Causes and Implications of Large Particle Penetration during PM$_{10}$ Sampling

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FRM PM10 Samplers

- Performance metrics specified in 40 CFR 53 Subpart D
  - Wind Tunnel Testing
**FRM PM10 Samplers**

The graph shows the sampling effectiveness as a function of particle diameter. The effectiveness decreases sharply as the particle diameter increases. The line represents a lognormal distribution with parameters $d_{50} = 10 \mu m$ and slope $= 1.5$. The blue dots indicate CFR data points.
FRM PM10 Samplers

- Performance metrics specified in 40 CFR 53 Subpart D
  - Wind Tunnel Testing
  - Sampler Cutpoint
  - Estimation of Mass Collected from a standard aerosol relative to an “ideal” sampler
FRM PM10 Samplers

![Graph showing fractional penetration vs. aerodynamic particle size](image-url)

- **Thoracic Fraction (ISO, 1995)**
- **Ideal PM10 Sampler (40 CFR 53.43)**
FRM PM10 Samplers

- Performance metrics specified in 40 CFR 53 Subpart D

- Speculations of “oversampling”
Study Objective

Characterize the performance of a FRM PM10 size-selective inlet using analysis methods designed to minimize the uncertainty in measured sampling effectiveness values for large particles.
Methods
Methods

Fluorometric Error
Quantech Fluorometer: Gain = 10X, PMT = Medium Low

QAQC for low signal differed from previous studies
Multiplet/Satellite Correction

- **Subpart D**
  - Microscopically count doublets and triplets
  - Ignores satellites
  - Limited sample size

- **TAMU Method**
  - Use APS to quantify distribution
  - Correct for particle stretching
Multiplet/Satellite Correction

Product of efficiency curve and test aerosol PSD proportional to expected sampling efficiency.
Results

8 km/h:
Cutpoint = 10.18µm
Slope = 1.52
Mass Conc. Diff. = 6.1%

3.5% Penetration of 25µm Particles
# Results

## Large Particle Penetration

<table>
<thead>
<tr>
<th>Wind Speed</th>
<th>20µm Particle</th>
<th>25µm Particle</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRM “Ideal” Sampler</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>2 kph</td>
<td>0.5±0.3%</td>
<td>0.01±0.01%*</td>
</tr>
<tr>
<td>8 kph</td>
<td>3.4±2.8%</td>
<td>3.5±0.8%</td>
</tr>
<tr>
<td>24 kph</td>
<td>5.4±3.3%</td>
<td>4.0±1.2%$</td>
</tr>
</tbody>
</table>

*Not statistically different than “zero”

§ Preliminary data
Implications

![Graph showing the relationship between particle size and fractional sampler penetration. The graph includes data points and curves representing measured values, lognormal data fit, EPA's "ideal" curve, and urban PSD.](image)
Implications
Measured Performance / “Ideal”

- Urban: 103%
- Dairy: 112%
- Feedyard: 115%
- Cotton Gin: 128%
- Broiler Housing: 153%
Implications/Questions

If so…
- Maybe the FRM sampler is okay for rural aerosols.
- What are the chemical or physical features of ag aerosols?
- At what point does penetration approach “zero”? 

Does the respiratory system work like this?
Implications/Questions

Does the respiratory system work like this? Or this?

If so…
- The FRM sampler does not work for rural aerosols.
- How do we sample large particles in a health-relevant manner?
Respiratory Modeling

Large Particle Penetration (Sampler)

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Respiratory Deposition Model# Simulation

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<th>20µm</th>
<th>25µm</th>
</tr>
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<tbody>
<tr>
<td>Extra thoracic</td>
<td>99%</td>
<td>99.6%</td>
<td>99.9%</td>
</tr>
<tr>
<td>Tracheobronchial</td>
<td>0.962%</td>
<td>0.367%</td>
<td>0.132%</td>
</tr>
<tr>
<td>Pulmonary</td>
<td>0.0057%</td>
<td>0.0002%</td>
<td>0.000003%</td>
</tr>
</tbody>
</table>

# Multiple-Path Particle Dosimetry Model; Applied Research Associates, Inc.
Implications

For healthy adults, it seems to be a lot closer to this...

If so...
- The FRM sampler does not work for rural aerosols.
- How do we sample large particles in a health-relevant manner?
Possible Path Forward

- Review new data with Dr. Vanderpool

- Is a Subpart D test similar to Subpart F testing more appropriate?

- What is leading to the penetration of large particles? What can be done about it?
Thanks…

- Cotton Foundation
- Texas AgriLife Air Quality Initiative
- Bob Vanderpool/EPA
- RTI for technical discussions
  - Seung-Hyun Cho
  - Christie Sayes
  - Quentin Malloy