Analysis of MOBILE6.2’s PM Emission Factor Estimating Function

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Federal Highway Administration
EPA's approval of the MOBILE6.2 emissions factor model is effective May 19, 2004.

M6.2 particulate matter (PM) module replaces PART5 (1995).
ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 51

[FRL–7663–6]


AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice of availability.

SUMMARY: EPA is approving and announcing the availability of the MOBILE6.2 motor vehicle emissions factor model for official use in particulate matter (PM_{10} and PM_{2.5}) SIPs and transportation conformity determinations outside of California. MOBILE6.2 is an update to MOBILE6 which adds the capability to estimate direct exhaust and brake and tire wear particulate matter emission factors for PM_{10} and PM_{2.5}, and exhaust emission factors for particulate precursors to the MOBILE6 model. MOBILE5.2 is a

entrained road dust is effective May 19, 2004. See below for further information regarding how today’s approval starts time periods after which MOBILE6.2 and the December 2003 AP–42 methods are required in new transportation conformity analyses and certain SIP and motor vehicle emissions budget revisions.

FOR FURTHER INFORMATION CONTACT: If you have questions on this notice, please send an e-mail to EPA at mobile@epa.gov or contact EPA at (734) 214–4636 for technical model questions about MOBILE6.2. Please send an e-mail to EPA at info.chief@epa.gov or contact EPA at (919) 541–1000 for technical questions about the December 2003 AP–42 methods.

SUPPLEMENTARY INFORMATION:

Availability of Models and Support Materials

Copies of the official version of the MOBILE6.2 model are available on EPA’s MOBILE Web site, http://www.epa.gov/otaq/m6.htm. The MOBILE Web site also contains the

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I. What Is MOBILE6.2 and How Is It Different From MOBILE6?

MOBILE is an EPA emissions factor model for estimating pollution from on-road motor vehicles in states outside of California. The model accounts for the emission impacts of factors such as changes in vehicle emission standards, changes in vehicle populations and activity, and variation in local conditions such as temperature, humidity, fuel quality, and air quality programs.
Outline

- PART5 vs. MOBILE6.2 Comparison
  - Model Year
  - Speed
- Sensitivity analysis of MOBILE6.2
  - VMT by Facility
  - Roadway Facility Speed Effects
  - Gasoline Sulfur Content
  - Diesel Sulfur Content
  - Minimum and Maximum Temperature
  - Fuel RVP Effects
- Conclusions
PART5 vs. MOBILE6.2
Comparison
## Comparison of M6.2 and PART5

<table>
<thead>
<tr>
<th>M6.2 Pollutants</th>
<th>Part5 Pollutants</th>
<th>Description [Sources: PART5 and M6.2 users manuals]</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCARBON (Organic CO)</td>
<td>SOF (soluble organic fraction)</td>
<td>Organic Carbon of diesel exhausts particulate emissions. Other than name change, no other change was done.</td>
</tr>
<tr>
<td>ECARBON (Elemental &amp; residual CO)</td>
<td>RCP (remaining carbon portion).</td>
<td>Elemental and residual Carbon of diesel exhausts particulate emissions. Other than name change, no other change was done.</td>
</tr>
<tr>
<td>GASPM</td>
<td>Carbon</td>
<td>Organic, elemental, and residual Carbon of gasoline exhausts particulate emissions.</td>
</tr>
<tr>
<td>SO$_4$</td>
<td>DIS</td>
<td>Direct Gasoline Sulfate Particle emissions: same algorithm, but now M6.2 calculations account for different fuel sulfur content.</td>
</tr>
<tr>
<td>Not available</td>
<td>INS</td>
<td>Indirect sulfate: sulfate formed in the air from vehicle emissions. In PART5 it is calculated based on measurements of ambient sulfur from 11 cities in the US. It also assumes that 12% of gaseous SO$_2$ reacts in the atmosphere to form SO$_4$.</td>
</tr>
</tbody>
</table>
### Comparison of M6.2 and PART5 (cont.)

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<tr>
<th>M6.2 Pollutants</th>
<th>Part5 Pollutants</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>Lead</td>
<td>Gasoline Lead particulate emissions based on fuel content. Both models assume that post 1975 model year vehicles, and after 1991 calendar years, are free of lead.</td>
</tr>
<tr>
<td>NH3</td>
<td>Not Available</td>
<td>Only gaseous ammonia directly emitted directly from a vehicle tailpipe are considered in Ammonia emission factors. Estimates are based in a 1981 report (EPA/AA/CTAB/PA/81-20).</td>
</tr>
<tr>
<td>BRAKE</td>
<td>BRAKE</td>
<td>PM emission factors from brake wear. The brake wear calculation portion of PART5 was not updated.</td>
</tr>
<tr>
<td>TIRE</td>
<td>TIRE</td>
<td>PM emission factors from tire wear. The tire wear calculation portion of PART5 was not updated.</td>
</tr>
<tr>
<td>Total PM</td>
<td>Total PM</td>
<td>Total PM includes: exhaust PM, indirect sulfate, brake-wear and tire-wear.</td>
</tr>
</tbody>
</table>
### Comparison of M6.2 and PART5 (cont.)

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</thead>
<tbody>
<tr>
<td>Not available</td>
<td>Fleet average unpaved road dust</td>
<td>PART5’s calculation of fugitive dust from paved and unpaved roads was removed in M6.2.</td>
</tr>
<tr>
<td>Not available</td>
<td>Fleet average paved road dust</td>
<td></td>
</tr>
<tr>
<td>SO$_2$</td>
<td>SO$_2$</td>
<td>Gaseous Sulfur Dioxide: same algorithm, but now M6.2 calculations account for different fuel sulfur content.</td>
</tr>
</tbody>
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Comparison of M6.2 and PART5
Emissions Comparison by Calendar Years

**PM 2.5**

- PART5 Total PM
- M6 Total PM

**PM 10**

- PART5 Total PM
- M6 Total PM

[Graphs showing the comparison of PM 2.5 and PM 10 emissions by calendar year from 2001 to 2020.]
Tire Wear and Break Wear Emissions by Calendar Year

**PM 2.5**: Over the years, PM 2.5 emissions have remained relatively stable, with slight increases observed in recent years.

**PM 10**: Emissions of PM 10 have shown a gradual increase over the years, with a more significant rise in the latter part of the period.

**PM 2.5 Brake**: Emissions for PM 2.5 from brakes have been consistent throughout the years, with no noticeable trend.

**PM 10 Brake**: Emissions for PM 10 from brakes have remained steady with slight fluctuations over the years.

The graphs indicate a general trend of increasing emissions for both PM 2.5 and PM 10, particularly from the brake wear, with the most significant increase observed in the latter years of the data.
Emissions Comparison by Speed

PM2.5

PM10

PART5 Exhaust PM

M6 Exhaust PM

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Emissions Comparison by Speed

**PM 2.5**

- Speed [mph]: 5 to 65
- Emissions: 0.0000 to 0.1200
- Data points for PART5 Gas. SO2 and M6 SO2

**PM10**

- Speed [mph]: 5 to 65
- Emissions: 0.0000 to 0.1200
- Data points for PART5 Gas. SO2 and M6 SO2
Tire Wear and Break Wear

Emissions by Speed

PM 2.5

- 0.0018
- 0.0019
- 0.0020
- 0.0021
- 0.0022
- 0.0023
- 0.0024
- 0.0025

Speed [mph]

PART5 Tire
M6 Tire

PM10

- 0.0087
- 0.0088
- 0.0089
- 0.0090
- 0.0091
- 0.0092
- 0.0093
- 0.0094
- 0.0095

Speed [mph]

PART5 Tire
M6 Tire

PM 2.5

- 0.0049
- 0.0050
- 0.0051
- 0.0052
- 0.0053
- 0.0054

Speed [mph]

PART5 Brake
M6 Brake

PM10

- 0.0131

Speed [mph]

PART5 Brake
M6 Brake
Sensitivity Analysis of MOBILE6.2
PM Components by Facility

PM2.5 Components vs. VMT by Facility

PM10 Components vs. VMT by Facility

VMT Ratio (Freeway/Arterial)
PM Trends by Calendar Year

PM2.5 and PM10 Trend 2002 through 2020

PM2.5 Components Trend 2002 through 2020

PM10 Components Trend 2002 through 2020

PM SO2 and NH3 Trend 2002 through 2020
Freeway Mainline Speed Effects on PM2.5

- **EXHAUST PM2.5**
- **TOTAL PM2.5**

**Components**
- GASPM
- EC
- OC
- SO4
- BRAKE
- TIRE
Gasoline sulfur effects

Gasoline Sulfure Effects on PM2.5

Gasoline Sulfure Effects on PM2.5 Components

Gasoline Sulfure Effects on PM10

Gasoline Sulfure Effects on PM10 Components
Diesel sulfur effects

**Diesel Sulfur Effects on PM2.5**

- **Graph 1:** Diesel Sulfur Effects on PM2.5 Components
  - Diesel Sulfur Content [ppm]: 0.000, 0.005, 0.010, 0.015, 0.020, 0.025, 0.030, 0.000, 1000, 2000, 3000, 4000, 5000
  - Diesel Sulfur Content [ppm]: 0.000, 0.005, 0.010, 0.015, 0.020, 0.025, 0.030, 0.000, 1000, 2000, 3000, 4000, 5000
  - Graph shows the effect of diesel sulfur content on PM2.5 components.

- **Graph 2:** Diesel Sulfur Effects on PM2.5
  - Diesel Sulfur Content [ppm]: 0.025, 0.035, 0.045, 0.055, 0.065, 0.075, 0.000, 1000, 2000, 3000, 4000, 5000
  - Graph shows the effect of diesel sulfur content on PM2.5.

**Diesel Sulfur Effects on PM10**

- **Graph 1:** Diesel Sulfur Effects on PM10 Components
  - Diesel Sulfur Content [ppm]: 0.000, 0.005, 0.010, 0.015, 0.020, 0.025, 0.030, 0.000, 1000, 2000, 3000, 4000, 5000
  - Diesel Sulfur Content [ppm]: 0.000, 0.005, 0.010, 0.015, 0.020, 0.025, 0.030, 0.000, 1000, 2000, 3000, 4000, 5000
  - Graph shows the effect of diesel sulfur content on PM10 components.

- **Graph 2:** Diesel Sulfur Effects on PM10
  - Diesel Sulfur Content [ppm]: 0.025, 0.035, 0.045, 0.055, 0.065, 0.075, 0.000, 1000, 2000, 3000, 4000, 5000
  - Graph shows the effect of diesel sulfur content on PM10.
Minimum and Maximum Temperature Effects on PM 2.5

Minimum Temperature Effects on PM2.5
(Hold Max at Constant)

Maximum Temperature Effects on PM2.5
(Hold Min at Constant)

Minimum Temperature Effects on PM2.5
Components (Hold Max at Constant)

Maximum Temperature Effects on PM2.5
Components (Hold Min at Constant)
Minimum and Maximum Temperature Effects on PM10

Minimum Temperature Effects on PM10 (Hold Max at Constant)

Maximum Temperature Effects on PM10 (Hold Min at Constant)

Minimum Temperature Effects on PM10 Components (Hold Max at Constant)

Maximum Temperature Effects on PM10 Components (Hold Min at Constant)
Fuel RVP Effects on PM2.5

Fuel RVP Effects on PM2.5 Components

Fuel RVP Effects on PM10

Fuel RVP Effects on PM10 Components
Conclusions

- Exhaust emissions factors tend to be lower using M6.2 than predicted by PART5, while tire wear and brake wear emission factors tend to be higher.
- M6.2’s PM emission factors benefit from:
  - the use of newer data (vehicle registration, diesel fractions, fuel economy, and mileage accumulation rates)
  - the inclusion of recent rulemaking (including fuel sulfur level reductions)
  - capability to account for the sulfur level of fuels (gasoline and diesel)
Conclusions

- The sensitivity analysis of the M6.2 PM module indicated that PM2.5 emission factors results are consistent with PM10 emission factors.
- It was found that emission factors tend to decrease for both PM2.5 and PM10 in later calendar years.
- The difference is apparently related to future model years updates reflecting more stringent vehicle emissions and fuel standards.
Conclusions

Negligible Effects:
- roadway facility types
- Speed
- Gasoline Sulfur
- Minimum and maximum temperature
- Fuel RVP

Highly Sensible Effects
- diesel sulfur content.
Conclusions

- Remember that you still need to use the December 2003 AP42 Methods for re-entrained dust!