Fine Fraction of Particulate Matter in Fugitive Dust

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Performing Organization
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Fugitive Dust Emissions

- Highly fluctuating plume impacts at emission measurement site
- PM concentrations vary from background to plume core values
- Emissions depend on energy inputs and properties of emitting surface material
Road Dust Plume Concentrations

DustTRAK 1.6(m) CS-X5

Concentration (mg/m³) vs. Time

- Blue line: DustTRAK 1.6(m) CS-X5
AP-42 Emission Factors

- Predictive equations with particle size multipliers
- Historically, particle size multipliers based on data from high-volume cyclone/cascade impactors
- Potential for particle size bias in overpredicting fine fractions
Discrepancy in Fine Fraction Data

- Emission data from the high-volume cyclone/impactor system have provided the basis for a $\text{PM}_{2.5}/\text{PM}_{10}$ of $\sim 0.20$ for many fugitive dust sources in EPA’s AP-42

- Ambient air monitoring data suggest that $\text{PM}_{2.5}/\text{PM}_{10}$ may be less than 0.10
MRI Cyclone/ Cascade Impactor System
Plume Characterization Options

- Field studies produce highly variable results because of wind variations.
- Laboratory exposure chambers can produce nearly steady-state conditions.
- Confounding factors can be reduced in controlled laboratory flow settings.
EPA Field Study in 1990s

- Purpose to resolve fine fraction emission biases for paved and unpaved roads
- Geographic distribution of test sites
- Cyclone/Impactor biases evident
- New AP-42 fine fractions were averages between cyclone/impactor and dichotomous sampler results
C/I Biases from Prior Field Study

![Graph showing PM 2.5/PM 10 Ratio vs. PM 10 Concentration](image)
Revisions to AP-42 Fine Fractions

- PM2.5/PM10 ratio for unpaved roads (dominated by fugitive dust) was reduced from 0.26 to 0.15
- PM2.5/PM10 ratio for paved roads was reduced from 0.46 to 0.25
- Non-dust component of paved road emissions assigned a PM2.5/PM10 ratio of 0.76, accounting for vehicle exhaust and brake and tire wear
Purpose of Controlled Lab Study

- Collect new controlled data from collocated reference PM monitors with MRI high-volume cyclone/impactor system
- Determine extent of any bias in the PM$_{2.5}$/PM$_{10}$ ratio as determined by the cyclone/impactor system
Looking through tunnel toward Inlet flow straighteners
Viewing Window with Continuous PM Mass Monitor
Ref. Method Sampling Equipment
Phase I Testing

- **Purpose:** Determine potential bias in PM-2.5 concentration as measured by cyclone/impactor system
- **RFM:** Partisol Model 2000 for PM-2.5
- **Test materials:** ISO 12103-1 Arizona Test Dusts—fine and coarse grades; Owens Dry Lake surface soil
## Air Samplers: Phase I

<table>
<thead>
<tr>
<th>Unit</th>
<th>Sampler</th>
<th>Manufacturer/ model</th>
<th>Flow rate</th>
<th>Particle size cutpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Cyclone pre-separators</td>
<td>Sierra Model 230 CP</td>
<td>20 acfm</td>
<td>10.2 µmA</td>
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<tr>
<td>2</td>
<td>Multistage impactor</td>
<td>Sierra Model 230</td>
<td>20 acfm</td>
<td>2.1 µmA</td>
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<td>2</td>
<td>Partisol</td>
<td>R&amp;P Model 2000</td>
<td>16.7 alpm</td>
<td>2.5 µmA</td>
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<td>2</td>
<td>DustTRAK</td>
<td>TSI Model 8520</td>
<td>5 alpm</td>
<td>2.5 µmA and 10 µmA</td>
</tr>
</tbody>
</table>
MRI Cyclone for Sampling of PM-10 in Fugitive Dust
Exposure Chamber with Sampler Inlets
Phase II Testing

• Purpose: Determine PM-2.5/PM-10 ratios for a variety of western surface materials

• RFMs: Partisol Model 2000 for PM-2.5 and PM-10

• Test materials: Soils, aggregates, and unpaved road surface materials

• Aerosolization system: Constant flow energy
## Air Samplers: Phase II

<table>
<thead>
<tr>
<th>Unit</th>
<th>Sampler</th>
<th>Manufacturer/ model</th>
<th>Flow rate</th>
<th>Particle size cutpoint</th>
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<td>2</td>
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<td>TSI Model 8520</td>
<td>5 alpm</td>
<td>2.5 µmA and 10 µmA.</td>
</tr>
</tbody>
</table>
Contributors of Test Samples

• Great Basin UAPCD—Owens Dry Lake
• CH2MHiIl—Salton Sea
• WY AQD—Thunder Basin mine
• NM AQB—South central New Mexico
• Alaska DEC—Matanuska Valley
• Arizona DEQ—Maricopa & Pima Counties
# Properties of Test Soils/Surface Materials

<table>
<thead>
<tr>
<th>Code</th>
<th>State</th>
<th>Location</th>
<th>Type of material</th>
<th>Moisture content (%)</th>
<th>Dry silt content (%)</th>
<th>Dry Silt rank</th>
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</thead>
<tbody>
<tr>
<td>TF</td>
<td>Arizona</td>
<td>–</td>
<td>Standard Test Dust—Fine</td>
<td>–</td>
<td>–</td>
<td>–</td>
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<tr>
<td>TC</td>
<td>Arizona</td>
<td>–</td>
<td>Standard Test Dust—Coarse</td>
<td>0.60</td>
<td>87.6</td>
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<tr>
<td>AK</td>
<td>Alaska</td>
<td>MAT-SU Knik River Bed</td>
<td>Sediments</td>
<td>0.80</td>
<td>8.69</td>
<td>6</td>
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<tr>
<td>AZal</td>
<td>Arizona</td>
<td>Phoenix Area</td>
<td>Alluvial Channel</td>
<td>0.33</td>
<td>17.3</td>
<td>3</td>
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<tr>
<td>AZag</td>
<td>Arizona</td>
<td>Phoenix Area</td>
<td>Agricultural Soil</td>
<td>1.06</td>
<td>21.6</td>
<td>2</td>
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<tr>
<td>NMr</td>
<td>New Mexico</td>
<td>Las Cruces Landfill</td>
<td>Road Dust</td>
<td>1.27</td>
<td>12.2</td>
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<tr>
<td>NMs</td>
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<td>Radium Springs</td>
<td>Grazing Soil</td>
<td>0.47</td>
<td>10.9</td>
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<td>OW</td>
<td>California</td>
<td>Owens Dry Lake</td>
<td>Lakebed Soil</td>
<td>0.27</td>
<td>3.14</td>
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<tr>
<td>SS</td>
<td>California</td>
<td>Salton Sea</td>
<td>Shoreline Soils</td>
<td>5.46*</td>
<td>3.63</td>
<td>8</td>
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<tr>
<td>WY</td>
<td>Wyoming</td>
<td>Thunder Basin Mine</td>
<td>Barrow Pit for Access Road Surface Material</td>
<td>2.47*</td>
<td>6.83</td>
<td>7</td>
</tr>
</tbody>
</table>
Wind Erodibility Groups

- WEG values developed by USDA/NRCS to indicate the susceptibility of surface soil to blowing (Nine WEG values)

- Soil blowing correlated with:
  - Soil texture
  - Organic matter content
  - Effervescence due to carbonate reaction with HCl
  - Rock and pararock fragment content
  - Mineralogy
  - Soil moisture and frozen soil
PM-10 Emission Categories vs. Wind Erodibility Groups

- 1 – Silty Sand & Clay (WEG 4 and 5)
- 2 – Sandy Silt (WEG 2 and 3)
- 3 – Loam (WEG 4L)
- 4 – Sand (WEG 1)
- 5 – Silt (WEG 6 and 7)

Note: USDA provides national soil database (SSURGO) with WEG values for GIS analysis.
Soil Texture Triangle
Test Soils
Results of Controlled Wind Tunnel Study

- PM2.5 concentrations measured by the high-volume cyclone/impactor were factor-of-2 higher than measured by reference-method samplers.
  - Geometric mean bias of 2.01
  - Arithmetic mean bias of 2.15
Comparability of Field and Laboratory Test Results

- PM2.5 bias of cyclone/impactor system
  - Measured under controlled laboratory conditions
  - Closely replicated by the bias observed in the prior EPA-funded field study
  - Both studies used reference method samplers for comparison
Reporting Process

• Test Plan--with opportunity to observe laboratory wind tunnel facility
• Draft Test Report--with independent peer reviewers
• Comment/Response Log--for each review comment
• Revised Test Report
C/I Biases from Lab Study

PM 2.5 / PM 10 Ratio

AZ Ag Soil
Knik River Sediments
Las Cruces Landfill Road
Thunder Basin Mine
AZ Alluvial Channel
Radium Springs
Salton Sea

PM 10 Concentration (mg/m3)
Recommended AP-42 Fine Fractions

- Paved Roads [13.2.1]
- Unpaved Roads (Public & Industrial) [13.2.2]
- Construction & Demolition [13.2.3]
- Aggregate Handling & Storage Piles [13.2.4]
- Industrial Wind Erosion [13.2.5]
- Agricultural Tilling
- Open Area Wind Erosion
Paved Roads

• Current PM2.5/PM10 Ratios
  – Dust component: 0.25
  – Non-dust component: 0.76

• Proposed Change
  – Dust component: 0.15

• Justification
  – Factor of 2 bias in cyclone/impactor data
Unpaved Roads

- Current PM2.5/PM10 ratio: 0.15
- Proposed PM2.5/PM10 ratio: 0.1
- Justification
  - Controlled wind tunnel test results
  - Field test results
Construction & Demolition

- AP-42 recommends referring to other sections (e.g., unpaved roads)
- Category emissions normally dominated by travel over unpaved surfaces
- Proposed PM2.5/PM10 ratio: 0.1 (ref. earlier justification)
- Large cleared areas possible significant source of wind erosion (ref. section on open area wind erosion)
Aggregate Handling and Storage Piles

- Open storage pile emissions usually dominated by traffic on unpaved surfaces around piles
- Proposed PM2.5/PM10 ratio: 0.1 (ref. earlier justification)
- Proposed PM2.5/PM10 ratio for transfer operations: 0.15 (justification based on factor-of-two bias in cyclone/impactor system)
Industrial Wind Erosion

• Examples include open tailings piles or raw material storage piles

• Proposed PM2.5/PM10 ratio: 0.15

• Justification based on
  – Controlled wind tunnel test results
  – Prior tests with portable wind tunnel
Agricultural Tilling

- Original AP-42 section “under review”
- WRAP Handbook recommends PM2.5/PM10 ratio of 0.2
- Ratio of 0.2 consistent with controlled wind tunnel results, considering lower plume concentrations generated by slow moving implements
Open Area Wind Erosion

• Examples are disturbed soils such as agricultural fields

• Prior portable wind tunnel tests show ratios in the range of 0.3

• Proposed PM2.5/PM10 ratio: 0.15

• Justification:
  – Factor-of-two bias in C/I system
  – Owens Lake plume data
## Summary of Proposed Fine Fractions

<table>
<thead>
<tr>
<th>Fugitive dust source category</th>
<th>AP-42 section</th>
<th>PM$<em>{2.5}$/PM$</em>{10}$ Ratio</th>
<th>Current</th>
<th>Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paved Roads</td>
<td>13.2.1</td>
<td>0.25</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Unpaved Roads (Public &amp; Industrial)</td>
<td>13.2.2</td>
<td>0.15</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Construction &amp; Demolition</td>
<td>13.2.3</td>
<td>0.208</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Aggregate Handling &amp; Storage Piles</td>
<td>13.2.4</td>
<td>0.314 (transfer)</td>
<td>0.1 (traffic)</td>
<td>0.15 (transfer)</td>
</tr>
<tr>
<td>Industrial Wind Erosion</td>
<td>13.2.5</td>
<td>0.40</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Agricultural Tilling</td>
<td>–</td>
<td>0.222</td>
<td>0.2 (no change)</td>
<td></td>
</tr>
<tr>
<td>Open Area Wind Erosion</td>
<td>–</td>
<td>–</td>
<td>0.15</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

- Tested materials showed consistent particle size characteristics under constant energy input
- Tests results consistent with prior field study
- Sound basis for proposed revisions to PM2.5/PM10 ratios in AP-42