentation

I/M Effects and Treatment of OBD

- MOBILE5 included fairly detailed algorithms to estimate the impacts of I/M, including various exhaust (Idle, TSI, ASM, IM240) and evap (pressure/purge) tests.
- MOBILE5 did not, however, incorporate an algorithm to address OBD checks.
- MOBILE6 incorporates most of the features included in MOBILE5 (except for purge testing) and adds flexibility (e.g., grace period and I/M exemption age).
- MOBILE6 also includes the ability to change cutpoint level by model year.
- OBD I/M checks are modeled by assuming:
  - 85% of high emitters are identified (MIL on)
  - 90% of identified vehicles are repaired
- In non-I/M areas, the response to MIL illumination is a function of vehicle mileage:
  - 90% for 0 - 36,000 miles
  - 10% for 36,000 to 80,000 miles
  - 0% for over 80,000 miles

No video available in this version of presentation

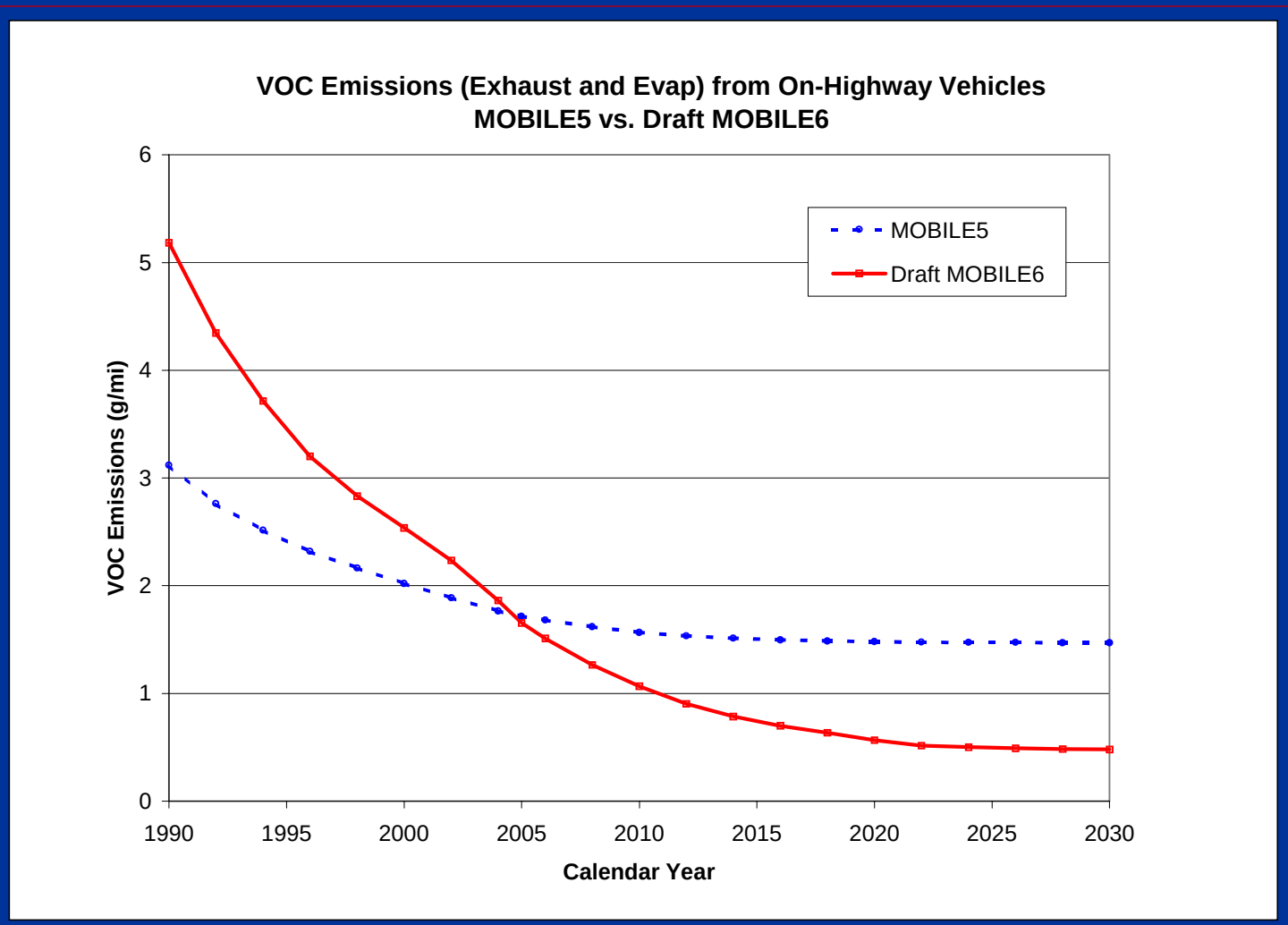
Fuel Corrections

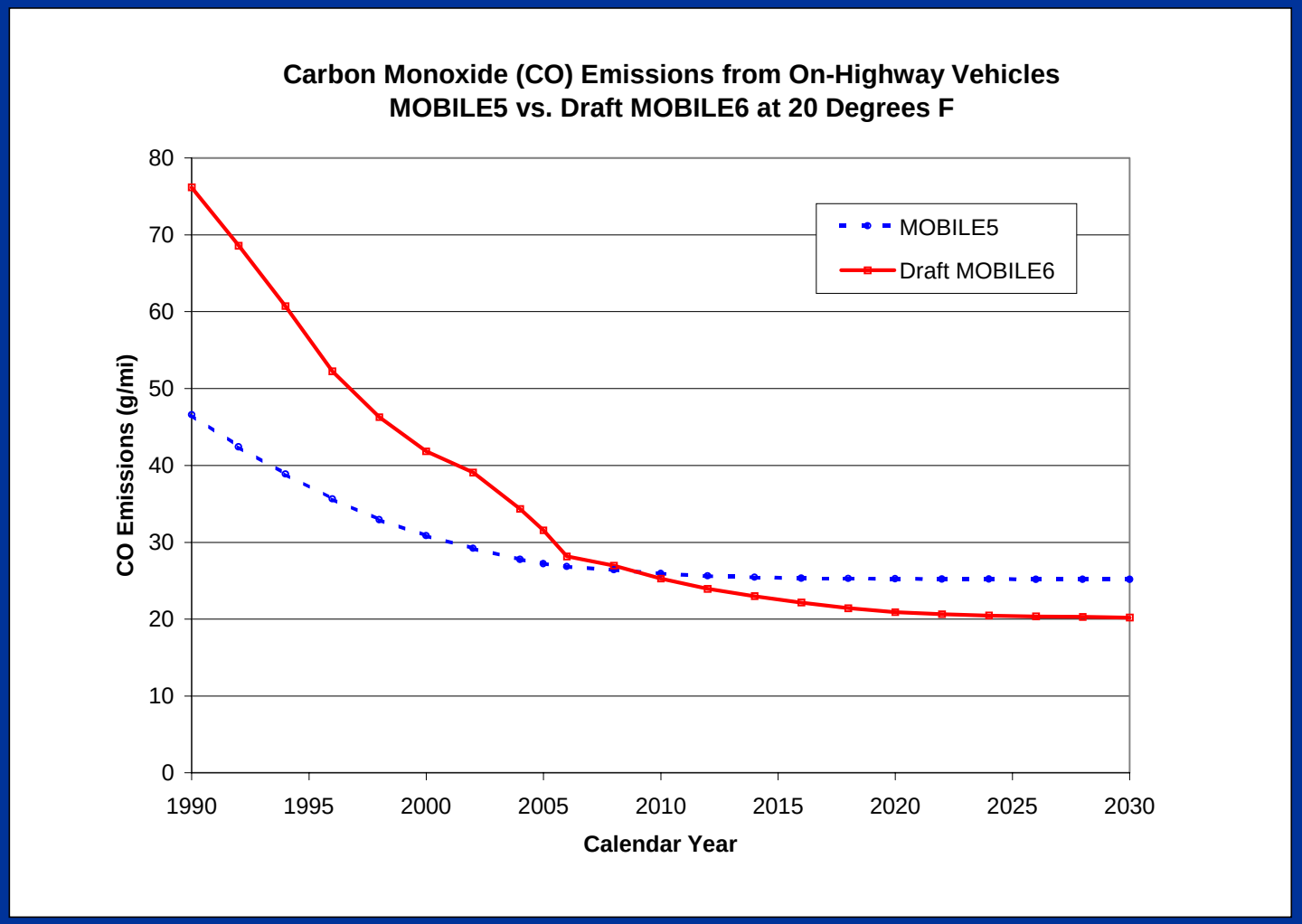
- MOBILE5 makes adjustments for the following fuel characteristics:
  - Certification to in-use
  - RVP (exhaust and evap)
  - Oxygenates
  - Reformulated gasoline (RFG)
- MOBILE6 also includes an adjustment for gasoline sulfur levels, including irreversibility effects.
- Modeling of oxygenated gasoline is significantly different between MOBILE5 and MOBILE6, with MOBILE6 predicting much lower benefit.

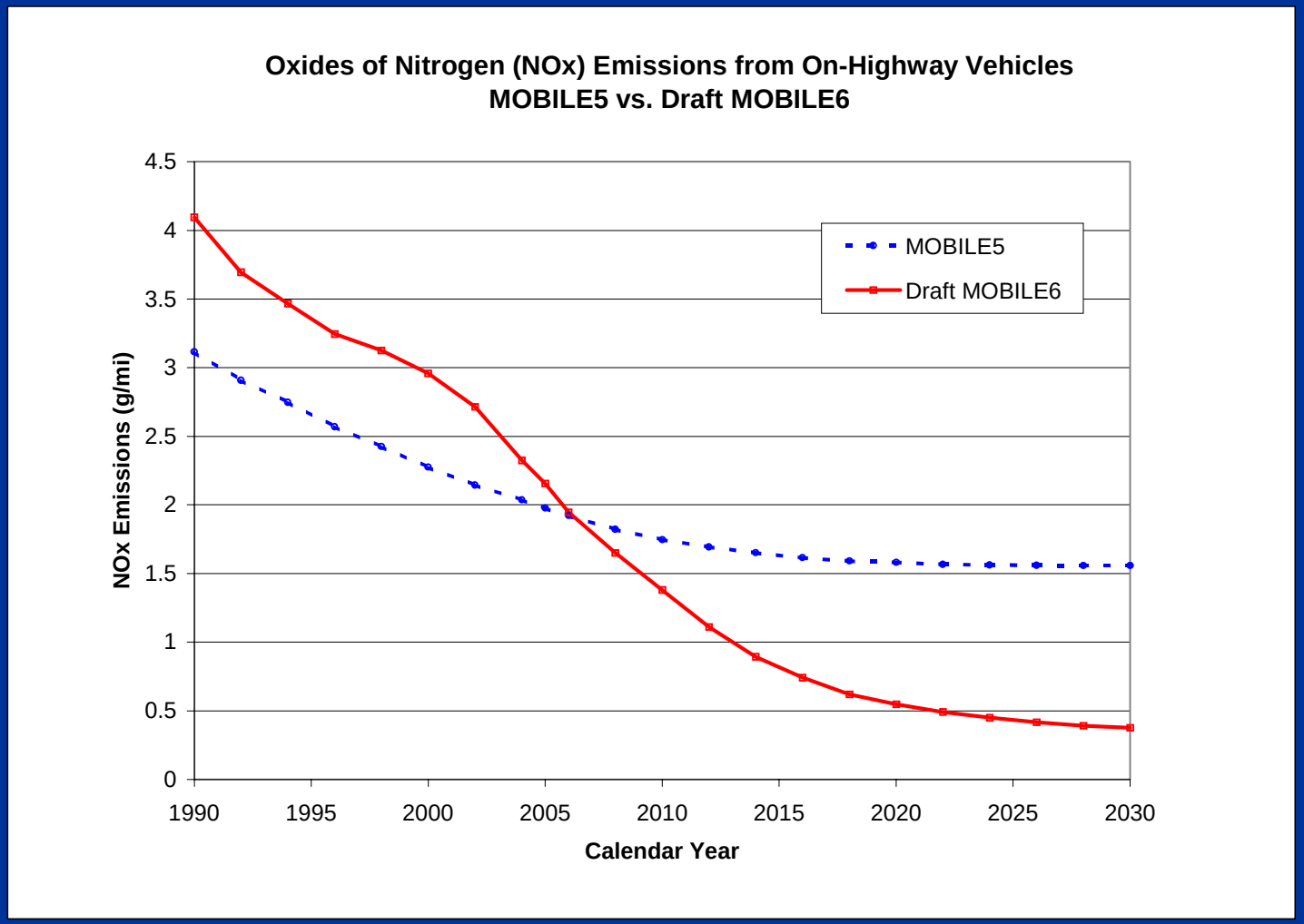
No video available in this version of presentation

Other Corrections

- Although MOBILE5 had an option to include the impacts of air conditioning and extra load, those adjustments were outdated and it was recommended that they not be used.
- MOBILE6 includes the emissions impacts of air conditioning usage based on data and algorithms developed to support the SFTP rulemaking.
- MOBILE6 also includes the impacts of aggressive driving, which are incorporated into the formulation of the speed correction factors.
- The emissions impacts of both aggressive driving and A/C usage decline in the future as SFTP standards are phased-in.


VOC Emissions (Exhaust and Evap) from On-Highway Vehicles
MOBILE5 vs. Draft MOBILE6
VOC Emissions (g/mi)
0
1
2
3
4
5
6
1990
1995
2000
2005
2010
2015
2020
2025
2030
Calendar Year
MOBILE5
Draft MOBILE6


Carbon Monoxide (CO) Emissions from On-Highway Vehicles
MOBILE5 vs. Draft MOBILE6 at 20 Degrees F
CO Emissions (g/mi)
0
10
20
30
40
50
60
70
80
1990
1995
2000
2005
2010
2015
2020
2025
2030
Calendar Year
MOBILE5
Draft MOBILE6


Oxides of Nitrogen (NOx) Emissions from On-Highway Vehicles
MOBILE5 vs. Draft MOBILE6
NOx Emissions (g/mi)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1990
1995
2000
2005
2010
2015
2020
2025
2030
Calendar Year
MOBILE5
Draft MOBILE6

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Summary of Overall Impacts

MOBILE6 emissions are higher than MOBILE5 in the past, lower in the future, because:

Higher	Lower
Off-cycle + A/C	SFTP Regulation
Sulfur Effects	Tier 2 Sulfur Limits
HDDV NOx (Defeat Device Issue)	Consent Decree HDDV 2007 Rule
Older Fleet (Age Dist.)	Better Durability
More LDTs/SUVs	Tier 2 Tailpipe Stds
Reduced Tailpipe I/M Benefits	OBD II Requirements

NO
VIDEO

IV. MOBILE6 OPERATION

No video available in this version of presentation

MOBILE6 Training Opportunities

- "User's Guide" and "Frequently Asked Questions" (FAQ) document (available on EPA's web site at http://www.epa.gov/otaq/m6.htm)
- This course and others like it, including materials prepared by EPA for the Colorado inventory conference (copies available on EPA's web site)
- All materials presented in this course will be posted on EPA's web site
- "Computer-Based Training" (CBT) on EPA's web site
- Most importantly: Run the model; make errors; repair errors; re-run the model.

No video available in this version of presentation

System Requirements

- IBM-compatible 80386 or better processor (i.e., Pentium)
- At least 5 megabytes of available RAM
- Math coprocessor chip
- DOS or Windows operating system
- Faster is better – Here are some benchmarks with a simple example (single CY, basic I/M program):

CPU	RAM (MB)	Run Time (min:sec)
486	8	14:20
P I-200	32	02:24
AMD K6-333	64	01:13
P II-266	32	00:52
P III-800	128	00:16
Duron-800	192	00:16

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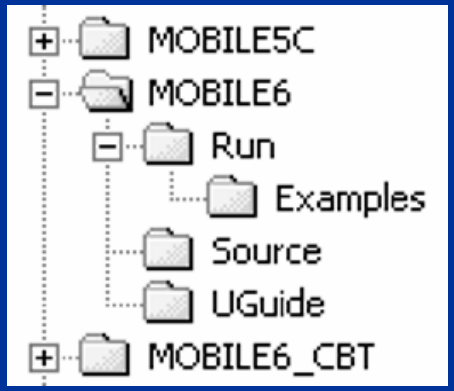
Basic Installation

- The draft MOBILE6 model has been released in a ZIP file with the following directory structure:



- Copy the ZIP file (M6ZIP.ZIP) onto the hard drive and unzip; the above directory structure will be established.

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Contents of Sub-Directories

- C:\MOBILE6
  - README.TXT, which contains brief instructions on how to run the model
- C:\MOBILE6\RUN
  - MOBILE6 executable and necessary external files (e.g., I/M credits); a sample MOBILE6 input file; sample data files (*.D and *.DEF)
- C:\MOBILE6\RUN\EXAMPLES
  - Example input/output files
- C:\MOBILE6\SOURCE
  - Source code (currently empty)
- C:\MOBILE6\UGUIDE
  - User's guide and FAQ document

No video available in this version of presentation

BASICS OF RUNNING MOBILE6

No video available in this version of presentation

Running MOBILE6
Input File Basics

- MOBILE6 is not interactive; an input file must be prepared.
- Input files **MUST**:
  - **Be in DOS text (ASCII) format**
  - **NOT contain TAB characters**
  - **NOT have a root name longer than 8 characters**
- Thus, to create input files:
  - Use a text editor (e.g., Notepad); or
  - Use a word processor and use the "Save As" command to save as a DOS text file (beware of auto-tabbing!).
- Recommendation:

  Use a non-proportional font (e.g., Courier) when creating input files. Although MOBILE6 is more forgiving than MOBILE5, inputs still need to be placed in the correct columns.

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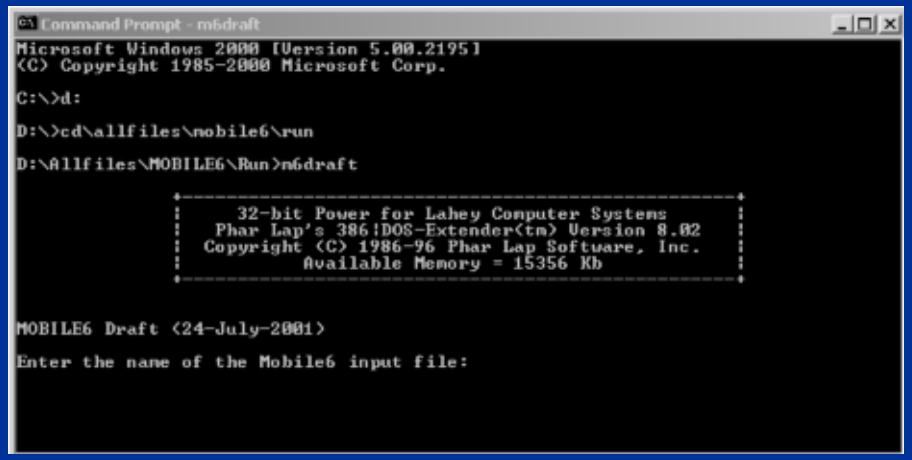
Running MOBILE6 Example

- Double-click on M6DRAFT.EXE from the Explorer window; or
- Open a DOS shell, move to the RUN directory, type M6DRAFT, and hit return.



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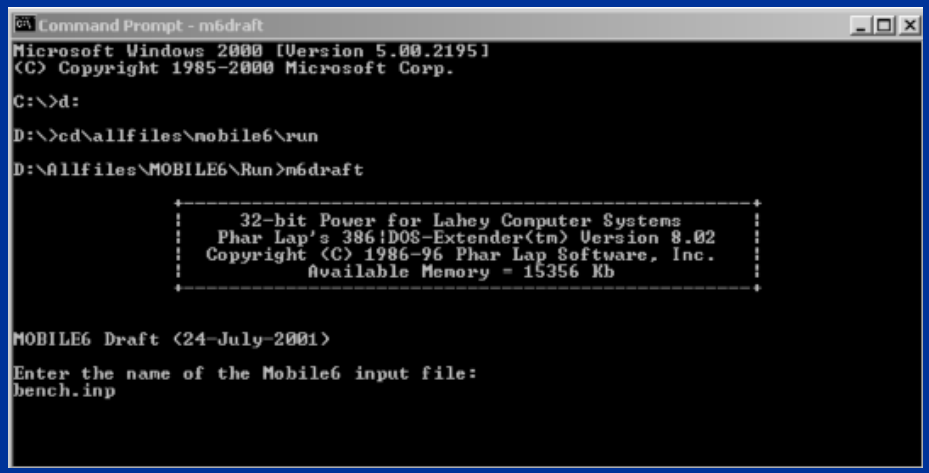
Running MOBILE6
Example

- Enter the input file name (need to include the path if in different directory than executable); or
- Drag the file into the DOS window.
- Hit return.



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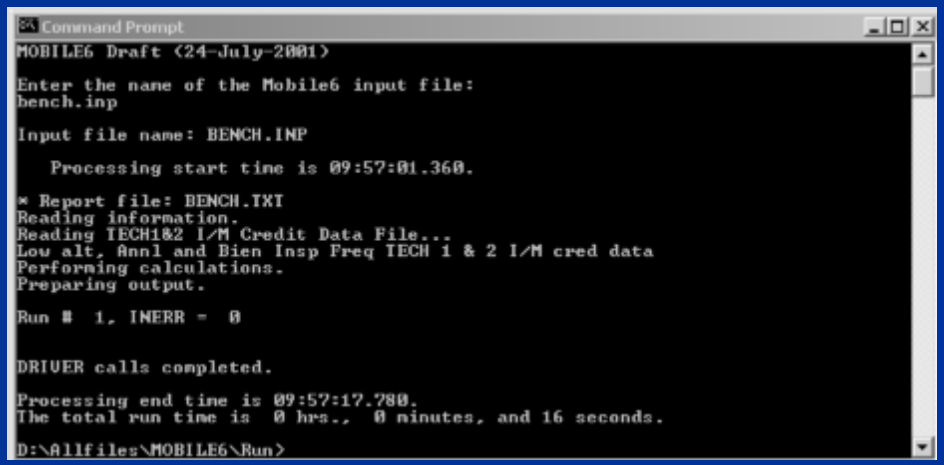
Running MOBILE6 Example

- Let the model run.
- The statement, "DRIVER calls completed," signifies that the run is finished.



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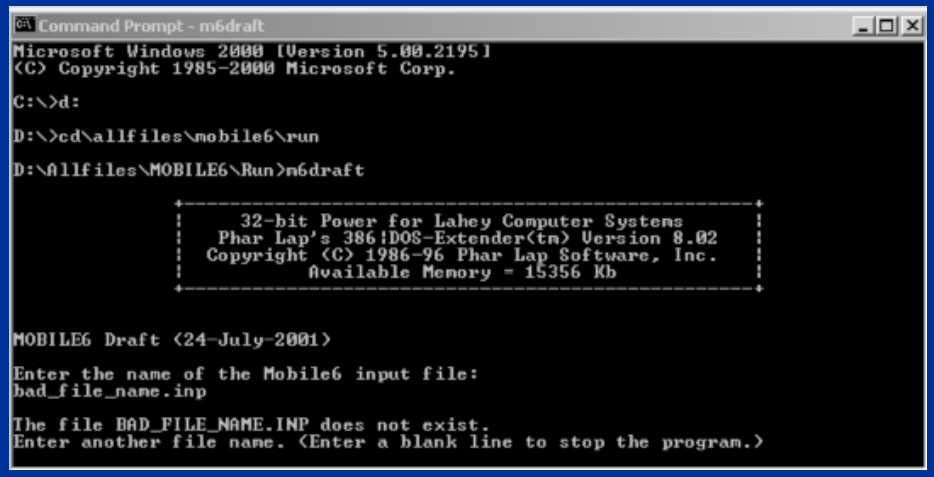
Running MOBILE6
Incorrect Input File Name

- If the file name is typed incorrectly, the model will prompt the user for a different file name:



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Input/Output File Specifics

- Input Files
  - Limited to 8 character root; 3 character extension.
  - If the input file is not in the same directory as the executable, the directory path must be explicitly entered (directories also limited to 8 characters).
  - If the *.IN extension is used, it does not need to be entered when running the model.
- Output Files
  - Default output file name has the same root name as the input file (user can specify different name).
  - Descriptive output has a *.TXT extension.
  - Database output has a *.TB1 extension.

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Output File Types

- Descriptive Output
  - Similar to the 112-column descriptive output in MOBILE5 (OUTFMT=3)
  - Can be printed or displayed with a text editor or word processor
  - Use Courier font
- Database Output
  - TAB-separated output that can be imported into spreadsheets and database applications

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Sample MOBILE6 Input File

```
* This is a test file for MOBILE6 input - Bench.inp
*
***************     Header Section     ****************
MOBILE6 INPUT FILE :

RUN DATA           :
***************     Run Section     ******************

> Basic I/M Program -- Idle Testing for MY68-MY95
I/M PROGRAM        : 1 1983 2020 1 T/O IDLE
I/M MODEL YEARS    : 1 1968 1995
I/M VEHICLES       : 1 22222 11111111 1
I/M STRINGENCY     : 1 20.0
I/M COMPLIANCE     : 1 96.0
I/M WAIVER RATES   : 1 3.0 3.0
NO I/M TTC CREDITS : 1


***************     Scenario Section     **************
SCENARIO RECORD    : Summer Basic I/M - CY2000


CALENDAR YEAR      : 2000
EVALUATION MONTH   : 7
MIN/MAX TEMP       : 72.0  92.0
FUEL RVP           : 8.7

***************     End of This Run     ***************
END OF RUN         :
```

Sample MOBILE6 Descriptive Output File

```
*************************************************************************
* MOBILE6 Draft (24-July-2001)                                          *
* Input file: D:\ALLFILES\MOBILE6\TEST\BENCH.INP (file 1, run 1).       *
*************************************************************************
* Basic I/M Program -- Idle Testing for MY68-MY95

* # # # # # # # # # # # # # # # # # # # # # # # # # # # #
* Summer Basic I/M - CY2000
* File 1, Run 1, Scenario 1.
* # # # # # # # # # # # # # # # # # # # # # # # # # # # #
*** I/M credits for Tech1&2 vehicles were read from the following external
    data file: TECH12.D
  M 48 Warning:
             there are no sales for vehicle class HDGV8b

                  Calendar Year:  2000
                          Month:  July
                       Altitude:  Low
             Minimum Temperature:  72.0 (F)
             Maximum Temperature:  92.0 (F)
               Absolute Humidity:   75. grains/lb
                Nominal Fuel RVP:   8.7 psi
                   Weathered RVP:   8.3 psi
             Fuel Sulfur Content:  300. ppm

             Exhaust I/M Program:  Yes
                Evap I/M Program:  No
                     ATP Program:  No
                Reformulated Gas:  No

      Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV      LDDV      LDDT      HDDV        MC   All Veh
             GVWR:                 <6000     >6000     (All)
                      ------    ------    ------    ------    ------    ------    ------    ------    ------    ------
  VMT Distribution:    0.4841    0.2894    0.0996              0.0358    0.0011    0.0016    0.0820    0.0063    1.0000
 -------------------------------------------------------------------------------------------------------------------------
Composite Emission Factors (g/mi):
    Composite VOC :      2.12      2.30      3.39      2.58      3.39      0.80      0.99      0.79      2.47     2.233
    Composite CO  :     16.39     21.65     29.80     23.74     33.93      1.78      1.72      4.10     16.57    18.831
    Composite NOX :      1.28      1.40      1.72      1.48      5.20      1.81      1.74     18.05      1.16     2.876
 -------------------------------------------------------------------------------------------------------------------------
```

Sample MOBILE6 Database Output File

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	FILE	RUN	SCEN	POL	VTYPE	ETYPE	FTYPE	AGE	GM_MILE	GM_DAY	STARTS	ENDS	MILES	MPG	FACVMT	REGDIST	VCOUNT	MYR
2	1	1	1	1	1	1	1	7	0.234	6.783	7.28	5.38	29.04	22.64	0.3421	0.0831	110.8046	1995
3	1	1	1	1	1	1	2	7	0.208	6.043	7.28	5.38	29.04	22.64	0.4978	0.0831	110.8046	1995
4	1	1	1	1	1	1	3	7	0.289	8.378	7.28	5.38	29.04	22.64	0.1305	0.0831	110.8046	1995
5	1	1	1	1	1	1	4	7	0.335	9.719	7.28	5.38	29.04	22.64	0.0297	0.0831	110.8046	1995
6	1	1	1	1	1	2	5	7	0.179	5.195	7.28	5.38	29.04	22.64	1	0.0831	110.8046	1995
7	1	1	1	1	1	5	5	7	0.092	2.664	7.28	5.38	29.04	22.64	1	0.0831	110.8046	1995
8	1	1	1	1	1	8	5	7	0.035	1.028	7.28	5.38	29.04	22.64	1	0.0831	110.8046	1995
9	1	1	1	1	1	3	5	7	0.090	2.622	7.28	5.38	29.04	22.64	1	0.0831	110.8046	1995
10	1	1	1	1	1	4	5	7	0.020	0.583	7.28	5.38	29.04	22.64	1	0.0831	110.8046	1995
11	1	1	1	1	1	7	5	7	0.010	0.299	7.28	5.38	29.04	22.64	1	0.0831	110.8046	1995
12	1	1	1	1	1	6	1	7	0.225	6.523	7.28	5.38	29.04	22.64	0.3421	0.0831	110.8046	1995
13	1	1	1	1	1	6	2	7	0.266	7.713	7.28	5.38	29.04	22.64	0.4978	0.0831	110.8046	1995
14	1	1	1	1	1	6	3	7	0.643	18.67	7.28	5.38	29.04	22.64	0.1305	0.0831	110.8046	1995
15	1	1	1	1	1	6	4	7	0.234	6.802	7.28	5.38	29.04	22.64	0.0297	0.0831	110.8046	1995
16	1	1	1	1	2	1	1	7	0.235	8.158	8.06	5.75	34.73	16.87	0.3421	0.0731	14.4963	1995
17	1	1	1	1	2	1	2	7	0.214	7.426	8.06	5.75	34.73	16.87	0.4978	0.0731	14.4963	1995
18	1	1	1	1	2	1	3	7	0.300	10.419	8.06	5.75	34.73	16.87	0.1305	0.0731	14.4963	1995
19	1	1	1	1	2	1	4	7	0.343	11.908	8.06	5.75	34.73	16.87	0.0297	0.0731	14.4963	1995
20	1	1	1	1	2	2	5	7	0.183	6.346	8.06	5.75	34.73	16.87	1	0.0731	14.4963	1995
21	1	1	1	1	2	5	5	7	0.077	2.664	8.06	5.75	34.73	16.87	1	0.0731	14.4963	1995
22	1	1	1	1	2	8	5	7	0.048	1.65	8.06	5.75	34.73	16.87	1	0.0731	14.4963	1995
23	1	1	1	1	2	3	5	7	0.071	2.463	8.06	5.75	34.73	16.87	1	0.0731	14.4963	1995
24	1	1	1	1	2	4	5	7	0.017	0.583	8.06	5.75	34.73	16.87	1	0.0731	14.4963	1995
25	1	1	1	1	2	7	5	7	0.014	0.499	8.06	5.75	34.73	16.87	1	0.0731	14.4963	1995
26	1	1	1	1	2	6	1	7	0.225	7.82	8.06	5.75	34.73	16.87	0.3421	0.0731	14.4963	1995
27	1	1	1	1	2	6	2	7	0.251	8.723	8.06	5.75	34.73	16.87	0.4978	0.0731	14.4963	1995
28	1	1	1	1	2	6	3	7	0.646	22.445	8.06	5.75	34.73	16.87	0.1305	0.0731	14.4963	1995
29	1	1	1	1	2	6	4	7	0.216	7.515	8.06	5.75	34.73	16.87	0.0297	0.0731	14.4963	1995

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MOBILE6 INPUT FILE DEVELOPMENT

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"Bare Bones" MOBILE6 Input File

```
1234567890123456789012345678901234567890123456789012...
MOBILE6 INPUT FILE
RUN DATA
SCENARIO RECORD    : The Title Goes Here
CALENDAR YEAR      : 2000
MIN/MAX TEMP       : 72.0  92.0
FUEL RVP           : 8.7
END OF RUN
```

Items to Note:

- Columns 1 to 19 contain "Command Names."
- By convention, column 20 contains a colon when data are input but is not required; column 21 is left blank.
- Columns 22-150 contain specific inputs that are either free-format or fixed-format, depending on the entry:
  - In free-format, the data values are entered into any column, but must be separated by a blank space.
  - In fixed-format, the inputs follow Fortran formatting rules.
- The seven lines reflected in the input file above are the **only required inputs** for a MOBILE6 run.

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Compare That to a MOBILE5 Input File

```
1          PROMPT - no prompting
Bare Bones MOBILE5 Run
1          TAMFLG - default tampering rates
1          SPDFLG - one speed per scenario for all IV
1          VMFLAG - default VMT mix
1          MYMRFG - default reg. distributions and MAR
1          NEWFLG - default BERs
1          IMFLAG - no I/M program
1          ALHFLG - no additional correction factor inputs
1          ATPFLG - no anti-tampering program
5          RLFLAG - zero out refueling emissions
1          LOCFLG - different LAP rec for each scenario
1          TEMFLG - ambient temperatures calc'd by model
3          OUTFMT - 112 column descriptive output format
4          PRTFLG - print HC, CO and NOx emission factors
1          IDLFLG - do not print idle emissions results
3          NMHFLG - calculate VOC emissions
3          HCFLAG - print detailed HC emission factors
1 00 19.6 86.0 20.6 27.3 20.6
Summer No I/M    C 72.0 92.0 10.1  8.7 89
```

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MOBILE6 Input File Structure

- MOBILE6 input files are broken up into three sections:
  - HEADER
  - RUN
  - SCENARIO
- Certain commands can only be placed in one of these three sections.
- An END OF RUN command appears at the end to mark the end of the run and to separate multiple runs.
- Our input file above becomes:

```
**********   Header Section   **********
MOBILE6 INPUT FILE :

RUN DATA           :
**********    Run Section     **********

********** Scenario Section   **********
SCENARIO RECORD    : The Title Goes Here
CALENDAR YEAR      : 2000
MIN/MAX TEMP       : 72.0  92.0
FUEL RVP           : 8.7

**********  End of This Run   **********
END OF RUN         :
```

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MOBILE6 Input File Structure
Separator Commands

- The commands

```
MOBILE6 INPUT FILE (for regular input files)
MOBILE6 BATCH FILE (for batch input files)
RUN DATA
SCENARIO RECORD
END OF RUN
```

  are known as "Separator Commands" because they mark the beginning or end of an input file, and/or establish the start or end of a HEADER, RUN, or SCENARIO section.

- The first command in each MOBILE6 input file **MUST** begin with either of the following:

```
MOBILE6 INPUT FILE (for regular input files)
MOBILE6 BATCH FILE (for batch input files)
```

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MOBILE6 Input File Structure
Comment Lines

- Blank lines and comment lines are disregarded by the program, and should be used liberally in your input file development.
- Comment lines are distinguished by:
  - "*" in the first column for non-printed comments
  - ">" in the first column for comments printed on the output file

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MOBILE6 Input File Structure
Multiple Runs

For multiple runs, the following input file structure is adopted:

Header Section

Run Section #1

Scenario Section #1-1
Scenario Section #1-2
Scenario Section #1-n

Run Section #2

Scenario Section #2-1
Scenario Section #2-2
Scenario Section #2-n

Run Section #m

Scenario Section #m-1
Scenario Section #m-2
Scenario Section #m-n

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Sample Input File for Multiple Run Sections

```
*********     Header Section      *************
MOBILE6 INPUT FILE :

RUN DATA            :
*********     Run Section #1      *************
MIN/MAX TEMP        : 72.0  92.0
FUEL RVP            : 8.7

*********     Scenario Section #1  ************
SCENARIO RECORD     : Run #1 - Scenario #1
CALENDAR YEAR       : 2000

SCENARIO RECORD     : Run #1 - Scenario #2
CALENDAR YEAR       : 2010

*********     End of Run #1       *************
END OF RUN          :


*********     Run Section #2      *************
MIN/MAX TEMP        : 72.0  92.0
FUEL RVP            : 6.7

*** *****     Scenario Section #2  ************
SCENARIO RECORD     : Run #2 - Scenario #1
CALENDAR YEAR       : 2000

SCENARIO RECORD     : Run #2 - Scenario #2
CALENDAR YEAR       : 2010
*********     End of Run #2       *************
END OF RUN          :
```

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MOBILE6 Input File Structure
Batch Files

- The format for batch input files is very simple:

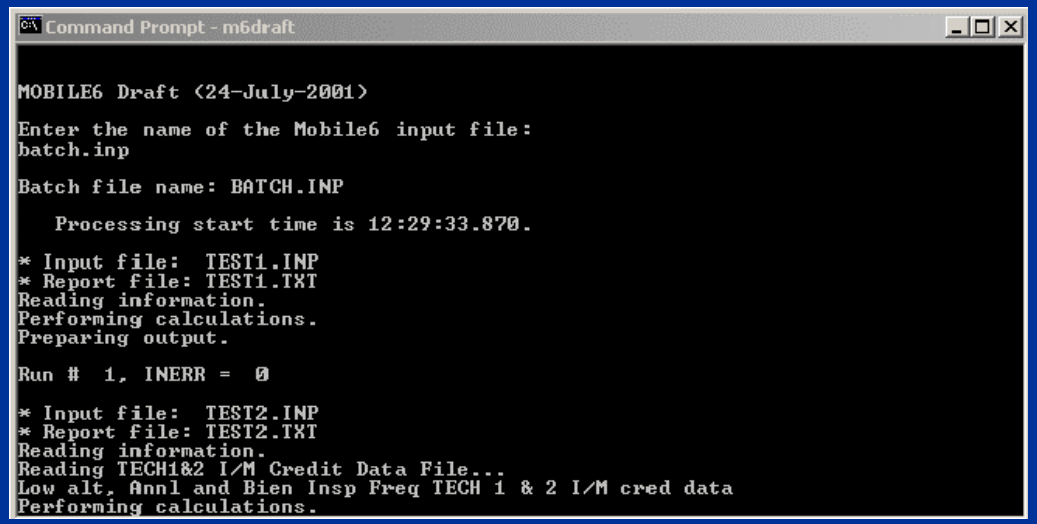
```
* Sample MOBILE6 Batch File
* Begin with batch file command

MOBILE6 BATCH FILE

* Now enter the input file names

Test1.inp
Test2.inp
Test3.inp d:\allfiles\m6\runs\test3
    .
    .
    .
```

- The run looks like this:



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MOBILE6 INPUTS AND COMMANDS

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Summary of MOBILE6
Required and Optional User Inputs

Required Inputs	
Parameter	Comments
Min/Max or Hourly Temperatures	Used to estimate TCF temp, evap temps, diurnal emissions.
RVP	Gasoline volatility.
Calendar Year	Range: 1955 to 2050.

Optional Inputs/Features	
Parameter	Comments
Output Options:	
Reporting HC Results	HC can be reported as THC, NMHC, VOC, TOG, NMOG
Specify Pollutant(s) to Print	HC, CO, and/or NOx can be printed.
Expanded Exhaust/Evap Results	Allows more detail to be output.
Expanded LDT/HDT/Bus Results	Allows more detail to be output.
Database Output	Allows for MY-specific and other detailed output.
Activity Parameters:	
VMT Mix by Veh Type	User may input locally derived VMT mix.
Alternate VMT Distribution by Hour	Takes the place of average speed.
Alternate VMT Distribution by Facility Type	Takes the place of average speed.
VMT by Speed Distribution	Takes the place of average speed.
Average Speed	"New" command in MOBILE6
Starts per Day	Alternate number of starts by hour of day.
Start Distribution	Alternate distribution of starts by hour of day.
Soak Time Distribution	Alternate distribution of hot soaks by hour of day.
Hot Soak Activity	Alternate distribution of hot soak length.
Diurnal Soak Activity	Alternate distribution of diurnal soak times.
Trip Length Dist - Weekend and Weekday	Used in estimating running loss emissions.
Weekend vs Weekday Activity	User can specify activity type, depending on need.
Fleet Characteristics:	
Registration Distribution	User may input locally derived registration distribution.
Mileage Accumulation	User may input locally derived mileage accumulation rates.
Alternate Diesel Sales Fraction	User may input locally derived LDV Diesel registration info.
NGV Fractions	User may specify a fraction of natural gas vehicles.
External Conditions:	
Month of Evaluation	Jan or Jul - choice based on winter or summer evaluation.
Altitude	Low/high altitude - low is default.
Humidity	Used for A/C calculations and impacts exhaust NOx.
Cloud Cover	Used primarily for A/C calculations.
Peak Sun	Used primarily for A/C calculations.
Sunrise/Sunset	Used primarily for A/C calculations.
Fuels Options:	
Reformulated Gasoline	Effects of reformulated gasoline can be included.
Gasoline Sulfur Level	Local data on gasoline sulfur level can be entered.
Oxygenated Fuels	Ether/alcohol market share and oxygen content required.
State Programs:	
I/M Program	Idle, Idle/2500, ASM, and IM240 tests included in MOBILE5.
Anti-Tampering Program	Effects of an anti-tampering program can be included.
Functional Pressure/Cap Check	Effects of a functional evap system check can be included.
Refueling Emissions	Uncontrolled, with Stage II, with on-board, or zeroed.
Miscellaneous Options:	
Disable CAAA Requirements	Cold CO, Tier 1 and 2, and evap benefits can be disabled.
Tier 1/Tier 2/LEV Implementation	Implemenation and emission rates can be modified.
HDDV Defeat Device Parameters	Inputs to the defeat device emissions calcs can be modified.
2007 HDDV Rule Disablement	Disables the impacts of this regulation.

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MOBILE6 Command Structure

- All of the preceding inputs and features are "enabled" with a command.
- Depending on the specific command, it is placed in the HEADER section, the RUN section, or the SCENARIO section of the input file.
- Command names are entered in columns 1-19, column 20 is a colon, column 21 is blank, and command data are entered in columns 22 - 150:

```
         1         2         3         4
1234567890123456789012345678901234567890123:

SCENARIO RECORD    : The Title Goes Here
CALENDAR YEAR      : 2000
MIN/MAX TEMP       : 72.0  92.0
FUEL RVP           : 8.7
```

- Some commands do not need data, while others have data entered below the command, and still others reference an external data file.
- Refer to the User's Guide for a complete description of each command.

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MOBILE6 Command Structure

- Commands requiring no data:

```
         1         2         3         4
1234567890123456789012345678901234567890123...
EXPAND EVAPORATIVE :
EXPRESS HC AS TOG  :
```

- Commands requiring input on same line:

```
         1         2         3         4
1234567890123456789012345678901234567890123...
POLLUTANTS         : HC NOX
SULFUR CONTENT     : 230.0
```

- Command requiring input below the command:

```
         1         2         3         4
1234567890123456789012345678901234567890123...
STAGE II REFUELING :
89 3 92. 84.
```

- Commands requiring an external data file:

```
         1         2         3         4
1234567890123456789012345678901234567890123...
VMT BY HOUR        : HVMT.DEF
REG DIST           : REGDATA.D
```

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MOBILE6 Command Structure
Location of Commands

- Recall the three input file sections:
  - HEADER
  - RUN
  - SCENARIO
- Some commands can be placed only in specific sections.
- Other commands may be placed in either the RUN or SCENARIO sections.
- Commands can occur more than once in a section, but only the last occurrence is used in the calculations.

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Data Entry Format

- Free Format
  - New for MOBILE6, allows data to be entered into any column in the data space, with values separated by spaces or single commas.
  - Allows data to be entered onto more than one data line.
- Fixed Format
  - Typical input format for MOBILE5, used for some inputs in MOBILE6.
  - Specifies precisely in which columns data must be placed.
  - Specifies the form of the data (real, integer).
  - Follows Fortran convention.

Required MOBILE6 Inputs

Parameter	Comments
Min/Max or Hourly Temperatures	Used to estimate TCF temp, evap temps, diurnal emissions.
RVP	Gasoline volatility.
Calendar Year	Range: 1955 to 2050.

Summary of MOBILE6 Required Commands

MOBILE6 Command	Header/ Run/ Scenario?	Comment
`MOBILE6 INPUT FILE`	H	First Line of Input File
`RUN DATA`	H	Ends Header/Begins Run
`SCENARIO RECORD`	S	Begins Scenario Section
`CALENDAR YEAR : 2000`	S	Calendar Year of Analysis
`FUEL RVP : 8.7`	R/S	Gasoline RVP (in psi)
`MIN/MAX TEMP : 72.0 92.0`	R/S	Min/Max Daily Temperature
`HOURLY TEMPERATURES: 72.0 73.0 74.5 76.5`	R/S	Hourly Temp (24 Entries)
`END OF RUN :`	R	Marks the End of the Run Section

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Sample MOBILE6 Input File
Required Inputs

```
**********   Header Section   **********
MOBILE6 INPUT FILE :

RUN DATA           :
**********    Run Section     **********
MIN/MAX TEMP       : 72.0  92.0
FUEL RVP           : 8.7

********** Scenario Section   **********
SCENARIO RECORD    : CY 1990 Run
CALENDAR YEAR      : 1990

SCENARIO RECORD    : CY 2000 Run
CALENDAR YEAR      : 2000

SCENARIO RECORD    : CY 2010 Run
CALENDAR YEAR      : 2010

SCENARIO RECORD    : CY 2020 Run
CALENDAR YEAR      : 2020

**********  End of This Run   **********
END OF RUN         :
```

Optional MOBILE6 Inputs and Features
Output Options

Parameter	Comments
Output Options:	
Reporting HC Results	HC can be reported as THC, NMHC, VOC, TOG, NMOG
Specify Pollutant(s) to Print	HC, CO, and/or NOx can be printed.
Expanded Exhaust/Evap Results	Allows more detail to be output.
Expanded LDT/HDT/Bus Results	Allows more detail to be output.
Database Output	Allows for MY-specific and other detailed output.

Optional MOBILE6 Inputs and Features

Summary of MOBILE6 Output Commands

MOBILE6 Command	Header/ Run/ Scenario?	Comment
POLLUTANTS : VOC NOX	H	Specify Pollutants to Print
EXPRESS HC AS NMHC :	R	Report HC as NMHC
EXPRESS HC AS NMOG :	R	Report HC as NMOG
EXPRESS HC AS THC :	R	Report HC as THC
EXPRESS HC AS TOG :	R	Report HC as TOG
EXPRESS HC AS VOC :	R	Report HC as VOC
NO REFUELING :	R	Zero Out Refueling Losses
REPORT FILE : FILENAME.OUT	H	User-Specified Output File Name
NO DESC OUTPUT :	H	Do Not Print Descriptive Output
EXPAND BUS EFS :	R	More Detailed Bus Output
EXPAND EVAPORATIVE :	R	More Detailed Evap Output
EXPAND EXHAUST :	R	More Detailed Exhaust Output
EXPAND HDDV EFS :	R	More Detailed HDDV Output
EXPAND HDGV EFS :	R	More Detailed HDGV Output
EXPAND LDT EFS :	R	More Detailed LDT Output
DATABASE OUTPUT :	H	MY-Specific and Other Details

Note: DATABASE commands will be covered in the next class.

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Sample MOBILE6 Input File
Optional Output Commands

```
**********   Header Section   **********
MOBILE6 INPUT FILE :
REPORT FILE        : TEST_B.OUT

RUN DATA           :
**********    Run Section     **********
EXPAND EXHAUST     :
EXPAND EVAP        :
EXPRESS HC AS NMOG :

********** Scenario Section   **********
SCENARIO RECORD    : CY 2000 Run
CALENDAR YEAR      : 2000
MIN/MAX TEMP       : 72.0  92.0
FUEL RVP           : 8.7

**********  End of This Run   **********
END OF RUN         :
```

Optional MOBILE6 Inputs and Features
Activity Parameters

Parameter	Comments
Activity Parameters:	
VMT Mix by Veh Type	User may input locally derived VMT mix.
Alternate VMT Distribution by Hour	Takes the place of average speed.
Alternate VMT Distribution by Facility Type	Takes the place of average speed.
VMT by Speed Distribution	Takes the place of average speed.
Average Speed	"New" command in MOBILE6
Starts per Day	Alternate number of starts by hour of day.
Start Distribution	Alternate distribution of starts by hour of day.
Soak Time Distribution	Alternate distribution of hot soaks by hour of day.
Hot Soak Activity	Alternate distribution of hot soak length.
Diurnal Soak Activity	Alternate distribution of diurnal soak times.
Trip Length Dist - Weekend and Weekday	Used in estimating running loss emissions.
Weekend vs Weekday Activity	User can specify activity type, depending on need.

Optional MOBILE6 Inputs and Features

Summary of MOBILE6 Activity Commands

MOBILE6 Command			Header/ Run/ Scenario?	Comment
VMT FRACTIONS 0.354 0.089 0.297 0.092 0.041 0.040 0.004 0.003 0.002 0.008 0.010 0.012 0.040 0.002 0.001 0.005	:		R/S	VMT Mix by Veh Type (Included in Fleet Commands)
VMT BY HOUR	:	HVMT.DEF[a]	R/S	VMT Distribution by Hour
VMT BY FACILITY	:	FVMT.DEF	R/S	VMT Distribution by Facility Type
SPEED VMT	:	SVMT.DEF	R/S	VMT by Speed Distribution
AVERAGE SPEED	:	38.0 Freeway	S	User-Input Average Speed
STARTS PER DAY	:	FTP_SPD.D	R	Starts per Day
START DIST	:	SDIST.D	R	Start Distribution
SOAK DISTRIBUTION	:	SOAKDST.D	S	Soak Time Distribution
HOT SOAK ACTIVITY	:	HSACT.D	S	Hot Soak Activity
DIURN SOAK ACTIVITY	:	DSACT.D	S	Diurnal Soak Activity
WE DA TRI LEN DI	:	WEDATRIP.D	R/S	Trip Length Dist - Weekday
WE EN TRI LEN DI	:	WEENTRIP.D	R/S	Trip Length Dist - Weekend
WE VEH US	:		S	Weekend Activity

[a] File names refer to the default, or template, files provided with the model.

No video available in this version of presentation

Sample MOBILE6 Input File
Optional Activity Commands

```
**********   Header Section   **********
MOBILE6 INPUT FILE :
REPORT FILE        : TEST_C.OUT

RUN DATA           :
**********    Run Section     **********
VMT BY HOUR        : HVMT.DEF

********** Scenario Section   **********
SCENARIO RECORD    : CY 2000 Run
CALENDAR YEAR      : 2000
MIN/MAX TEMP       : 72.0  92.0
FUEL RVP           : 8.7
AVERAGE SPEED      : 38.0 Freeway

**********  End of This Run   **********
END OF RUN         :
```

Optional MOBILE6 Inputs and Features
Fleet Characteristics

Parameter	Comments
Fleet Characteristics:	
Registration Distribution	User may input locally derived registration distribution.
Mileage Accumulation	User may input locally derived mileage accumulation rates.
Alternate Diesel Sales Fraction	User may input locally derived LDV Diesel registration info.
NGV Fractions	User may specify a fraction of natural gas vehicles.

Summary of MOBILE6 Fleet Characteristics Commands

MOBILE6 Command	Header/ Run/ Scenario?	Comment
`REG DIST : REGDATA.D`[a]	R	User-Input Registration Data
`DIESEL FRACTIONS : DIESFRAC.DEF`	R/S	User-Input Diesel Fractions
`MILE ACCUM RATE : MARDATA.DEF`	R	Mileage Accumulation Rates

`VMT FRACTIONS :`
`0.354 0.089 0.297 0.092 0.041 0.040 0.004 0.003`
`0.002 0.008 0.010 0.012 0.040 0.002 0.001 0.005`
	R/S	VMT Mix by Veh Type
		(Included in Activity Commands)

`NGV FRACTION : NGVFR.D`	R	Natural Gas Vehicle Analyses

[a] File names refer to the default, or template, files provided with the model.

Optional MOBILE6 Inputs and Features
External/Ambient Conditions

Parameter	Comments
External Conditions:	
Month of Evaluation	Jan or Jul - choice based on winter or summer evaluation.
Altitude	Low/high altitude - low is default.
Humidity	Used for A/C calculations and impacts exhaust NOx.
Cloud Cover	Used primarily for A/C calculations.
Peak Sun	Used primarily for A/C calculations.
Sunrise/Sunset	Used primarily for A/C calculations.

Summary of MOBILE6 External/Ambient Condition Commands

MOBILE6 Command	Header/ Run/ Scenario?	Comment
EVALUATION MONTH : 7	S	7 for July; 1 for Jan (Default=1)
ALTITUDE : 1	S	1 for Low; 2 for High (Default=1)
ABSOLUTE HUMIDITY : 94.8	R/S	Humidity in grains water/lb dry air
CLOUD COVER : 0.07	R/S	Fraction Cloud Cover (0 to 1.0)
PEAK SUN : 10 4	R/S	Time for Peak Sun (9 to 5)
SUNRISE/SUNSET : 6 9	R/S	Sunrise (AM)/Sunset (PM)

NO VIDEO

Mapping for Distribution of Hourly Inputs
(e.g., START DIST and HOURLY Temperature Commands)

Number	Abbreviation	Description
1	6 a.m.	6 a.m. through 6:59 a.m.
2	7a.m.	7 a.m. through 7:59 a.m.
3	8 a.m	8 a.m. through 8:59 a.m.
4	9 a.m.	9 a.m. through 9:59 a.m.
5	10 a.m	10 a.m. through 10:59 a.m.
6	11 a.m.	11 a.m. through 11:59 a.m.
7	12 Noon	12 Noon through 12:59 p.m.
8	1 p.m.	1 p.m. through 1:59 p.m.
9	2 p.m.	2 p.m. through 2:59 p.m.
10	3 p.m.	3 p.m. through 3:59 p.m.
11	4 p.m.	4 p.m. through 4:59 p.m.
12	5 p.m.	5 p.m. through 5:59 p.m.
13	6 p.m.	6 p.m. through 6:59 p.m.
14	7 p.m.	7 p.m. through 7:59 p.m.
15	8 p.m.	8 p.m. through 8:59 p.m.
16	9 p.m.	9 p.m. through 9:59 p.m.
17	10 p.m	10 p.m. through 10:59 p.m.
18	11 p.m.	11 p.m. through 11:59 p.m.
19	12 Midnight	12 Midnight through 12:59 a.m.
20	1 a.m.	1 a.m. through 1:59 a.m.
21	2 a.m.	2 a.m. through 2:59 a.m.
22	3 a.m.	3 a.m. through 3:59 a.m.
23	4 a.m.	4 a.m. through 4:59 a.m.
24	5 a.m.	5 a.m. through 5:59 a.m.

Optional MOBILE6 Inputs and Features
Fuels Options

Parameter	Comments
Fuels Options:	
Reformulated Gasoline	Effects of reformulated gasoline can be included.
Gasoline Sulfur Level	Local data on gasoline sulfur level can be entered.
Oxygenated Fuels	Ether/alcohol market share and oxygen content required.

Summary of MOBILE6 Fuels Commands

MOBILE6 Command	Header/ Run/ Scenario?	Comment
FUEL PROGRAM : 2 N	R/S	Used to Specify RFG
FUEL PROGRAM : 4 300.0 299.0 279.0 259.0 121.0 92.0 33.0 33.0 30.0 30.0 30.0 30.0 30.0 30.0 30.0 30.0 1000 1000 1000 1000 303.0 303.0 87.0 87.0 80.0 80.0 80.0 80.0 80.0 80.0 80.0 80.0	R/S	Used to Specify Alt Sulfur Levels For CY2000 and Later Years
SULFUR CONTENT : 230.0	S	Gasoline Sulfur (30-600 ppm)
OXYGENATED FUELS : .200 .800 .027 .035 1	R/S	Specification of Oxy Fuels
SEASON : 1	R/S	Season for RFG (1=Sum;2=Win)

Optional MOBILE6 Inputs and Features
State Programs

Parameter	Comments
State Programs:	
I/M Program	Idle, Idle/2500, ASM, and IM240 tests included in MOBILE5.
Anti-Tampering Program	Effects of an anti-tampering program can be included.
Functional Pressure/Cap Check	Effects of a functional evap system check can be included.
Refueling Emissions	Uncontrolled, with Stage II, with on-board, or zeroed.

Summary of MOBILE6 State Programs Commands

MOBILE6 Command	Header/ Run/ Scenario?	Comment
I/M PROGRAM : 1 1983 2020 2 T/O IDLE	R	I/M Program
ANTI-TAMP PROG : 83 68 20 22222 11111111 1 11 096. 22112222	R	Anti-Tampering Program
STAGE II REFUELING 89 3 92. 84.	R	Stage II Refueling Vapor Recovery

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Summary of I/M Program Commands

- I/M and ATP program specifications are placed in the RUN section of the MOBILE6 input file or in an external file read by the input file.
- Up to seven I/M programs can be specified.
- The following commands apply to I/M programs:

```
I/M PROGRAM       :
I/M MODEL YEARS   :
I/M VEHICLES      :
I/M STRINGENCY    :
I/M COMPLIANCE    :
I/M WAIVER RATES  :
I/M CUTPOINTS     :
I/M EXEMPTION AGE :
I/M GRACE PERIOD  :
NO I/M TTC CREDITS :
I/M EFFECTIVENESS :
I/M DESC FILE     :
```

- The following command specifies an ATP program:

```
ANTI-TAMP PROG    :
83 68 20 22222 11111111 1 11 096. 22112222
```

- Details of specific user inputs for these commands will be covered on Day 2.

Optional MOBILE6 Inputs and Features
Miscellaneous Options

Parameter	Comments
Miscellaneous Options:	
Disable CAAA Requirements	Cold CO, Tier 1 and 2, and evap benefits can be disabled.
Tier 1/Tier 2/LEV Implementation	Implemenation and emission rates can be modified.
HDDV Defeat Device Parameters	Inputs to the defeat device emissions calcs can be modified.
2007 HDDV Rule Disablement	Disables the impacts of this regulation.

- These miscellaneous options allow for estimating the emissions impacts of individual programs.
- These model features will be covered on Day 2.

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Summary MOBILE6 Input File

```
**********   Header Section   **********
MOBILE6 INPUT FILE :

RUN DATA           :
**********    Run Section     **********

NO REFUELING       :
REG DIST           : REG_99.DAT
WE DA TRI LEN DI   : TripL_99.DAT
VMT BY FACILITY    : VFC99.DAT
VMT BY HOUR        : VHR99.DAT
SPEED VMT          : VSP99.DAT

I/M PROGRAM        : 1 1990 2001 1 TRC IDLE
I/M MODEL YEARS    : 1 1975 1995
I/M VEHICLES       : 1 22222 22222222 2
I/M STRINGENCY     : 1 20.0
I/M COMPLIANCE     : 1 96.0
I/M WAIVER RATES   : 1 3.0 3.0

*********  Scenario Section  **********
SCENARIO RECORD    : CY1999 Run
CALENDAR YEAR      : 1999
EVALUATION MONTH   : 7
MIN/MAX TEMP       : 72.0  92.0
ABSOLUTE HUMIDITY  : 94.9
CLOUD COVER        : 0.03
FUEL RVP           : 7.1
FUEL PROGRAM       : 2 S

*********  End of This Run  **********
END OF RUN
```

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Converting MOBILE5 Inputs To MOBILE6 Inputs

- Most of the MOBILE5 inputs and features can be used directly in MOBILE6 once the corresponding command has been identified.
- Appendix C of the User's Guide contains a summary table listing all MOBILE5 inputs and the corresponding MOBILE6 commands.
- Because MOBILE6 has expanded features relative to MOBILE5, direct conversion of MOBILE5 input files will under-utilize MOBILE6; however, guidance from EPA will be needed for official inventory work.
- In addition, a number of user-supplied inputs need conversion from MOBILE5 format to MOBILE6 format:
  - Data provided daily
  - Data provided by vehicle class
  - User-supplied operating modes
  - Average speed
  - Specific roadway/facility type modeling
- These will be covered in Days 2 and 5.

No video available in this version of presentation

Miscellaneous Materials

- Summary of MOBILE6 command names (from the MOBILE6 User's Guide)
- MOBILE6 Readme File
- Listing of MOBILE6 documentation available on EPA's web site

Alphabetical List of MOBILE6 Commands

Command Name	User's Guide Section	Command Input File Section	Exhaust or Evap	Command Parameter Type	Required Command?	Command Function
ABSOLUTE HUMIDITY	External Conditions 2.8.6.6	Run or Scenario	Exhaust	Value		Absolute humidity in grains per pound.
AGGREGATED OUTPUT	Database Output 2.8.5.1.k	Header	Both	On/Off		Database output by daily time periods aggregated to the level of the descriptive output.
ALTITUDE	External Conditions 2.8.6.5	Scenario	Both	Option		High or low altitude of area evaluated.
ANTI-TAMP PROG	State Programs 2.8.9.3	Run	Both	Program description		Anti-Tampering Programs.
AVERAGE SPEED	Activity 2.8.8.2.d	Scenario	Exhaust	Value		Allows the user to enter a single average speed value, rather than an average speed distribution.
CALENDAR YEAR	External Conditions 2.8.6.1	Scenario	Both	Value	Yes	Calendar year of scenario evaluated.
CLOUD COVER	External Conditions 2.8.6.7.a	Run or Scenario	Exhaust	Value		Allows user to input fraction of cloud cover for a given day.
DAILY OUTPUT	Database Output 2.8.5.1.j	Header	Both	On/Off		Database output by time periods.
DATABASE AGES	Database Output 2.8.5.1.g	Header	Both	Vehicle age choice		Limits which of the 25 vehicle ages have emissions reported in database output format.
DATABASE EMISSIONS	Database Output 2.8.5.1.d	Header	Both	Etype choice		Limits which of the eight types of emissions are reported in database output format.
DATABASE FACILITIES	Database Output 2.8.5.1.e	Header	Both	Facility choice		Limits which of five roadway types have emissions reported in database output format.
DATABASE HOURS	Database Output 2.8.5.1.h	Header	Both	Hours of day choice		Limits which of the 24 hours of the day have emissions reported in database output format.
DATABASE OPTIONS	Database Output 2.8.5.1.c	Header	Both	File name		Specifies a name for the external file holding a set of database output selection records.
DATABASE OUTPUT	Database Output 2.8.5.1.a	Header	Both	On/Off		Specifies MOBILE6 to report output in database format.

Command Name	User's Guide Section	Command Input File Section	Exhaust or Evap	Command Parameter Type	Required Command?	Command Function
ABSOLUTE HUMIDITY	External Conditions 2.8.6.6	Run or Scenario	Exhaust	Value		Absolute humidity in grains per pound.
AGGREGATED OUTPUT	Database Output 2.8.5.1.k	Header	Both	On/Off		Database output by daily time periods aggregated to the level of the descriptive output.
ALTITUDE	External Conditions 2.8.6.5	Scenario	Both	Option		High or low altitude of area evaluated.
ANTI-TAMP PROG	State Programs 2.8.9.3	Run	Both	Program description		Anti-Tampering Programs.
AVERAGE SPEED	Activity 2.8.8.2.d	Scenario	Exhaust	Value		Allows the user to enter a single average speed value, rather than an average speed distribution.
CALENDAR YEAR	External Conditions 2.8.6.1	Scenario	Both	Value	Yes	Calendar year of scenario evaluated.
CLOUD COVER	External Conditions 2.8.6.7.a	Run or Scenario	Exhaust	Value		Allows user to input fraction of cloud cover for a given day.
DAILY OUTPUT	Database Output 2.8.5.1.j	Header	Both	On/Off		Database output by time periods.
DATABASE AGES	Database Output 2.8.5.1.g	Header	Both	Vehicle age choice		Limits which of the 25 vehicle ages have emissions reported in database output format.
DATABASE EMISSIONS	Database Output 2.8.5.1.d	Header	Both	Etype choice		Limits which of the eight types of emissions are reported in database output format.
DATABASE FACILITIES	Database Output 2.8.5.1.e	Header	Both	Facility choice		Limits which of five roadway types have emissions reported in database output format.
DATABASE HOURS	Database Output 2.8.5.1.h	Header	Both	Hours of day choice		Limits which of the 24 hours of the day have emissions reported in database output format.
DATABASE OPTIONS	Database Output 2.8.5.1.c	Header	Both	File name		Specifies a name for the external file holding a set of database output selection records.
DATABASE OUTPUT	Database Output 2.8.5.1.a	Header	Both	On/Off		Specifies MOBILE6 to report output in database format.

Command Name	User's Guide Section	Command Input File Section	Exhaust or Evap	Command Parameter Type	Required Command?	Command Function
FUEL PROGRAM	State Programs 2.8.10.1	Run or Scenario	Both	Program description		Designates fuel sulfur level of gasoline and whether RFG use should be assumed.
FUEL RVP	Fuels 2.8.10.4	Run or Scenario	Both	Values	Yes	Required input of average fuel Reid vapor pressure.
HOT SOAK ACTIVITY	Activity 2.8.8.6	Scenario	Evap	External file		Specifies alternative distribution of lengths of hot soaks.
HOURLY TEMPERATURES	External Conditions 2.8.6.4	Run or Scenario	Both	Values	Yes*	Allows entry of 24 hourly temperatures. *Required unless MIN/MAX TEMP is used.
I/M COMPLIANCE	State Programs 2.8.9.4.e	Run	Both	Value		Required input indicating percentage of total vehicle fleet certified or waived by I/M program.
I/M CUTPOINTS	State Programs 2.8.9.4.g	Run	Exhaust	External file		Optional command for cutpoints if I/M 240 used.
I/M DESC FILE	State Programs 2.8.9.4.l	Run	Both	File name		Optional external input file containing I/M program description records.
I/M EFFECTIVENESS	State Programs 2.8.9.4.k	Run	Both	Value		Reduce I/M effectiveness to account for Test and Repair losses.
I/M EXEMPTION AGE	State Programs 2.8.9.4.h	Run	Both	Value		Optional command indicating age that vehicle automatically becomes exempt from I/M program.
I/M GRACE PERIOD	State Programs 2.8.9.4.i	Run	Both	Value		Optional command indicating when vehicle first becomes subject to I/M program.
I/M MODEL YEARS	State Programs 2.8.9.4.b	Run	Both	Values		Required command indicating vehicle model years subject to I/M program.
I/M PROGRAM	State Programs 2.8.9.4.a	Run	Both	Values		Required command indicating program start and end dates, frequency and test type.
I/M STRINGENCY	State Programs 2.8.9.4.d	Run	Exhaust	Values		Required command indicating initial test failure rate (%) for pre-1981 LDGVs and pre-1984 LDGTs.
I/M VEHICLES	State Programs 2.8.9.4.c	Run	Exhaust	Vehicle choice		Required command indicating vehicle types subject to I/M.
I/M WAIVER RATES	State Programs 2.8.9.4.f	Run	Exhaust	Values		Required command indicating percentage of vehicles failing initial I/M test and do not have to pass a retest.
MILE ACCUM RATE	Fleets 2.8.7.3	Run	Both	External file		Allows user to supply annual accumulation rates by age for each of the 28 vehicle types.
MIN/MAX TEMP	External Conditions 2.8.6.3	Run or Scenario	Both	Values	Yes*	Specifies minimum and maximum daily temperature. * This command is required unless HOURLY TEMPERATURES is used.

Command Name	User's Guide Section	Command Input File Section	Exhaust or Evap	Command Parameter Type	Required Command?	Command Function
MOBILE6 BATCH FILE	Separators 2.8.2.2	Header	Both	On/Off		Identifies MOBILE6 input file as batch file as opposed to a regular command input file.
MOBILE6 INPUT FILE	Separators 2.8.2.1	Header	Both		Yes	Identifies MOBILE6 input file as a regular command input file as opposed to a batch input file.
NGV EF	Fleets 2.8.7.6	Run	Both	External file		Allows the user to enter alternate NGV emission factors for each of the 28 vehicle types, for each of the three pollutants, and (where applicable) for running and start emissions. Must be used in conjunction with NGV FRACTION command.
NGV FRACTION	Fleets 2.8.7.5	Run	Both	External file		Indicates percentage of natural gas vehicles in each of the 28 vehicles classes.
94+ LDG IMP	Alternative Regulations and Control Programs 2.8.11.4	Run	Both	File name		Allows the user to input optional 1994 and later fleet penetration fractions for light-duty gasoline vehicles under the Tier 1, NLEV (or California LEV 1), and Tier 2 standards.
NO 2007 HDDV RULE	Alternative Regulations and Control Programs 2.8.11.5	Run	Exhaust	On/Off		Allows the user to disable the 2007 heavy duty vehicle emission standards.
NO CLEAN AIR ACT	State Programs 2.8.11.1	Run	Both	On/Off		Allows users to model vehicle emissions as if the Federal Clean Air Act Amendments of 1990 had not been implemented.
NO DEFEAT DEVICE	Alternative Regulations and Control Programs 2.8.11.2.a	Run	Exhaust	On/Off		Allows users to turn off the effects of the heavy-duty diesel vehicle NOx off-cycle emission effects (defeat device emissions).
NO DESC OUTPUT	Descriptive Output 2.8.4.2	Header	Both	On/Off		Optional command that prevents production of descriptive output.
NO I/M TTC CREDITS	State Programs 2.8.9.4.j	Run	Exhaust	On/Off		Optional command to eliminate credit for a technician training program.
NO NOX PULL AHEAD	2.8.11.2.b Alternative Regulations and Control Programs	Run	Exhaust	On/Off		Allows the user to turn off the effects of the Pull Ahead mitigation program used to reduce heavy-duty diesel vehicle off-cycle emissions.
NO REBUILD	2.8.11.2.c Alternative Regulations and Control Programs	Run	Exhaust	On/Off		Allows the user to turn off the effects of the Rebuild mitigation program used to reduce heavy-duty diesel off-cycle emissions.
NO REFUELING	All Output 2.8.3.3	Run	Both	On/Off		Allows user to "zero out" refueling (Stage 2) emissions, which then must be accounted for in stationary source part of SIP.
NO TIER2	Alternative Regulations and Control Programs 2.8.11.3.a	Run	Both	On/Off		Allows the user to disable the Tier 2 emission standards and fuel sulfur requirements.

Command Name	User's Guide Section	Command Input File Section	Exhaust or Evap	Command Parameter Type	Required Command?	Command Function
OXYGENATED FUELS	Fuels 2.8.10.3	Run or Scenario	Both	Values		Allows modeling of the effects of use of oxygenated fuels on exhaust emissions.
PEAK SUN	External Conditions 2.8.6.7.b	Run or Scenario	Exhaust	Value		Allows input of 2 daily times demarcating period of peak sun.
POLLUTANTS	All Output 2.8.3.1	Header	Both	Pollutant choice		Controls which pollutants will be calculated and output to the database report and descriptive output.
REBUILD EFFECTS	Alternative Regulations and Control Programs 2.8.11.2.d	Run	Exhaust	Value		Allows the user to change the Rebuild program effectiveness rate used to reduce heavy-duty diesel vehicle NOx off-cycle emissions.
REG DIST	Fleets 2.8.7.1	Run	Both	External file		Allows user to supply vehicle registration distributions by age for all 16 composite vehicles types.
REPORT FILE	Descriptive Output 2.8.4.1	Header	Both	File name		Specifies name for descriptive output file.
RUN DATA	Separators 2.8.2.3	End of Header	Both		Yes	Marks end of Header section and beginning of Run section of regular MOBILE6 command input file.
SCENARIO RECORD	Separators 2.8.2.4	Start of Scenario	Both		Yes	Allows user to label individual scenario results. Marks start of new scenario.
SEASON	Fuels 2.8.10.5	Run or Scenario	Both	Value		Allows users to specify winter or summer RVP independent of evaluation month.
SOAK DISTRIBUTION	Activity 2.8.8.5	Scenario	Exhaust	External file		Allows user to enter soak duration distributions for each hour of the day that will override MOBILE6 defaults.
SPEED VMT	Activity 2.8.8.2.c	Run or Scenario	Exhaust	External file		Allows user to enter VMT distribution across 14 preselected average speed ranges for each of the 24 hours of the day for each scenario.
STAGE II REFUELING	State Programs 2.8.9.2	Run	Evap	Program description		Allows modeling of impact of stage II "at-the-pump" vapor recovery system for refueling emissions.
STAR DIST	Activity 2.8.8.4	Run	Both	External file		Allows user to change the default for the hourly temporal distribution of engine starts (trips) across the day.
STARTS PER DAY	Activity 2.8.8.3	Run	Both	External file		Allows user to change default average number of engine starts per day per vehicle.
SULFUR CONTENT	Fuels 2.8.10.2	Scenario	Exhaust	Value		Allows user to enter alternate sulfur content of gasoline (ppm) that overrides MOBILE6 default of 300 ppm.
SUNRISE/SUNSET	External Conditions 2.8.6.7.c	Run or Scenario	Exhaust	Values		Specifies times for sunrise and sunset for A/C calculations.

NO VIDEO

Command Name	User's Guide Section	Command Input File Section	Exhaust or Evap	Command Parameter Type	Required Command?	Command Function
T2 CERT	Alternative Regulations and Control Programs 2.8.11.3.d	Run	Both	File name		Allows the user to specify alternative Tier 2 50,000 mile certification standards. Must be used to model the effects of California's LEV II requirement.
T2 EVAP PHASE-IN	Alternative Regulations and Control Programs 2.8.11.3.b	Run	Evap	File name		Allows the user to replace the default phase-in fractions (by certification bin) for the Tier 2 evaporative emissions standards, permitting different phase-in schedules to be modeled. Also necessary to model the evaporative effects of California's LEVII requirement.
T2 EXH PHASE-IN	Alternative Regulations and Control Programs 2.8.11.3.c	Run	Exhaust	File name		Allows the user to replace the default phase-in fractions (by certification bin) for the Tier 2 exhaust emission standards, allowing different phase-in schedules to be modeled. Also necessary to model the exhaust effects of the California LEV II requirement.
VMT BY FACILITY	Activity 2.8.8.2.a	Run or Scenario	Both	External file		Allows user to supply alternate VMT distributions by facility type that override MOBILE6 defaults for each scenario.
VMT BY HOUR	Activity 2.8.8.2.b	Run or Scenario	Both	External file		Allows user to supply alternate hourly distributions of VMT that override MOBILE6 defaults for each scenario.
VMT FRACTIONS	Activity 2.8.8.1	Run or Scenario	Both	Values		Allows user to apply alternate vehicle miles traveled fractions by each of 16 combined vehicle types.
WE DA TRI LEN DI	Activity 2.8.8.8	Run or Scenario	Both	External file		Allows user to supply alternate weekday hourly running loss trip length distribution.
WE EN TRI LEN DI	Activity 2.8.8.9	Run or Scenario	Both	External file		Allows user to supply alternate weekend hourly running loss trip length distribution.
WE VEH US	Activity 2.8.8.10	Scenario	Both	On/Off		Directs MOBILE6 to use the weekend activity fractions in its calculations.
WITH FIELDNAMES	Database Output 2.8.5.1.b	Header	Both	On/Off		Specifies that a header record of field names is to be generated for the database output.

MOBILE6 Readme File

Draft MOBILE6
February 22, 2001

This file describes the draft version of the EPA MOBILE6 mobile source emission factor model.

System Requirements:

MOBILE6 requires a DOS or Microsoft Windows based computer system with a math coprocessor and at least 5 megabytes of free RAM.

To Install the Model:

The best way to install MOBILE6 is simply to copy the entire contents of the CD, including its directory structure, to your hard drive.

To Run the Model:

To run MOBILE6 in DOS, simply type the command M6DRAFT. In Windows, double click on the M6DRAFT icon and a DOS window will appear. The MOBILE6 application requires the use of an input file containing commands describing the parameters to be modeled by MOBILE6. The user is required to indicate which input file is to be used by entering the name of the file at the prompt.

If you have Questions:

Please consult the User Guide document (UGDRAFT.WPD or UGDRAFT.PDF) included with this material. Appendix A lists all MOBILE6 input commands alphabetically and indicates the section number of the user guide which documents the command.

If you have Comments or Problems:

You may send Email to mobile@epa.gov

The files provided with the MOBILE6 model are:

In the MOBILE6/RUN Directory:

M6DRAFT.EXE	Contains the MOBILE draft executable application.
LF90.EER	Contains text for FORTRAN error statements.
MOBILE6.IN	Contains an example input file demonstrating many of the available commands and using the default file name for input files.
MOBILE6.TXT	Contains the descriptive output results using the MOBILE6.IN file.

NO VIDEO

```
MOBILE6.TB1    Contains the database output results
                    using the MOBILE6.IN file.
    ASMDATA.D       Contains the I/M credits for the ASM
                    test procedure required when using the
                    I/M PROGRAM command.
    CUTPOINT.D      Contains the I/M credits for the IM240
                    test procedure required when using the
                    I/M PROGRAM command.
    DBASE.D         Contains commands used with the DATABASE
                    OPTIONS command.
    DIESFRAC.DEF    Contains alternate data using the DIESEL
                    FRACTIONS command.
    DSACT.D         Contains alternate data using the DIURN
                    SOAK ACTIVITY command.
    FTP_SPD.D       Contains alternate data using the STARTS
                    PER DAY command.
    FVMT.DEF        Contains alternate data using the VMT BY
                    FACILITY command.
    HSACT.D         Contains alternate data using the HOT
                    SOAK ACTIVITY command.
    HSACTDAY.D      Contains alternate data using the HOT
                    SOAK ACTIVITY command.
    HSACTEND.D      Contains alternate data using the HOT
                    SOAK ACTIVITY command.
    HVMT.DEF        Contains alternate data using the VMT BY
                    HOUR command.
    IMTEST.D        Contains commands used with the I/M DESC
                    FILE command.
    MARDATA.DEF     Contains alternate data using the MILE
                    ACCUM RATE command.
    MILEDAT.D       Contains alternate data using the MILE
                    ACCUM RATE command.
    NGVFR.D         Contains alternate data using the NGV
                    FRACTION command.
    REGDATA.D       Contains alternate data using the REG
                    DIST command.
    SDIST.D         Contains alternate data using the START
                    DIST command.
    SOAKDST.D       Contains alternate data using the SOAK
                    DISTRIBUTION command.
    STPERDAY.D      Contains alternate data using the STARTS
                    PER DAY command.
    SVMT.DEF        Contains alternate data using the SPEED
                    VMT command.
    TECH12.D        Contains the I/M credits for pre-1981
                    model year vehicles required when using
                    the I/M PROGRAM command.
    VMTMIX.DEF      Contains alternate data using the VMT
                    FRACTIONS command.
    WEDATRIP.D      Contains alternate data using the WE DA
                    TRI LEN DI command.
    WEENTRIP.D      Contains alternate data using the WE EN
                    TRI LEN DI command.

    In the MOBILE6\RUN\EXAMPLES directory:

    EXAMPLE1.IN     Contains an example input demonstrating
                    the NO REFUELING command and commands to
```

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control output hydrocarbon speciation.

EXAMPLE1.TXT	Contains the resulting descriptive output using the EXAMPLE1.IN file.
EXAMPLE2.IN	Contains an example input demonstrating the extent of the I/M PROGRAM command options.
EXAMPLE2.TXT	Contains the resulting descriptive output using the EXAMPLE2.IN file.
EXAMPLE3.IN	Contains an example input demonstrating the database output options using the DAILY OUTPUT and NO DESC OUTPUT commands.
EXAMPLE3.TXT	Contains the resulting descriptive output using the EXAMPLE3.IN file.
EXAMPLE3.TB1	Contains the resulting database output using the EXAMPLE3.IN file.
EXAMPLE4.IN	Contains an example input demonstrating the MOBILE6 BATCH FILE command option. This file will run the other example input files in a "batch" mode.
EXAMPLE4.TXT	Contains the resulting descriptive output using the EXAMPLE2.IN file. The file name was designated using the batch file option.
MYCUTS.D	Contains IM240 cutpoint combinations used in EXAMPLE2.IN and needed when running EXAMPLE4.
EXAMPLE5.IN	Contains an example input demonstrating the AGGREGATED form of the database output.
EXAMPLE5.TXT	Contains the resulting descriptive output using the EXAMPL5.IN file.
EXAMPLE5.TB1	Contains the resulting database output using the EXAMPLE5.IN file.

In the MOBILE6\UGUIDE directory:

UGDRAFT.WPD	Contains the Draft MOBILE6 User Guide in Wordperfect 8.0 format.
UGDRAFT.PDF	Contains the Draft MOBILE6 User Guide in Adobe Acrobat PDF format.
FAQs.WPD	This contains our answers to "Frequently Asked Questions" on MOBILE6.

In the MOBILE6\SOURCE directory:

Note: No source code is provided with the draft version of MOBILE6.

*.FOR	Will contain FORTRAN source code for routines.
*.I	Will contain FORTRAN source code include files.

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MOBILE6Technical Reports on EPA's Web Site

1. In-Use Exhaust Deterioration and I/M Benefits of 1981 and Newer Model Year Cars and Trucks: Package of Related Material for Stakeholder Review
2. Estimating Benefits of Inspection/Maintenance Programs for Evaporative Control Systems (M6.IM.003, posted 11/17/99, EPA420-P-99-031)
3. Determination of Methane Offsets as a Function of Mileage for Light-Duty Cars and Trucks (M6.EXH.006, posted 11/15/99, EPA420-P-99-029)
4. Development and Use of Heavy-Duty Defeat Device Emission Effects for MOBILE5 AND MOBILE6 (M6.HDE.003, posted 10/27/99, EPA420-P-99-030)
5. Facility-Specific Speed Correction Factors (M6.SPD.002, posted 8/24/99, EPA420-P-99-002)
6. Estimating Weighting Factors for Evaporative Emissions in MOBILE6 (M6.EVP.006, posted 7/15/99, EPA420-P-99-023)
7. Estimating Running Loss Evaporative Emissions Based on Real-time Data (M6.EVP.008, posted 7/15/99, EPA420-P-99-024)
8. Evaporative Emissions of Gross Liquid Leakers in MOBILE6 (M6.EVP.009, posted 7/15/99, EPA420-P-99-025)
9. Comparison of MOBILE6 Basic Emission Rates for 1981-1993 Model Year Light-Duty Cars and Trucks with FTP and IM240 Data (M6.EXH.010, posted 5/21/99, EPA420-P-99-021)
10. Determination of CO Basic Emission Rates, OBD and I/M Effects for Tier 1 and Later LDVs and LDTs (M6.EXH.009, posted 5/21/99, EPA420-P-99-017)
11. Modeling Emission Factors for Compressed Natural Gas Vehicles (M6.FUL.004, posted 5/17/99, EPA420-P-99-012)
12. Determining Repair Effects on IM240 Cold Start Emissions for 1981 and later Light Duty Vehicles (M6.IM.002, posted 5/17/99, EPA420-P-99-019)
13. Modeling Diurnal and Resting Loss Emissions from Vehicles Certified to the Enhanced Evaporative Standards (M6.EVP.005, posted 5/17/99, EPA420-P-98-012)
14. Basic Exhaust Emission Rates of Open Loop Vehicles for MOBILE6: Exhaust Emissions at High and Low Altitudes for Engine Starts and Running Emissions for

Motorcycles, Light Duty Diesel Vehicles and Trucks and Pre-1981 Model Year Light Duty Gasoline Vehicles and Trucks (M6.EXH.005, posted 5/17/99, EPA420-P-99-020)

15. Overview of Methodology for Tier 0 In-Use Deterioration and Key Issues for Comment (M6.EXH.008, posted 5/3/99, EPA420-P-99-016)

16. Determination of Running Emissions as a Function of Mileage for 1981-1993 Model Year Light-Duty Cars and Trucks (M6.EXH.001, posted 5/3/99, EPA420-P-99-010)

17. Analysis of Emissions Deterioration Using Ohio and Wisconsin IM240 Data (M6.EXH.002, posted 5/3/99, EPA420-P-99-013)

18. 10/97 Determination of Hot Running Emissions from FTP Bag Emissions (M6.STE.002, reposted 5/3/99, EPA420-P-99-014)

19. Determination of Start Emissions as a Function of Mileage and Soak Time for 1981-1993 Model Year Light-Duty Vehicles (M6.STE.003, reposted 5/3/99, EPA420-P-99-015)

20. MOBILE6 Inspection / Maintenance Benefits Methodology for 1981 through 1993 Model Year Light Vehicles (M6.IM.001, posted 5/3/99, EPA420-P-99-007)

21. Determination of NOx and HC Basic Emission Rates, OBD and I/M Effects for Tier 1 and Later LDVs and LDTs (M6.EXH.007, posted 5/3/99, EPA420-P-99-009)

22. Fleet Characterization Data for MOBILE6: Development and Use of Age Distributions, Average Annual Mileage Accumulation Rates and Projected Vehicle Counts for Use in MOBILE6 (M6.FLT.007, posted 5/3/99, EPA420-P-99-011)

23. Fuel Sulfur Effects on Exhaust Emissions: Recommendations for MOBILE6 (M6.FUL.001, posted 5/3/99, EPA420-P-99-008)

24. Evaluating Multiple Day Diurnal Evaporative Emissions Using RTD Tests (M6.EVP.003, posted 3/9/99, EPA420-P-99-003)

25. Soak Length Activity Factors for Diurnal Emissions (M6.FLT.006 posted 3/9/99, EPA420-P-98-019)

26. Guidance for the Development of Facility Type VMT and Speed Distributions (M6.SPD.004, posted 3/9/99, EPA420-P-99-004)

27. Exhaust Emission Temperature Correction Factors for MOBILE6: Engine Start and Running LA4 Emissions for Gasoline Vehicles (M6.STE.004, posted 3/9/99, EPA420-P-99-001)

28. Development of Methodology for Estimating VMT Weighting by Facility Type

29. Update of Hot Soak Emissions Analysis (M6.EVP.004 posted 3/8/99, EPA420-P-99-005)
30. Hot Soak Emissions as a Function of Soak Time (M6.EVP.007 posted 6/23/98)
31. Emission Control Technology Distribution (M6.FLT.008, posted 6/19/98)
32. Update of Fleet Characterization Data for Use in MOBILE6 (M6.FLT.002, posted 6/19/98, re-posted with correct figures 11/30/98)
33. Update Heavy-Duty Engine Emission Conversion Factors for MOBILE6: Analysis of BSFCs and Calculation of Heavy-Duty Engine Emission Conversion Factors (M6.HDE.004 posted 5/29/98)
34. Update Heavy-Duty Engine Emission Conversion Factors for MOBILE6: Analysis of Fuel Economy, Non-Engine Fuel Economy Improvements, and Fuel Densities (M6.HDE.002 posted 5/29/98)
35. Modeling Hourly Diurnal Emissions and Interrupted Diurnal Emissions Based on Real-Time Diurnal Data (M6.EVP.002 originally posted 5/21/98, revision posted 7/15/99, EPA420-P-99-027)
36. Fuel Oxygen Effects on Exhaust CO Emissions (M6.FUL.002 posted 3/30/98)
37. Air Conditioning Correction Factors in MOBILE6 (M6.ACE.002 posted 3/13/98)
38. Soak Length Activity Factors for Start Emissions (posted 2/18/98)
39. Soak Length Activity Factors for Hot Soak Emissions (posted 2/18/98)
40. Trip Length Activity Factors for Running Loss and Exhaust Running Emissions (posted 2/18/98)
41. Air Conditioning Activity Effects in MOBILE6 (posted 1/27/98)
42. Evaluating Resting Loss and Diurnal Evaporative Emissions Using Real Time Diurnal Tests (M6.EVP.001, originally posted 10/97 as M6.RTD.001, revision posted 7/15/99, EPA420-P-99-026)
43. 9/97 Update of Fleet Characterization Data for Use in MOBILE6 (Superseded by M6.FLT.002)
44. Development of Speed Correction Cycles
45. Comparison of Start Emissions in the LA92 and ST01 Test Cycles