

# Lung Deposition Sampler for Inhalable Aerosol

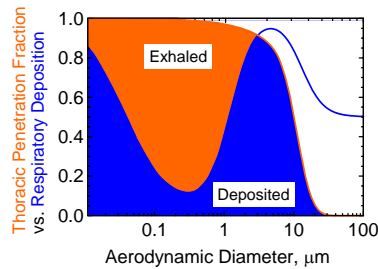
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## I. Abstract

The goal of this research is to develop a more powerful exposure assessment tool that estimates the deposition of inhaled particles to the human lung. A device that estimates lung deposition of inhaled particles will improve the power of risk assessment by providing a more physiologically-relevant measure of dose, and hence, inhalation hazard. We developed a model to predict particle penetration through porous foam media as a function of foam characteristics, particle size, and flowrate. Our semi-empirical model builds upon the work of Vincent et al.<sup>(1)</sup> and Kenny et al.<sup>(2)</sup> and utilizes three particle collection mechanisms: diffusion, inertia, and gravity. Four foam types of differing thickness and porosity were tested, along with solid and liquid particles ranging in size from 0.02 to 1 μm. **Application of the model indicates that a foam sampler may be developed with collection efficiency that approximates the ICRP lung-deposition curve.**

## Misclassification with Penetration-Based Samplers

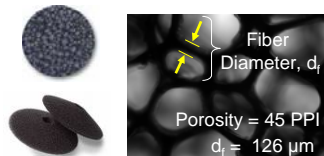


Penetration-based samplers (inhalable, thoracic, respirable) account for particle intake, but not deposition.

Exhaled aerosol does not contribute to dose, and the degree of exhaled aerosol depends strongly on the particle size distribution. A sampler that measures only deposition will better estimate dose, and hence, risk.

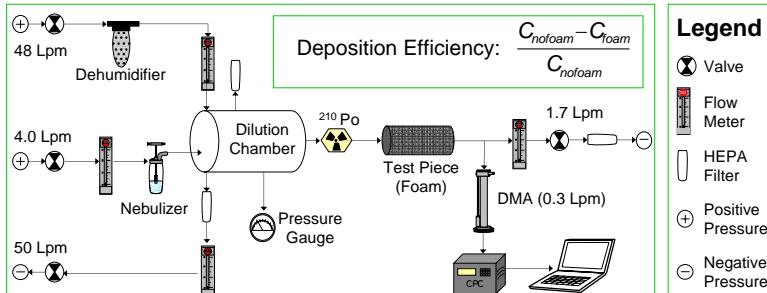
## II. Materials and Methods

### Porous Polyurethane Foam



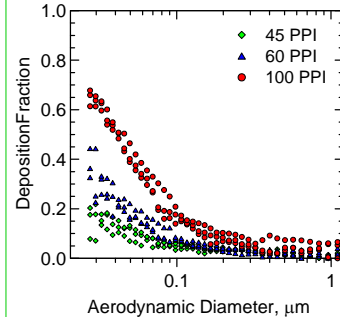
Experimental Variable	Level of Variation
Foam Thickness	5, 10, 20 mm
Foam Porosity	45, 60, 80, 100 PPI
Particle Size Range	0.011 – 1.08 μm
Aerosol Type	NaCl and Oil
Foam Diameter	17 mm (IOM Diam.)
Flow Rate	2 Lpm (IOM Flow)

### Experimental Setup



## III. Results

### Deposition vs. Porosity

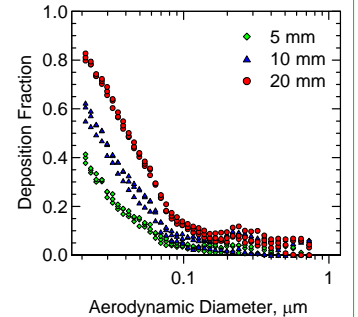


Increasing foam porosity (smaller  $d_f$ ) and thickness tend to increase particle deposition efficiency.

Results from multiple tests are repeatable.

No statistical difference in deposition between solid and liquid aerosols.

### Deposition vs. Thickness



### Particle-Foam Deposition Model

The semi-empirical model takes the following form<sup>1,2</sup>:

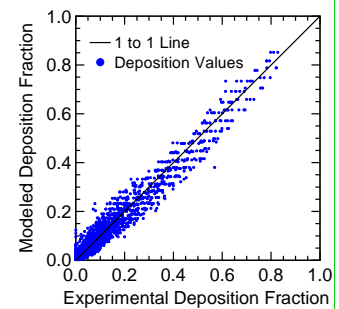
$$D = 1 - \exp\left[-\frac{t}{d_f} \left\{ \underbrace{0.0549(St)^{2.38} + 0.039(Ng)^{0.880}}_{\text{Vincent}^{(1)} \text{ and Kenny et al.}^{(2)}} + \underbrace{0.633(Pe)^{-0.732}}_{\text{This work}} \right\}\right]$$

where:

- D = Deposition fraction, t = foam thickness,  $d_f$  = fiber diameter,
- St = Stokes Number (Impaction),
- Ng = Gravitational Number (Settling),
- Pe = Peclet Number (Diffusion).

Based on a non-linear regression of deposition data vs. foam and aerosol characteristics. The model predicts deposition within 10%, shown at right.

### Model Performance



## IV. Conclusions and Future Work

Using a solver function within Excel, we have inverted the model with appropriate constraints to design a foam with deposition characteristics that mimic the ICRP lung deposition curve. While the design shown at right shows promise, we expect that further investigation will yield a sampler with an improved match.

Future work will evaluate the deposition characteristics of the proposed sampler in laboratory and field settings. We hope to design a second generation of deposition samplers calibrated to match regional deposition efficiencies of the nasal-pharyngeal, bronchial, and respiratory regions of the lung.

