MAKING USE OF MOBILE6’S CAPABILITIES FOR MODELING START EMISSIONS

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Overview

- Why Start Emissions Are Important
- Overview of MOBILE6 Capabilities for Handling Start Emissions
- Methods for Accounting for Start Emissions in SIP and Conformity Analyses
- Conclusions & Recommendations
Introduction

- Start emissions are a significant portion of total on-highway vehicle emissions in MOBILE6.
- Although MOBILE6 offers new and improved capabilities for handling start emissions, most model users don’t take advantage of them.
Why Start Emissions Are Important

- Starts account for 28% of total on-road VOC emissions (exhaust and evaporative combined), 31% of CO exhaust emissions, and 20% of NOx exhaust emissions in a typical 2001 summertime model scenario.

- Under wintertime conditions, start emissions can comprise up to 50% of total CO exhaust emissions.
Start Emissions in MOBILE5

- In MOBILE5, as in the Federal Test Procedure, VMT in the cold start (Bag 1) and hot start (Bag 3) modes were weighted (43% cold, 57% hot).
- MOBILE5 combined the weighted start mode emissions with hot stabilized operation to produce emission rates.
- Users could modify the cold start, hot start, and hot stabilized percentages.
Start Emissions in MOBILE6

- MOBILE6 calculates start emissions separately, as a start “offset”
- Starts are not either hot or cold, but vary based on the *soak distribution* (length of time parked before the start)
- Unless instructed otherwise, MOBILE6 combines the weighted start mode emissions with hot stabilized (running) emissions to produce combined emission rates (just like MOBILE5)
Real World Start & Running Emissions

(a minute or two)
MOBILE5 Start Calculations

Start Emissions

Running Emissions

3.59 mi
(505 sec)

7.5 mi

Emissions rate
MOBILE6 Start Calculations

- Start Emissions
- Running Emissions

Emissions rate vs distance: 7.5 mi
MOBILE5 & MOBILE6: Default Reporting Method

- Start Emissions
- Running Emissions

Emissions rate

3.59 mi
7.5 mi
Start Emissions in MOBILE6

- Rather than rely on MOBILE’s default mode of reporting emissions, users now have new flexibility:
  - Users can report start and running emissions separately
  - Users can modify the various distributions that affect start emission rates
Reporting Start Emissions Separately in MOBILE6

- Use the EXPAND EXHAUST command in the descriptive output.
- Using the database output, emissions can be calculated in terms of grams per hour, grams per day, grams per mile, or grams per start (note: this generates a lot of data!)
Modifying the Distributions

- **STARTS PER DAY**
  - Allows users to specify the average number of starts (trips) per day by vehicle class

- **START DIST**
  - Allows users to allocate engine starts (trips) by hour of day

- **SOAK DISTRIBUTION**
  - Allows users to modify the default soak distribution, which defines, by hour of day, how long vehicles have been parked prior to an engine start
# STARTS PER DAY Default Values

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Weekday</th>
<th>Weekend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Duty Car</td>
<td>7.28</td>
<td>5.41</td>
</tr>
<tr>
<td>Light Duty Truck</td>
<td>8.06</td>
<td>5.68</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>1.35</td>
<td></td>
</tr>
<tr>
<td>Heavy Duty Gas Vehicle and Bus</td>
<td>6.88</td>
<td></td>
</tr>
<tr>
<td>Heavy Duty Diesel Vehicle and Bus</td>
<td>6.65</td>
<td></td>
</tr>
</tbody>
</table>
Some Notes . . .

- Start emissions are not reported separately in MOBILE6 for heavy duty gas or HD diesel vehicles, or buses.
- Start emissions are not reported separately for particulate matter.
- Users may modify the starts per day and soak distributions, but EPA recommends that an instrumented vehicle study be conducted.
New Methods for Handling Start Emissions

- Addressing the impact of MOBILE6’s default mileage accumulation rates on calculated grams per mile start emission factors
- Modifying the default hourly start distribution to reflect local travel patterns
New Methods for Handling Start Emissions

- Modifying the default starts per day for trips that are not started or completed within the urban area (external/internal and external/external (through) trips)
- Using travel model trips as a surrogate for MOBILE model starts
New Methods for Handling Start Emissions

- Assigning starts to travel model zones
- Considering starts for purposes of project-level analysis
1. MOBILE6’s MAR and start emission factors

- MOBILE6 calculates total daily start emissions and then divides by miles/day to estimate grams/mile.
- Miles/day comes from default or user-supplied mileage accumulation rate (MAR).
- Default daily weighted MAR for LDV/LDT/MC is 31.24 miles/day: is this appropriate for your area?
MOBILE6’s MAR and start emission factors

- Example for Denver:
  - Default MAR: 31.24 mi/day
    - MOBILE6 CO start emissions: 387.4 gm/day
    - Start emission rate = 12.4 gm/mi
  - Denver MAR: 35.87 mi/day
    - MOBILE6 CO start emissions: 387.4 gm/day
    - Start emission rate = 10.8 gm/mi
MOBILE6’s MAR and start emission factors

- Apply these emissions rates to Denver VMT (51,300,000 for LDV, LDT, MC):
  - CO start emissions using default MAR = 700 tons/day
  - CO start emissions using Denver MAR = 610 tons/day
MOBILE6’s MAR and start emission factors

Solutions:

- Use National Household Travel Survey data (if available for your area) to adjust MOBILE6 emissions based on default MAR

- Use local MAR data in MOBILE6
  - Note: using local MAR data has other effects in the model: MAR is used to “age” the fleet, so changing the MAR will change more than just start emissions rates.
2. Modifying the Start Distribution with Local Data

- Users can modify the model’s default distribution of trips by hour of day (instrumented vehicle study not required)
- This has a smaller impact on total emissions (0% - 3%) but is easy to do.
  - Sometimes a 3% difference is significant for an attainment demonstration or conformity determination
Modifying the Start Distribution with Local Data

Options:

- Use hourly VMT distribution (obtained from traffic recorders or other source) as a surrogate for hourly start distribution
- Use hourly trip distribution from the travel model to represent the hourly start distribution
Modifying the Start Distribution with Local Data

![Graph showing M6 hourly VMT and M6 hourly starts over a 24-hour period.](image-url)
Modifying the Start Distribution with Local Data
Modifying the Start Distribution with Local Data

<table>
<thead>
<tr>
<th></th>
<th>Defaults</th>
<th>Local HVMT</th>
<th>Percent Difference</th>
<th>Local HVMT &amp; Starts</th>
<th>Percent Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOC, gm/mi</td>
<td>1.75</td>
<td>1.763</td>
<td>0.74%</td>
<td>1.801</td>
<td>2.91%</td>
</tr>
<tr>
<td>CO, gm/mi</td>
<td>20.925</td>
<td>21.074</td>
<td>0.71%</td>
<td>21.669</td>
<td>3.56%</td>
</tr>
<tr>
<td>NOx, gm/mi</td>
<td>2.933</td>
<td>2.933</td>
<td>0.00%</td>
<td>2.939</td>
<td>0.21%</td>
</tr>
</tbody>
</table>

Comparison of defaults, local HVMT, and local HVMT plus start distribution based on HVMT for Galveston, Texas.
3. Dealing with Trips that Begin/End Outside the Area

- In most areas, some portion of VMT is made up of trips that don’t start within the modeling area (external/internal and through trips).
- If MOBILE6 start emissions rates are applied to all regional VMT, which is common practice, start emissions will be overcounted.
Dealing with Trips that Begin/End Outside the Area

Example for Denver

- 60,600,000 total daily VMT
  - 800,000 due to through trips
  - 5,300,000 due to external-to-internal trips
  - 6,100,000 daily VMT does not have a start in the modeling area

- Applying start emissions rates to all VMT would overestimate start emissions by about 10%
- In the winter, would overestimate total CO emissions by about 5%
Dealing with Trips that Begin/End Outside the Area

- Solutions
  - Model emissions for VMT from through and external-to-internal trips separately, with STARTS PER DAY set to zero (or with just running and evap emissions)
  - Modify the default starts per day estimate to account for VMT without an associated start
Dealing with Trips that Begin/End Outside the Area

Notes

- This issue is especially important for rural/fringe counties, with large amounts of through VMT, to consider.
- Changing starts/day also changes hot soak activity. External-to-internal trips don’t have a start in the area, but there will still be a hot soak at the end of the trip; be careful not to undercount these emissions.
4. Using Travel Model Trips for MOBILE6 Starts

- Travel models are not a good source of information for the number of starts per day; they are not good at capturing trip chaining.
- A quick stop at the coffee shop on the way to work usually isn’t reported as a separate trip, but it does result in an additional start.
Using Travel Model Trips for MOBILE6 Starts

- Can get around this by calculating a ratio of travel model trips to MOBILE default starts, and using this as an adjustment factor.
- Travel model outputs can then be used to develop inventories, without the risk of undercounting start emissions.
5. Assigning Starts to Travel Model Zones

- Start emissions can be calculated in terms of grams/start (either on a daily average or hourly basis)
- Start emissions can be assigned to the travel model zones where trips originate
  - Result: better definition of the geographic and temporal distribution of emissions for photochemical modeling
6. Considering Starts for Project-Level Analysis

- EPA recommends that in most cases, start emissions should not be included in the CO emissions rates used in CAL3QHC intersection modeling.
- MOBILE6 capabilities facilitate this, along with specialized consideration of start impacts for some projects (park & ride lots and other TCMs, sports arenas)
Conclusions & Recommendations

- If local MAR is very different than local defaults, use local MAR data or calculate start emissions separately.
- Use a local hourly start distribution, or use the hourly VMT distribution as a surrogate.
- Factor out start emissions for VMT on trips that don’t have a start in the modeling area.
Conclusions & Recommendations

- For photochemical modeling applications, refine the inventory by assigning start emissions to the zones where they occur.
- For project-level analysis, don’t include start emissions for most hotspot analysis; for analysis of TCMs and other special projects, consider how the project will affect start activity.
For Further Information . . .

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- Paper posted at www.fhwa.dot.gov/resourcecenter/teamaq_pubs.htm