

MOVES

Light Duty Vehicle Engine Start Emissions & Exhaust Emission Adjustments

David Brzezinski
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MOVES



Engine Starts Basics

- Engine start is the excess emissions which occur prior to catalyst “light-off” or engine warm up beginning with the engine at ambient temperature.
- Obtained by subtracting Bag 3 from Bag 1 emissions using FTP or LA92 testing results.
- Engine start emissions are added to the inventory for each trip beginning with an engine start.
- Engine starts are not associated with roadways, they are allocated to locations.

Engine Starts Background

- **Not all emission testing includes engine starts.**
- **The Federal Test Procedure (FTP), includes cold start (Bag 1), hot running (Bag 2), and hot start portions (Bag 3).**
- **California's redesigned drive cycle (LA92) also includes three bags.**
- **The driving schedules of Bag 1 and Bag 3 are identical, which allows the comparison.**

Engine Starts Data Sources

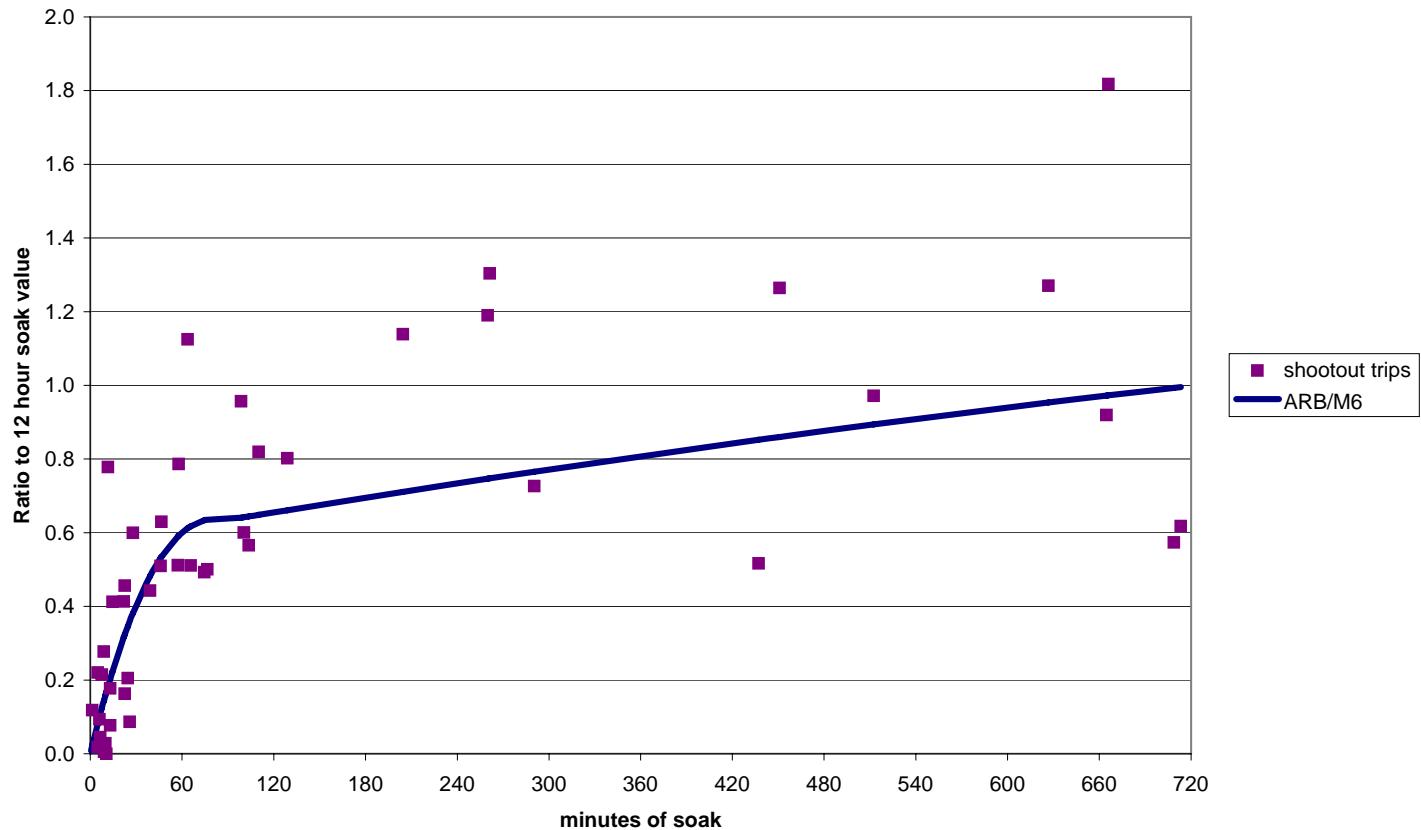
- There are many FTP tests in the EPA database and some LA92 tests.
- All gasoline vehicle PM measurements are from LA92 tests (from the Kansas City Study).
- Basic engine start emission rates use only tests done at FTP temperatures.
- Instrumented vehicle (second by second) measurements were not used.

Engine Starts Soak Time Effects

- Soak time (the time between key off and the next key on) can dramatically affect engine start emissions.
- Basic emission rates for engine starts are stored for eight soak time periods.
- The emission rates for soak times other than 12 hours are obtained by adjusting the 12 hour soak estimates using the adjustment factors developed by California and used in MOBILE6.
- Soak effects validated using PEMS measurements.

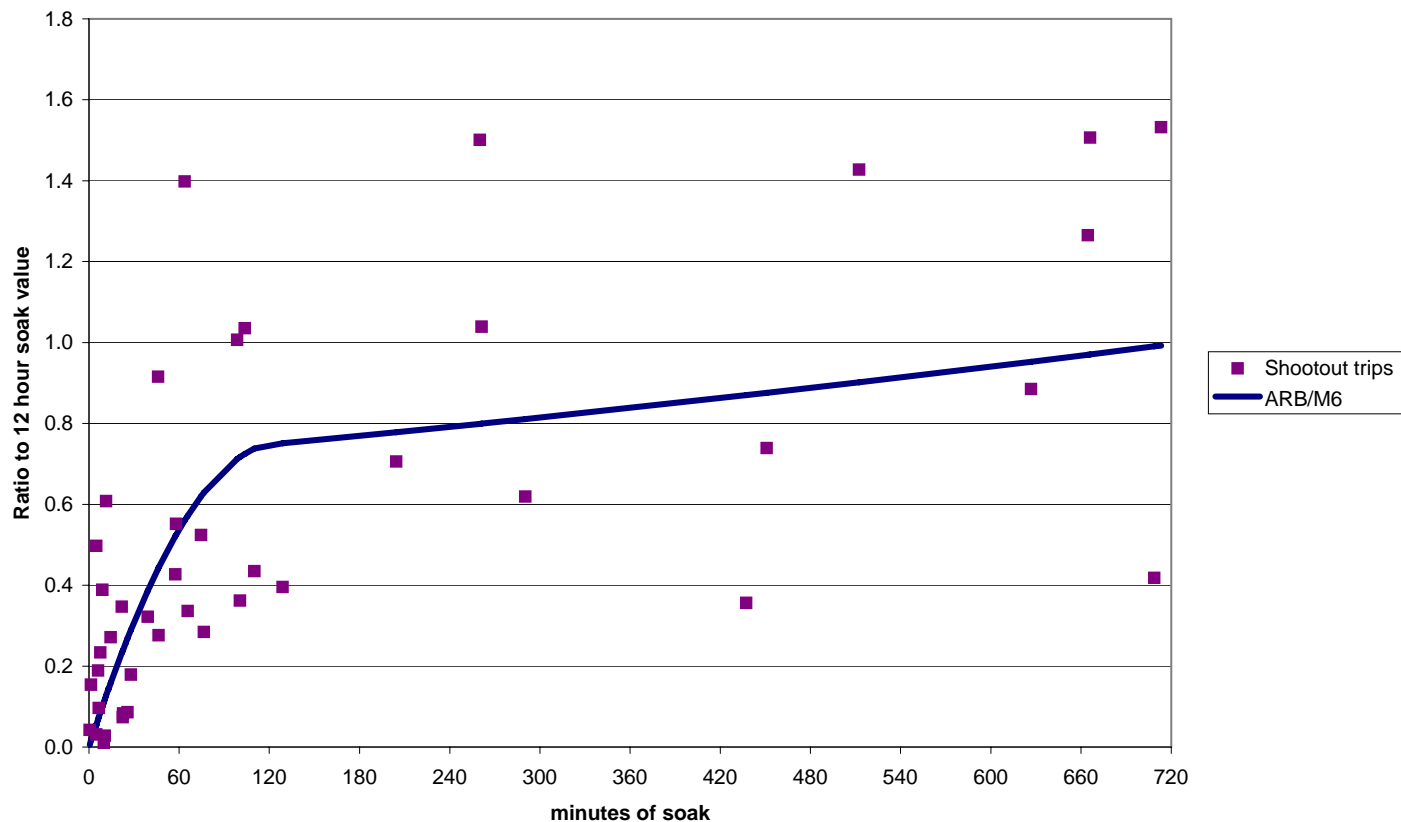
Engine Starts Soak Time HC

Effects of Soak Time on Engine Start HC



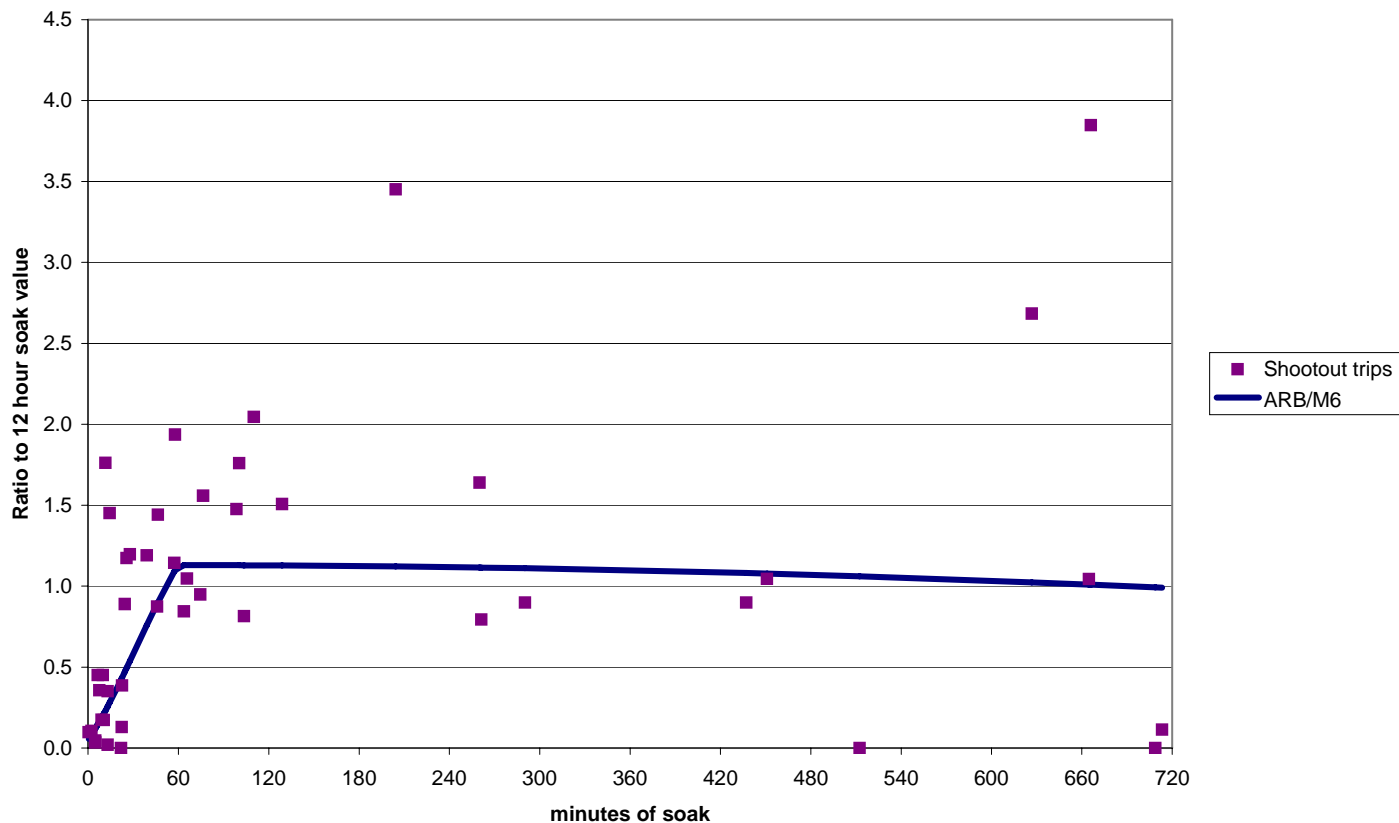
Engine Starts Soak Time CO Emissions

Effects of Soak Time on Engine Start CO



Engine Starts Soak Time NOx Emissions

Effects of Soak Time on Engine Start NOx



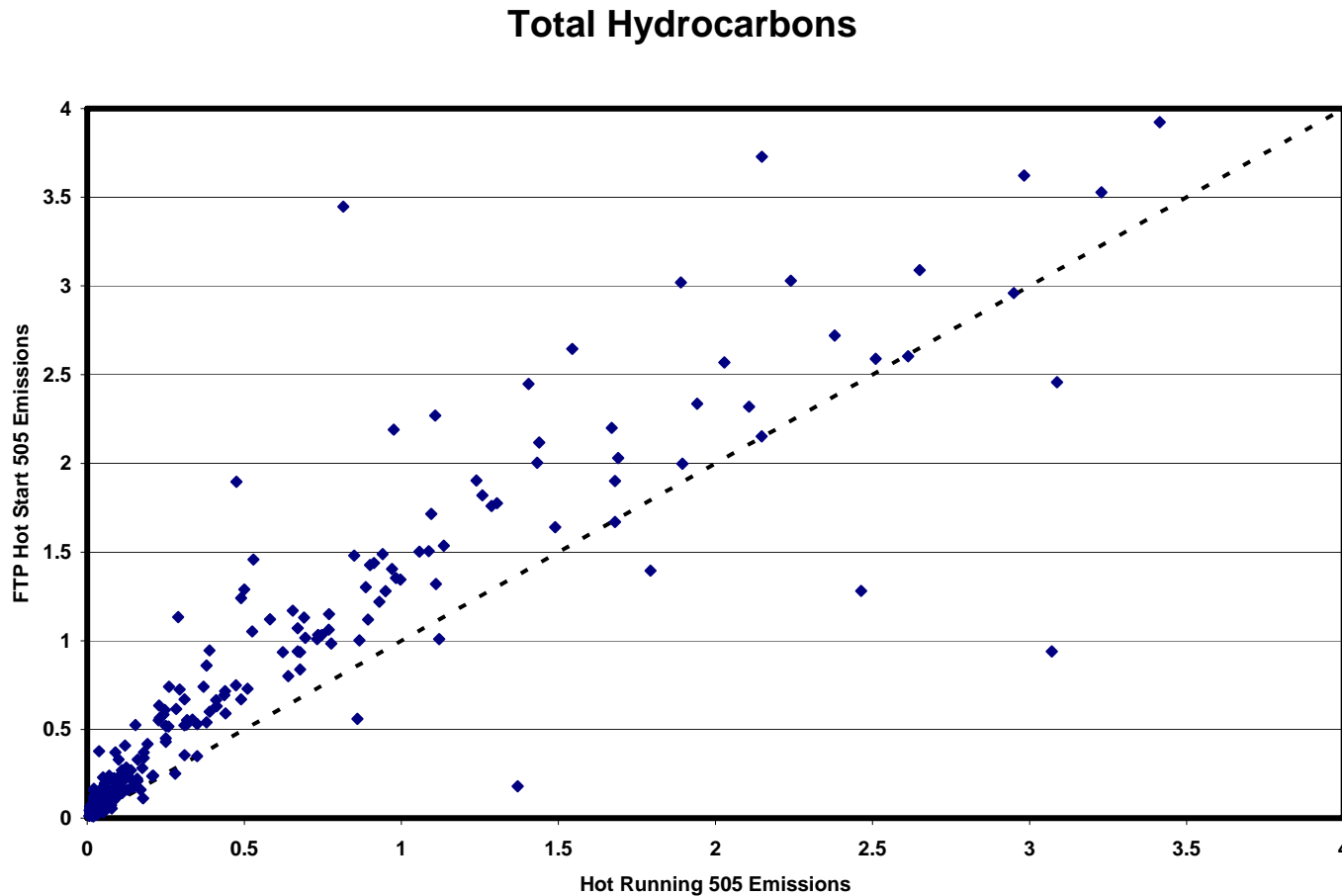
Engine Starts Operating Modes

opmodeid	Operating Mode Description
101	Soak Time < 6 minutes
102	6 minutes <= Soak Time < 30 minutes
103	30 minutes <= Soak Time < 60 minutes
104	60 minutes <= Soak Time < 90 minutes
105	90 minutes <= Soak Time < 120 minutes
106	120 minutes <= Soak Time < 360 minutes
107	360 minutes <= Soak Time < 720 minutes
108	720 minutes <= Soak Time

Engine Starts Issues

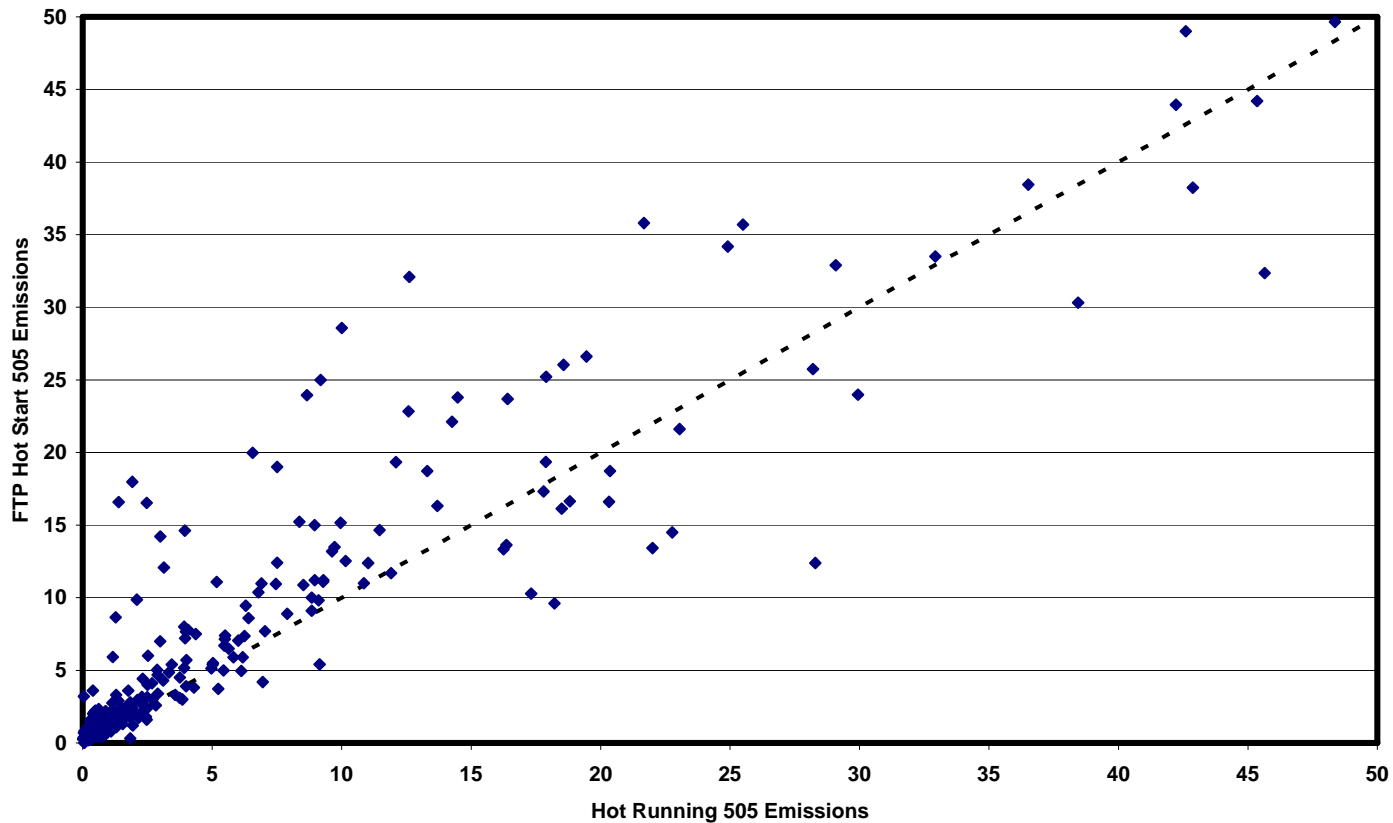
- **Key Assumptions:**
 - Engine start effects in Bag 3 are negligible.
 - Effects of differences in the driving schedule after engine starts are negligible.
 - Age effects (deterioration) are negligible.
- **How important is the interaction between soak time effects and temperature?**
- **It is not clear yet how excess emissions due to engine starts will be obtained from real world second-by-second measurements.**

Engine Starts Hot Start Total Hydrocarbons



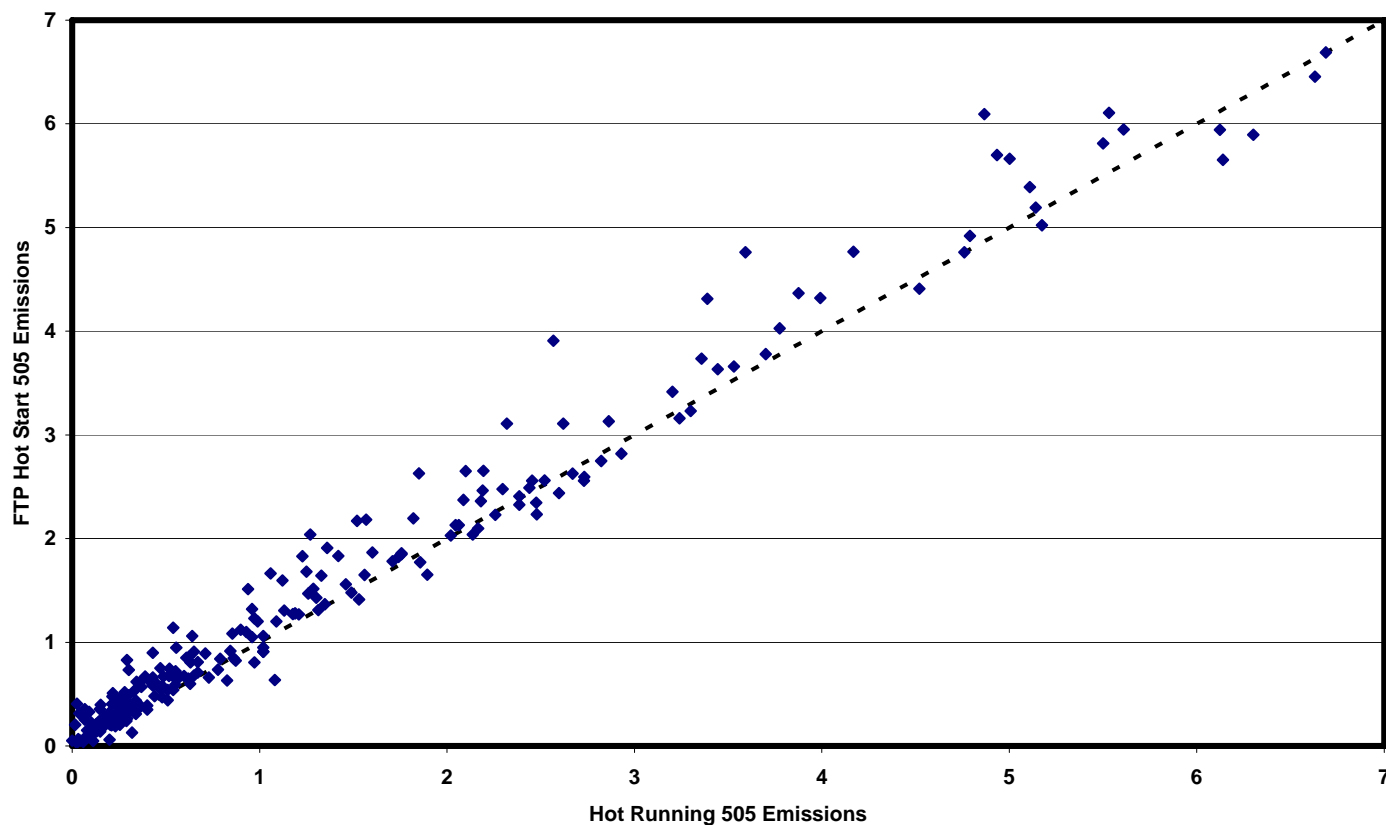
Engine Starts Hot Start Carbon Monoxide

Carbon Monoxide

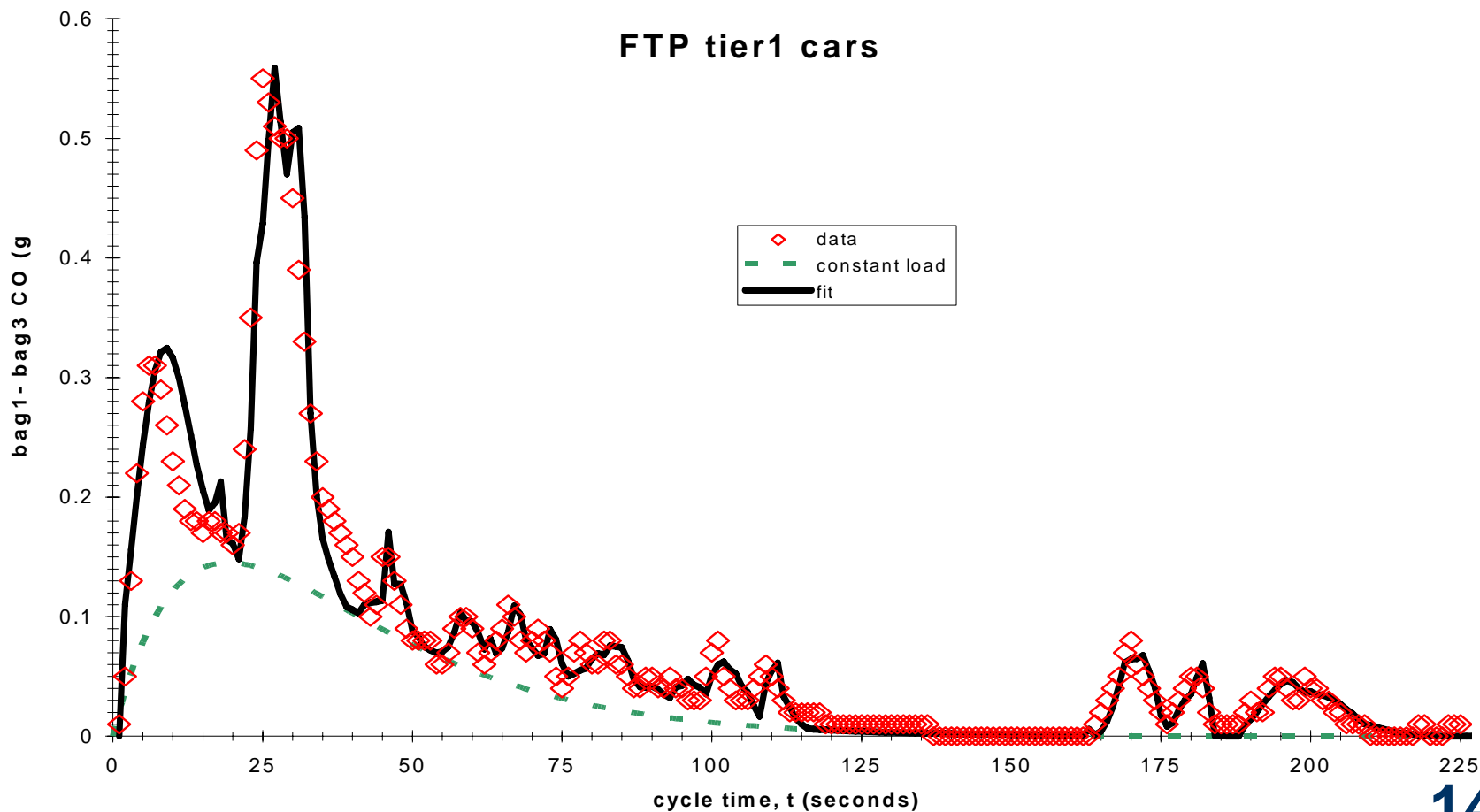


Engine Starts Hot Start Oxides of Nitrogen

Oxides of Nitrogen



Engine Starts Driving Cycle Issue



Adjustments for Exhaust Emissions

- Basic emission rates represent the specific set of test conditions observed during the testing.
- Adjustment factors are used to better match the emission estimates with local conditions.
- Some adjustments (speed, soak time) are handled by using separate emission rates for each operating mode.
- Adjustments are made for air conditioning usage, temperature, humidity, fuel properties and altitude.

Adjustments

Fuel Effects

- **MOVES2006 fuel adjustments are from MOBILE6.**
 - Single adjustment factor based on unique combinations of fuel parameters.
 - List of modeled fuel formulations taken from the National Mobile Inventory Model (NMIM).
- **Basic exhaust emission rates are assumed to be measured using a baseline fuel formulation.**
- **MOVES2007**
 - Plan to directly model fuel properties.
 - Plan to include information from more recent studies.

Adjustments

Temperature Effects

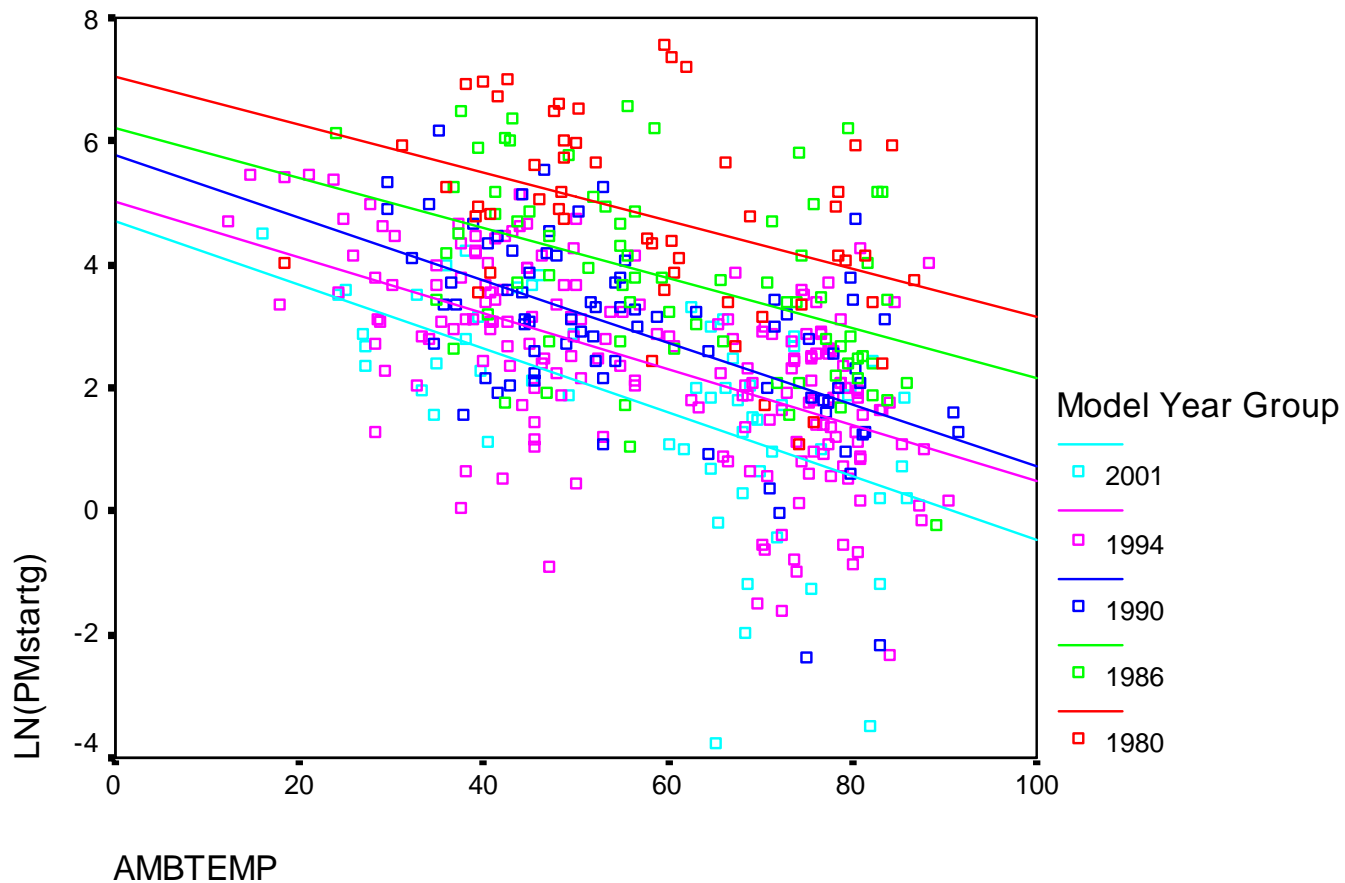
- Assume that the temperature effect for exhaust running emissions is negligible.
- Assume that the temperature effect for temperatures above 75 degrees F is negligible.
- Cold temperatures will affect HC, CO, NOx and PM engine start emissions.
- Using an additive adjustment for engine start emissions.
- Adjustments are calculated using a quadratic function fit to the data.

Adjustments

Temperature Effects Data

- Temperature effects are derived from only the bag data (FTP and LA92).
- PM temperature effects for gasoline vehicles are derived from the Kansas City data.
- Data were available from a small sample of recently tested Tier 2 vehicles (SwRI).
- Some testing data was available for temperatures down to below zero degrees.

Adjustments Temperature Effect on Start PM



Adjustments

Air Conditioning Effects

- Used sec-by-sec emission measurements made during testing used for MOBILE6.
- Calculated VSP binned AC on/off emissions effect.
- Found very little difference across non-idle bins.
- Will have an "idle" and "non-idle" adjustment.
- Heat index activity adjustment applied as in MOBILE6.
 - Includes the A/C fleet penetration.
 - Includes combined temperature/humidity effects.

Adjustments

Air Conditioning Issues

- EPA is not aware of air conditioning testing that demonstrates the effects of air conditioning load on PM emission rates.
- EPA proposes to use the same effects for PM as are used for HC emissions in MOVES.

Adjustment Humidity & Altitude Effects

- **Humidity**
 - Affects NO_x emission rates for both gasoline and diesel fueled vehicles.
 - Used in the calculation of air conditioning demand.
- **Altitude effects will not be addressed in the MOVES2006 (draft).**

Adjustments Other Issues

- No adjustments are made to account for roadway grade.
- Adjustments do not vary by age.
- EPA plans to make changes in the draft (MOVES2006) fuel adjustments.