Case Study
Nanoparticle Containment

Dennis Ford

Staff Engineer / Laser Safety Officer

Abbott Vascular

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AP2937332-MIS Rev. A

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Agenda

Background

Toxicology

Measurement Systems

Data Analysis

Mitigation

End Results

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5/07 - Became LSO

7/07 - Attended LSO Workshop

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Why worry about nanoparticles?

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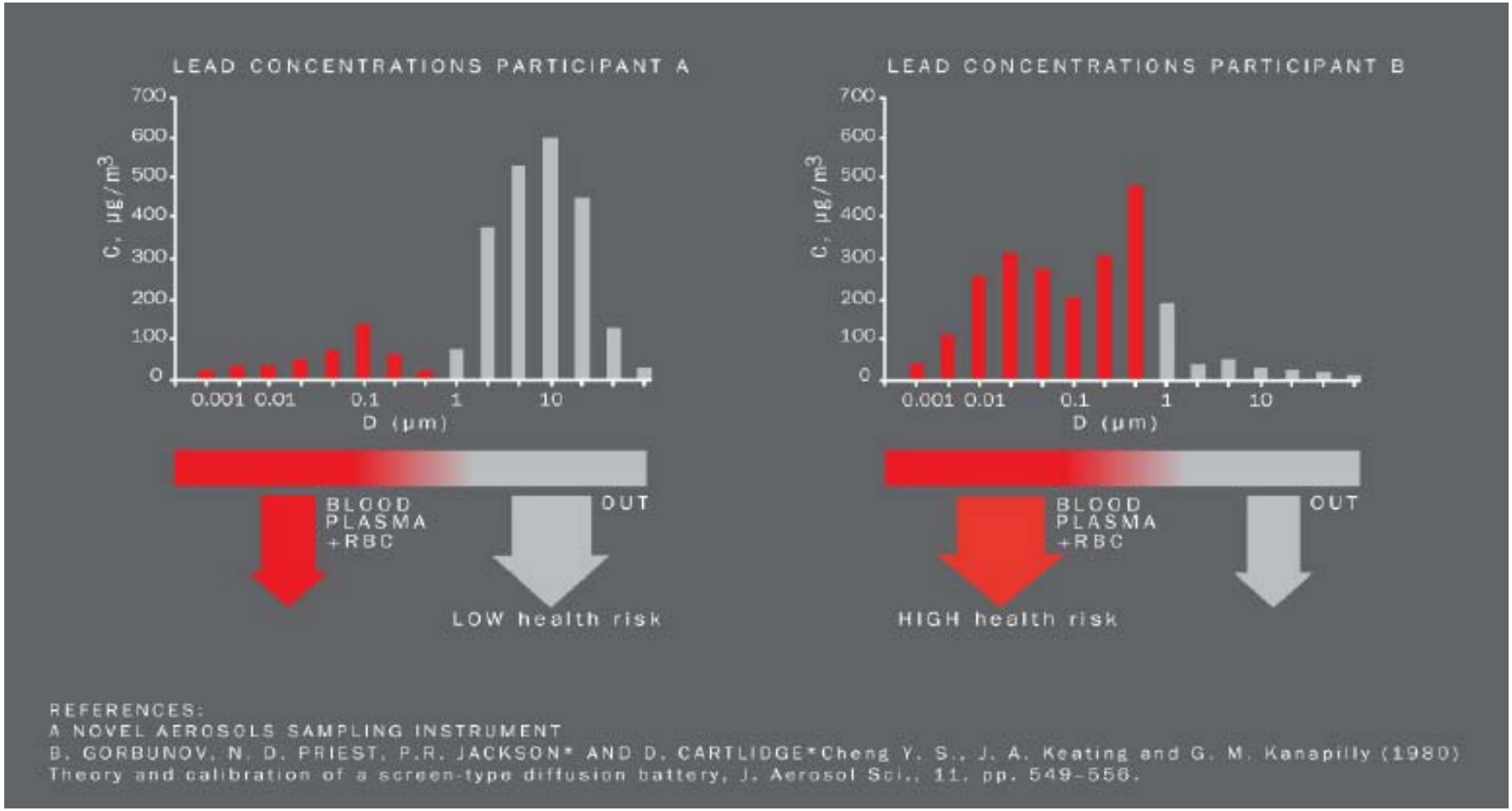
Size, Shape, and Surface Area Matters



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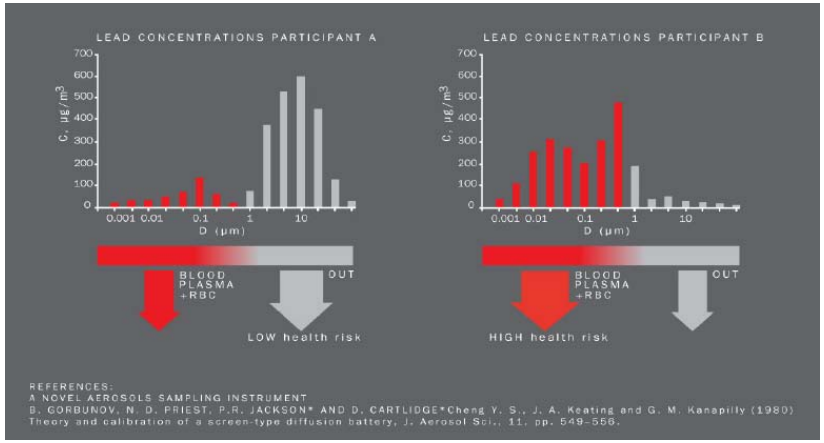

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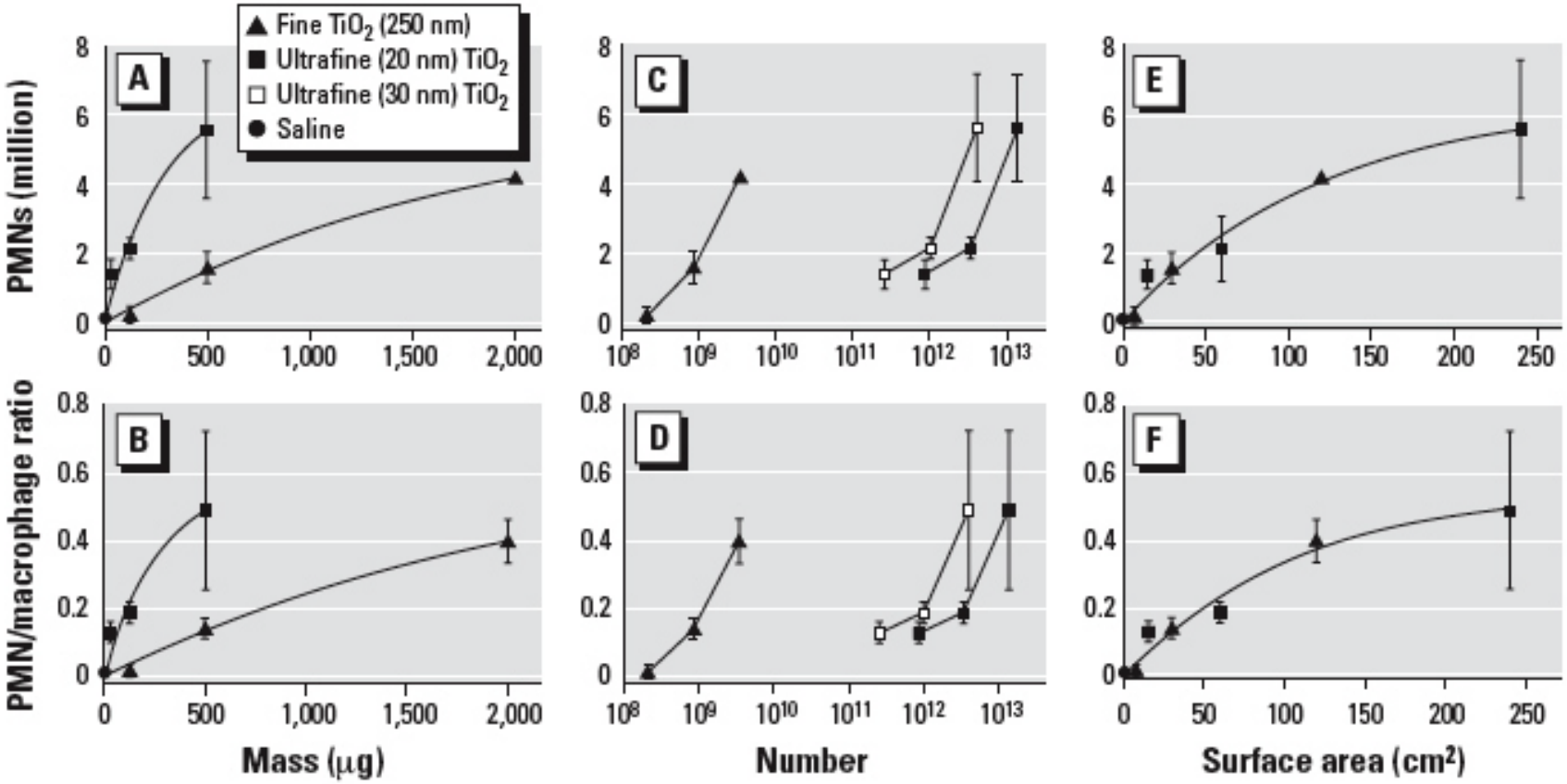

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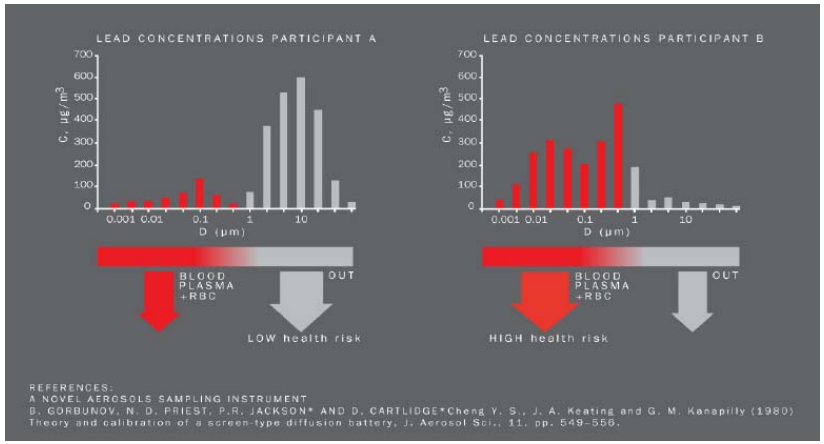

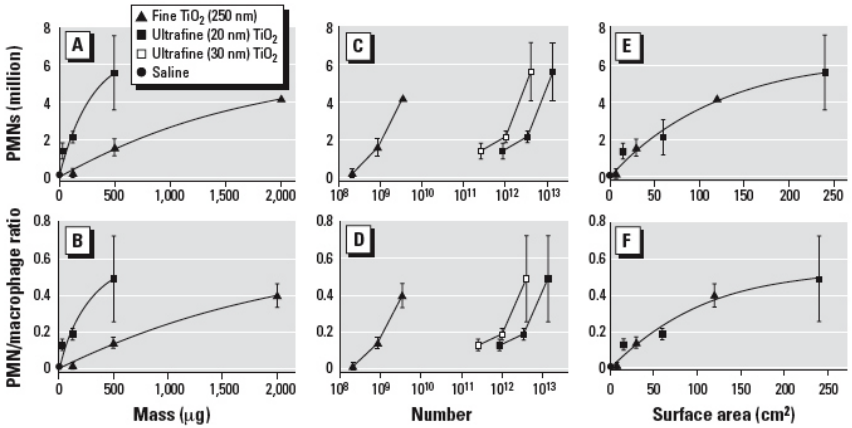

Oberdörster, Günter; Oberdörster, Eva; Oberdörster, Jan. "Concepts of Nanoparticle Dose Metric and Response Metric"

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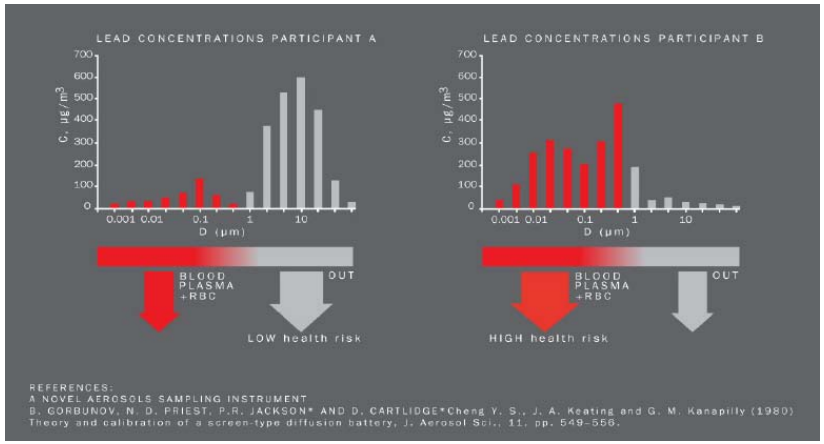

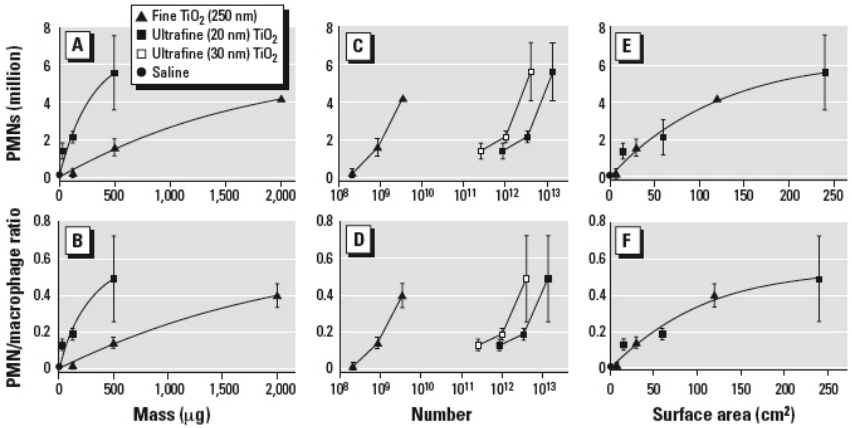

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Bullis, Kevin. "Shape Matters for Nanoparticle: Particles the size and shape of bacteria could more effectively deliver medicine to cells."

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Toxicology

National Institute for Occupational Safety and Health

- 1.5 mg/m^3 for fine TiO_2 (diameter greater than 100 nm)
- 0.1 mg/m^3 for ultrafine TiO_2 particles (diameter less than 100 nm)

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British Standards Institute

- benchmark level of 0.066 × WEL (workplace exposure limit)
- urban UK pollution is 20,000 to 50,000 particles/ml
  - lower end of this range 20,000 particles/ml discriminated from the ambient environmental particle concentration is an appropriate benchmark

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Institute of Occupational Medicine

- particle surface area is the most appropriate metric for assessment of inhalation exposure to nanoparticles

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Instrument Comparison

PMS Nano-ID	TSI SMPS 3936L75	TSI AeroTrak 9000
• Mass	• Number • Mass & SA by calc.	• Surface area
1 nm – 35 µm	10 nm – 1 µm	100 – 400 nm
• Samples saved for later analysis	• Real-time • Size distribution	• Real-time

Abbott Vascular chose these machines based on availability for evaluation. The machines were loaned to Abbott Vascular for the purposes of completing these tests. Abbott Vascular would like to thank both Particle Measuring Systems and TSI for their generous support. Abbott Vascular makes no recommendation regarding the applicability of these machines to any measurement.

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Particle Measuring Systems Nano-ID

1 nm - 35 µm

Collects samples onto 7 glass slides and 5 nylon filters for later analysis

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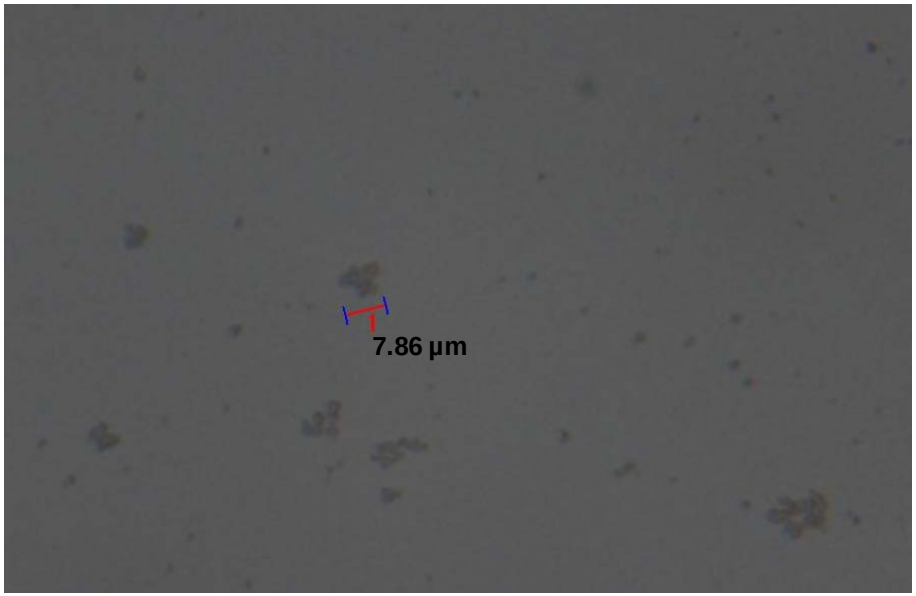
Particle Measuring Systems Nano-ID

Analysis:

- Optical Microscope



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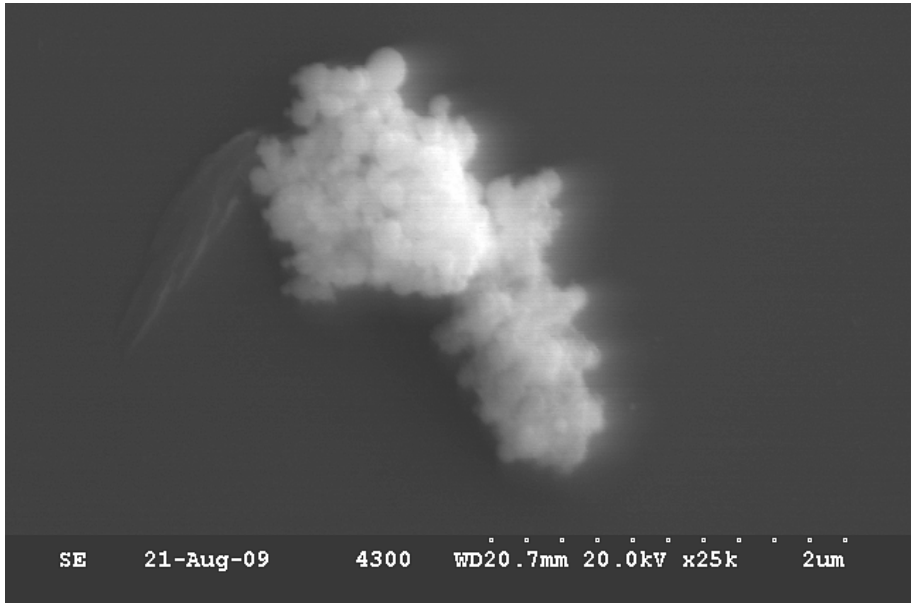
Particle Measuring Systems Nano-ID

Analysis:

- Scanning Electron Microscope



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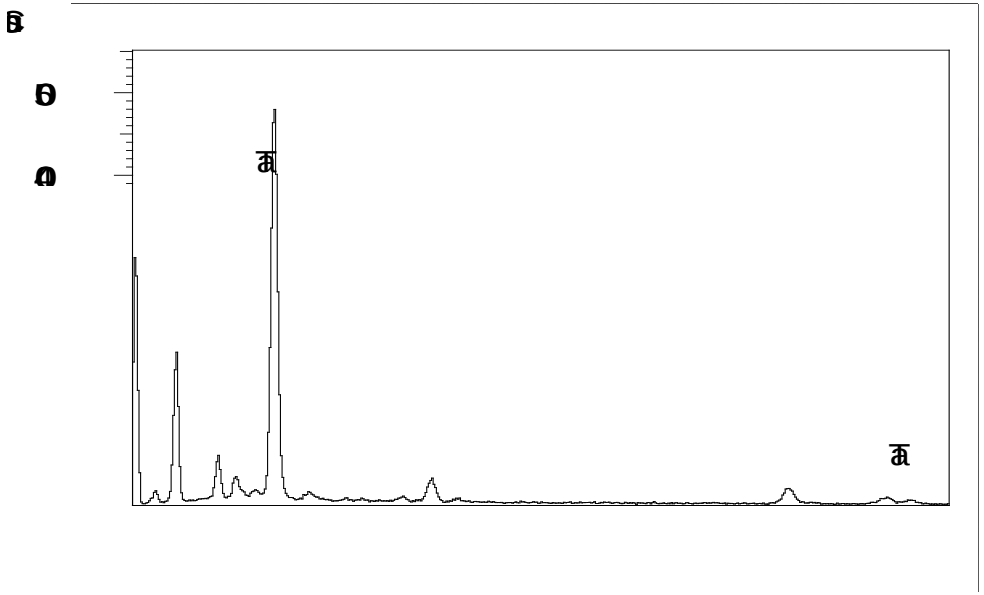
Particle Measuring Systems Nano-ID

Analysis:

- Energy Dispersive Spectroscopy



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TSI Scanning Mobility Particle Sizer 3936L75

Provides complete size distributions in 16 seconds
Broad size range – from 2.5 nm to 1,000 nm

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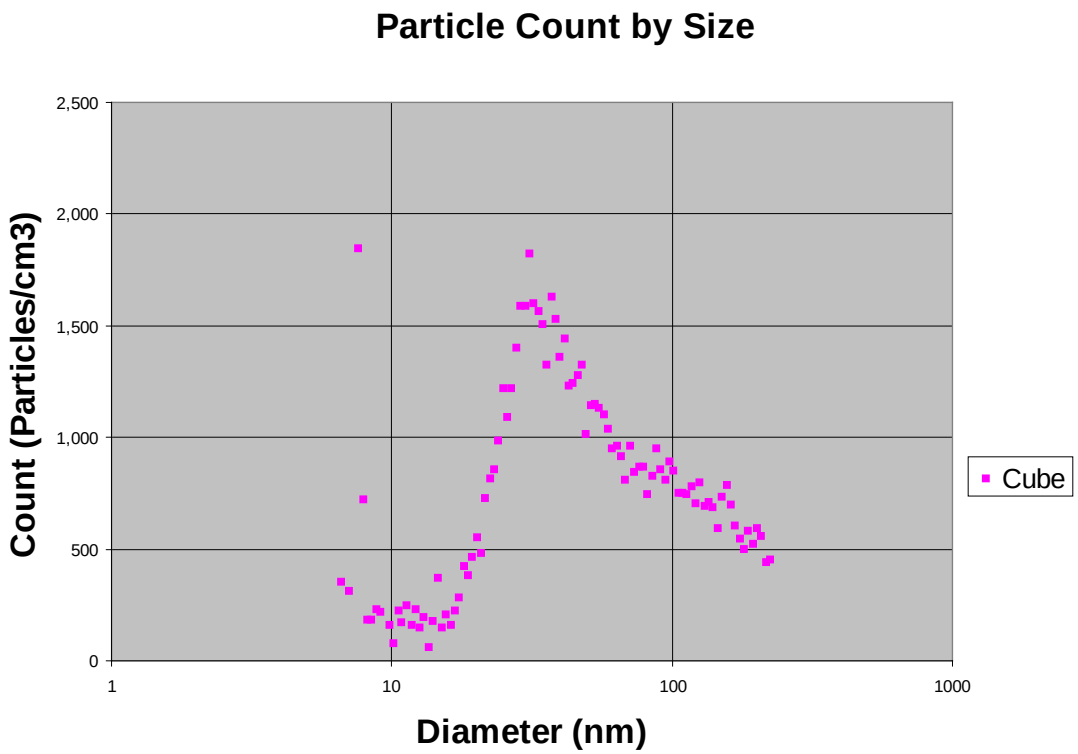
TSI Scanning Mobility Particle Sizer 3936L75

Particle size distribution at engineering cubicle



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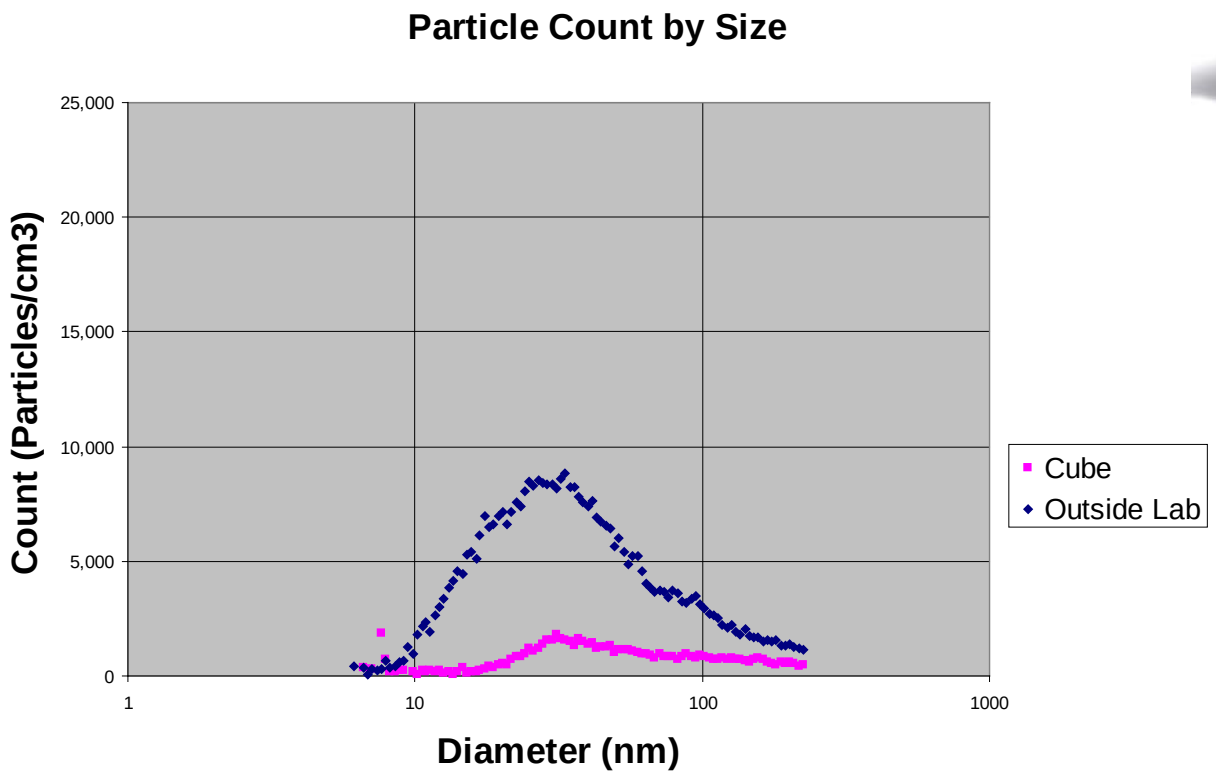
TSI Scanning Mobility Particle Sizer 3936L75

Particle size distribution at engineering cubicle and outside lab



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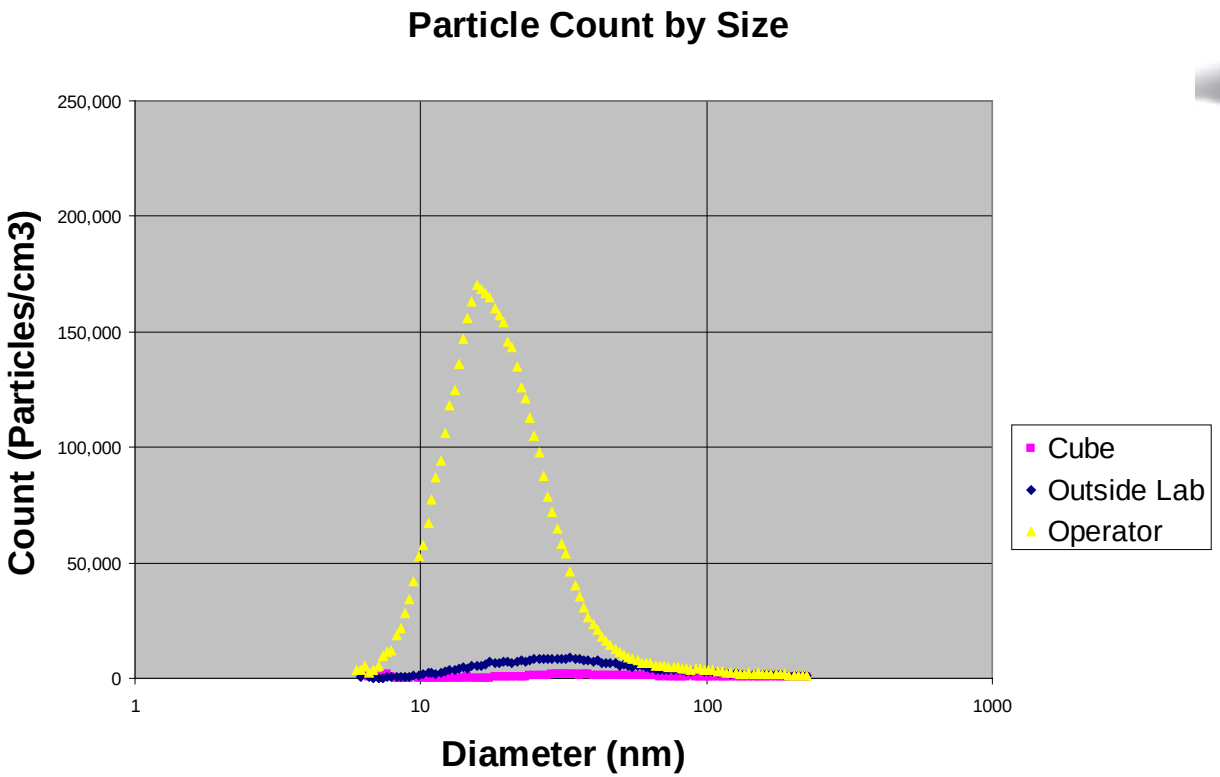
TSI Scanning Mobility Particle Sizer 3936L75

Particle size distribution at engineering cubicle, outside lab and near operator



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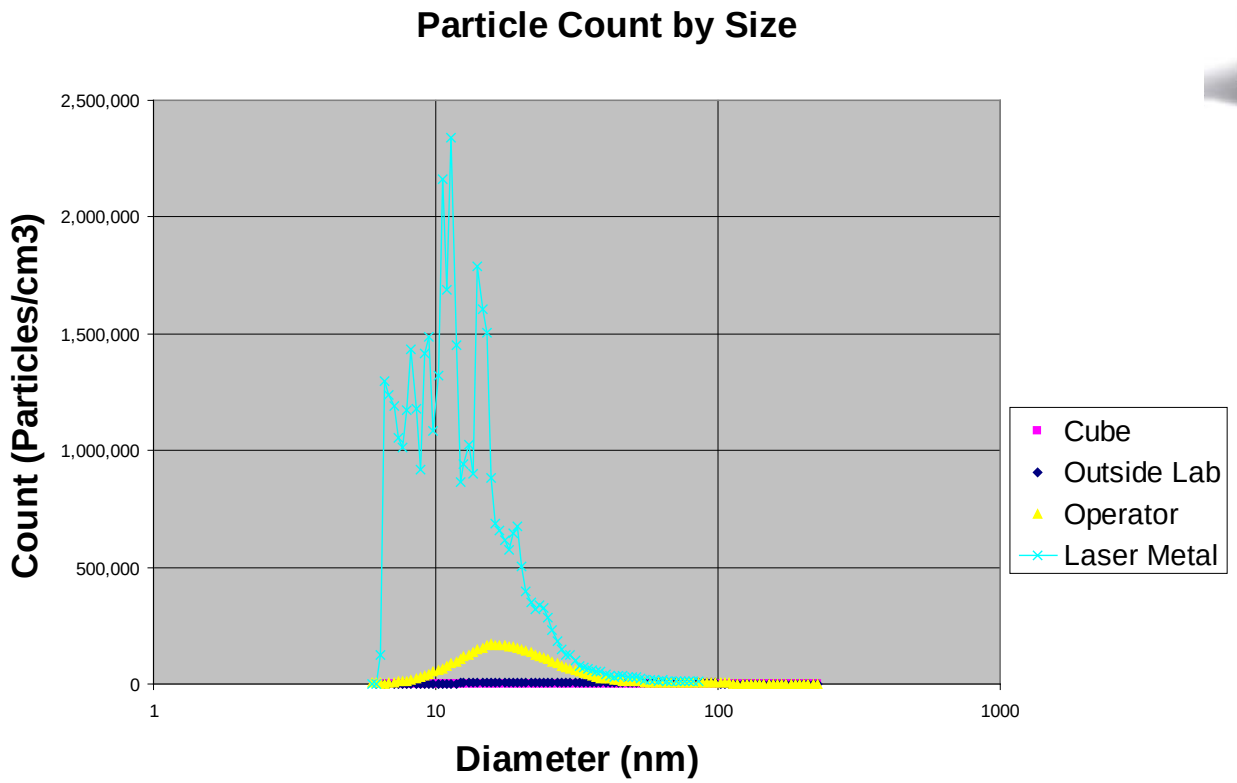
TSI Scanning Mobility Particle Sizer 3936L75

Particle size distribution at engineering cubicle, outside lab, near operator and at process head while cutting metal.



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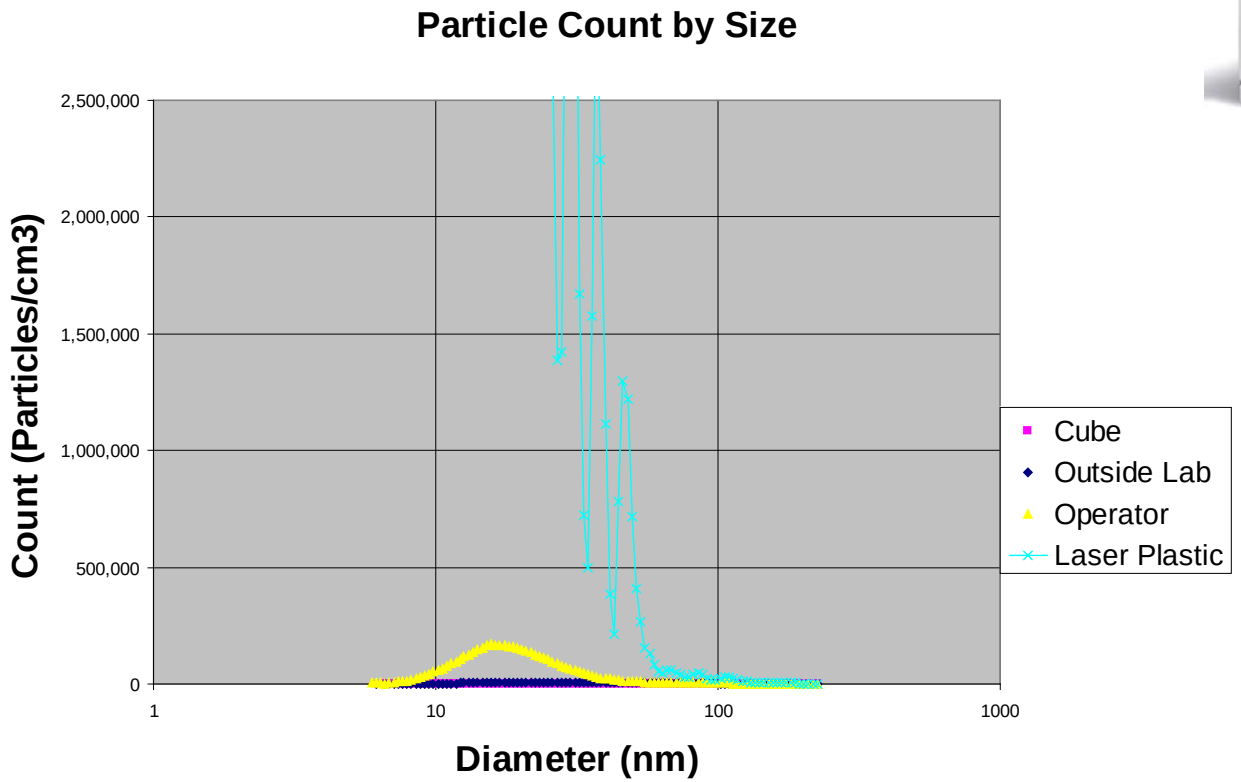
Particle size distribution at engineering cubicle, outside lab, near operator and at process head while cutting plastic.



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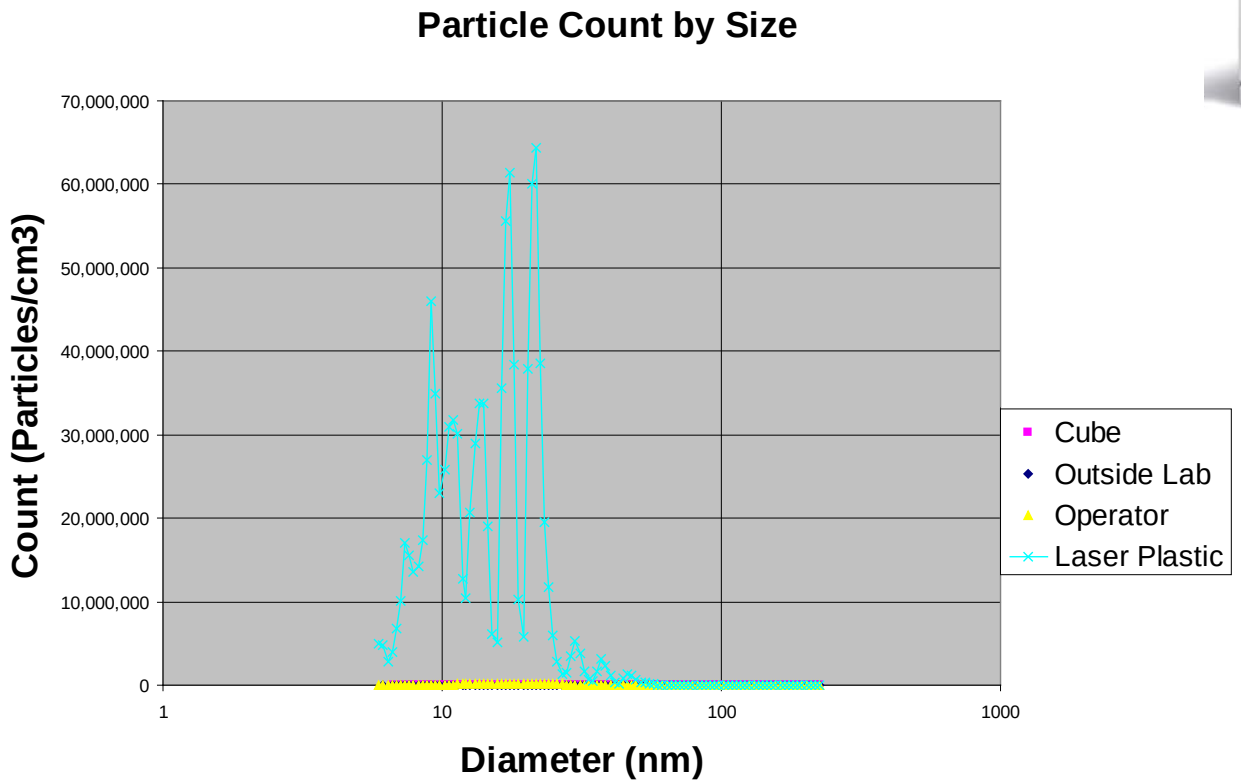

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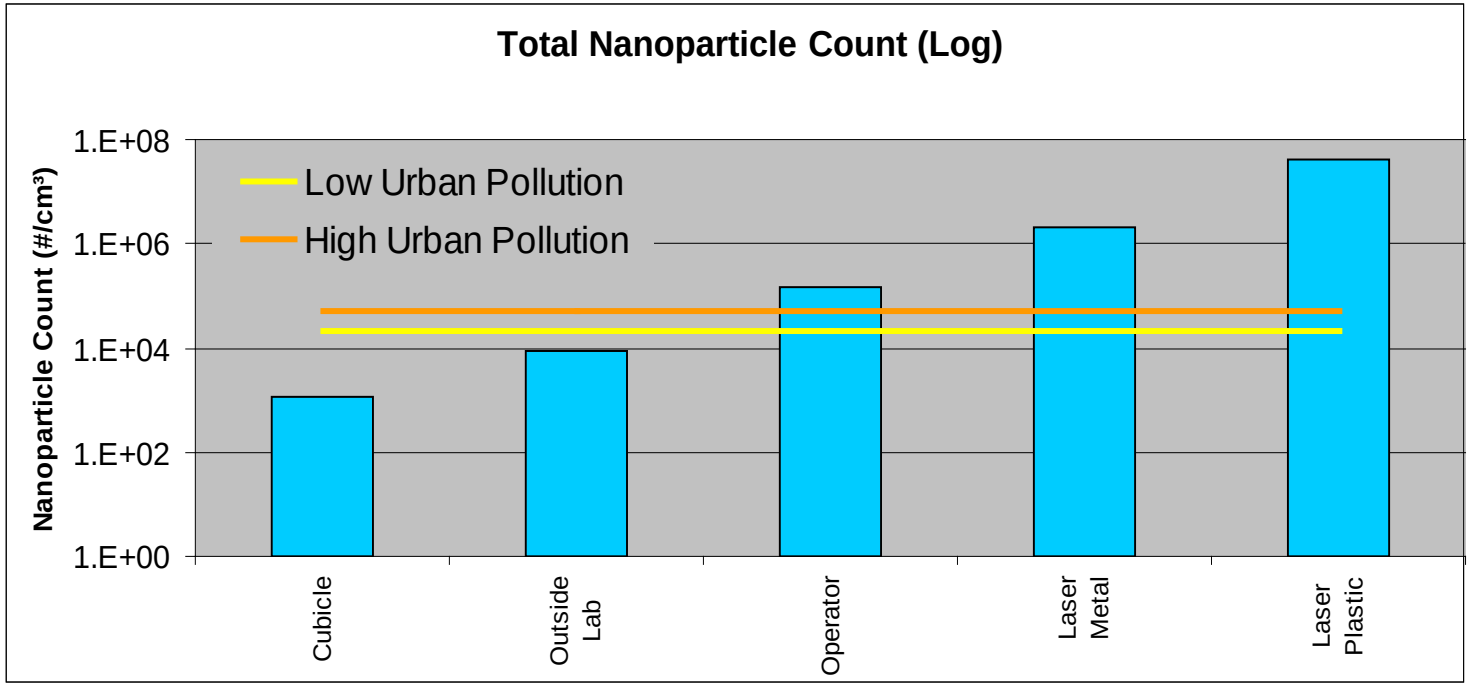
TSI Scanning Mobility Particle Sizer 3936L75

Summary of data taken with TSI 3936

- BSI benchmark: 20,000 particles/ml pollution index
- BSI WEL for metal tested: 0.066 x 5 mg/m^3 = 330 µg/m^3
- No available WEL for plastic tested



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TSI AeroTrak 9000

10 nm - 400 nm

Provides real-time surface area deposition in alveolar or tracheobronchial regions of respiratory system

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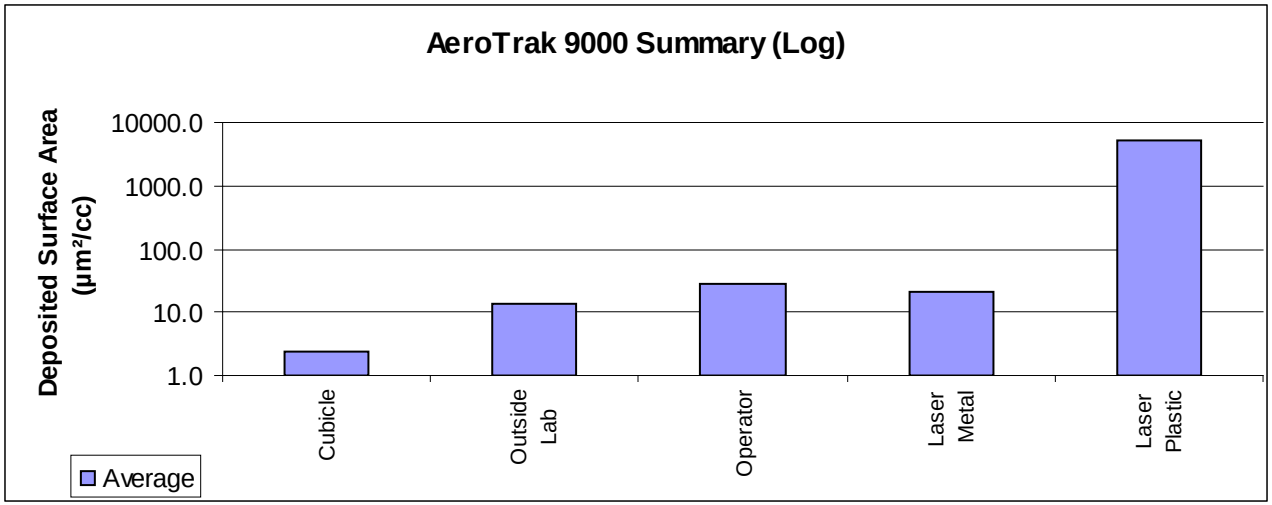
TSI AeroTrak 9000

Average deposited surface area over five minutes at cube, outside lab, operator and laser for both metal and plastic samples.



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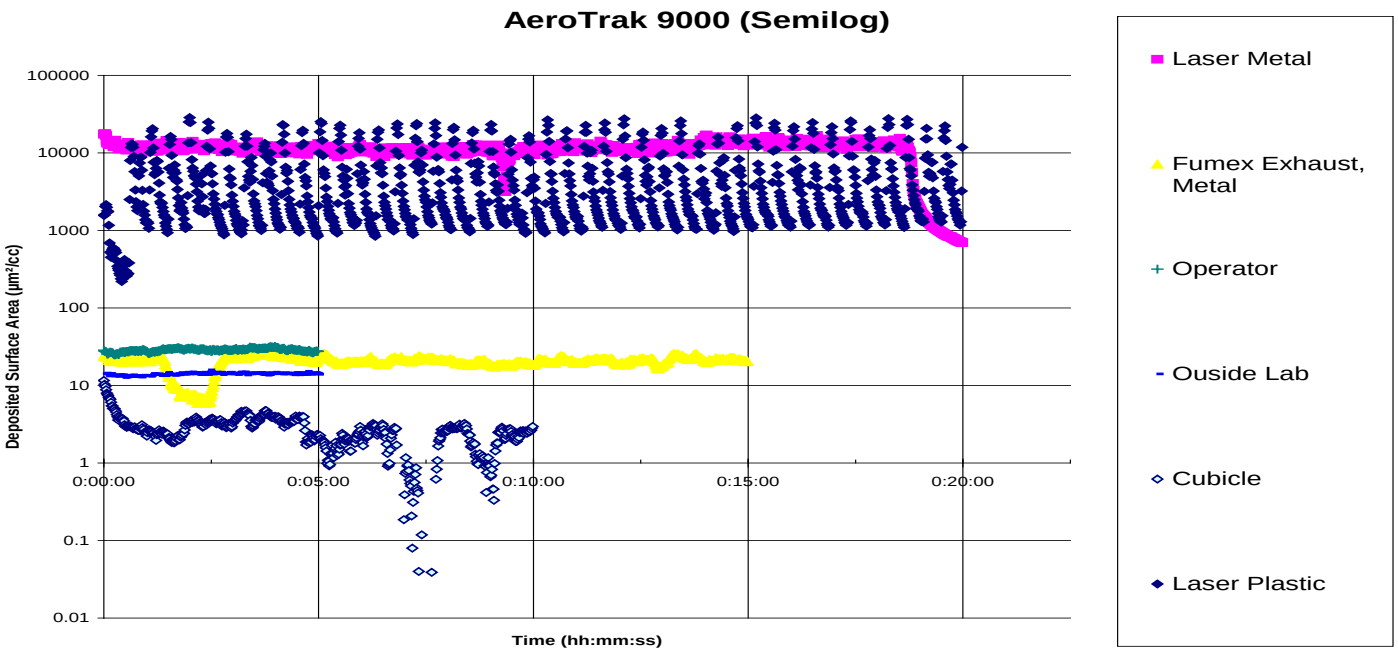
TSI AeroTrak 9000

Deposited surface area over time at cube, outside lab, operator and laser for both metal and plastic samples



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Institute of Occupational Medicine

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Conclusions, are our people safe?

Three data sets taken:

- Particle count - high, but toxicologists tell us particle count is the least indicative of hazard.
- Mass- Within Work Exposure Limit for metals. Plastic used is considered non toxic and has no WEL
- Surface Area – WEL not yet set for either material tested.

ALARA recommended. As Low As Reasonably Achievable

- Nanoparticle toxicology is just now being investigated. As a result, WEL numbers are not yet available. The ALARA approach is often used in circumstances where the effects of exposure are not fully known.

Are our people safe?

- Data taken after mitigations should answer that question.

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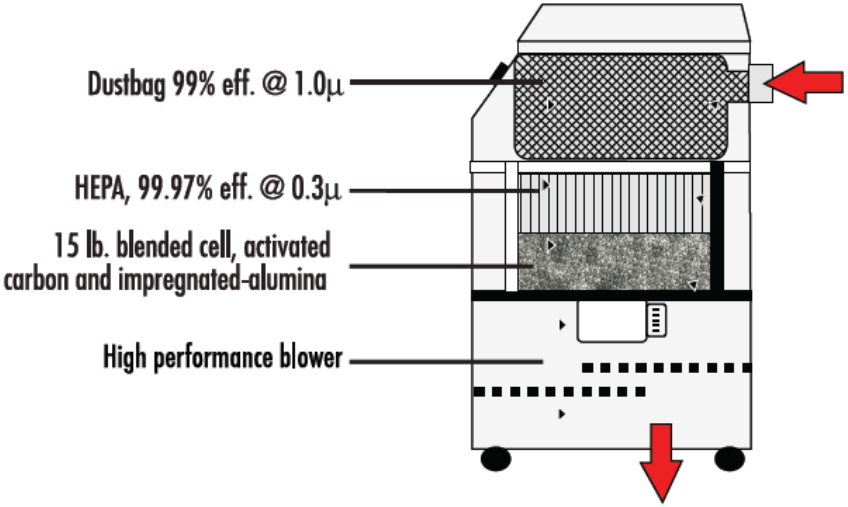
Recommendations Based on Results

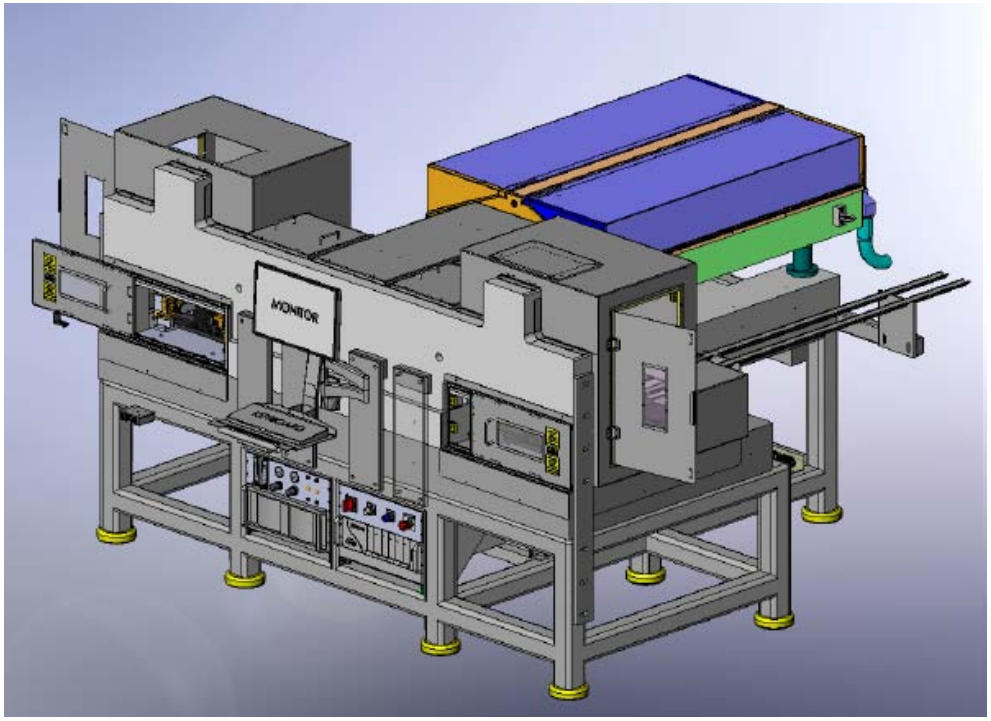
Safety mechanism for proper operation of Fumex filter unit



Bag in / bag out filter system

Exhaust interlocked

Enclosure of laser systems in R&D lab



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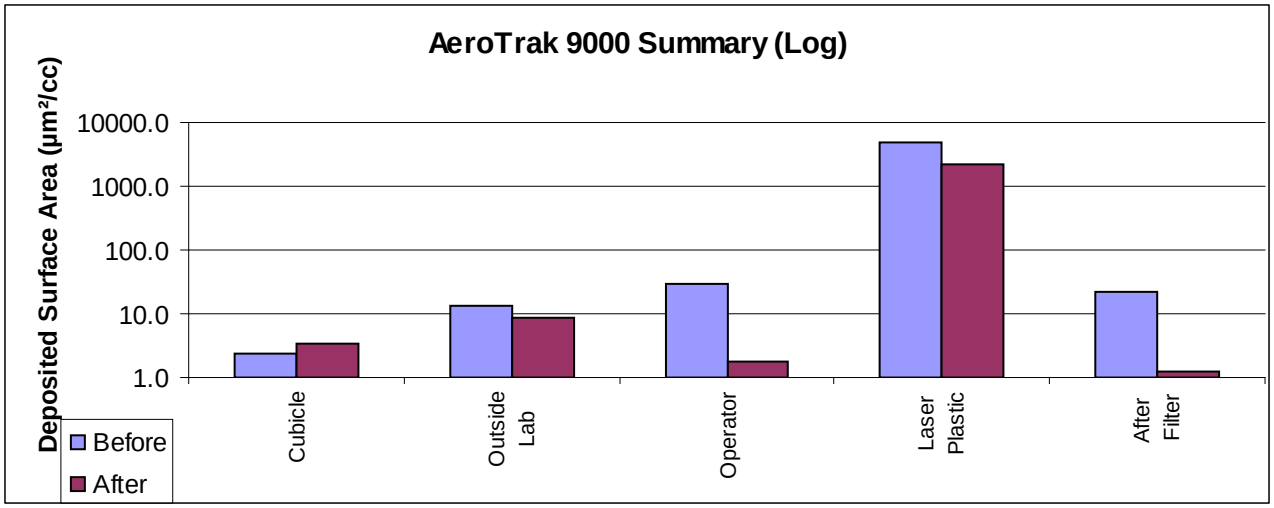
TSI AeroTrak 9000

Average deposited surface area over five minutes at cube, outside lab, operator, laser and after filter system for plastic sample both before and after mitigations in place.



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Conclusions, are our people safe?

Surface area measurements chosen at recommendation of toxicology.

Operators exposed to less surface area than found in background.

In fact, readings were so low that they were questioned. The measurement at the laser was recreated to verify the measurement system was working correctly.

Are our people being exposed to nanoparticles? Data indicates AV operators are exposed to fewer nanoparticles at work than then at home.

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Acknowledgments

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Henry Robles, Staff Coordinator EH&S

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Santa Clara

Presley Millare, Staff Coordinator EH&S

Mark Wright, DLSO

ENGINEERING INTERN

Jammie Peng

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