

NIOSH CIB

**Occupational Exposure to Carbon
Nanotubes and Nanofibers**

Exposure Assessment and Control

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Exposure Assessment and Control

Overview

- ❑ Measurement of Occupational Exposure to Engineered Nanoparticles
- ❑ Measurement of Occupational Exposure to Carbon Nanotubes and Nanofibers
- ❑ Control of Occupational Exposure to Carbon Nanotubes and Nanofibers

Simple Measurement Methods for Nanoparticles

Condensation Particle Counter (CPC)



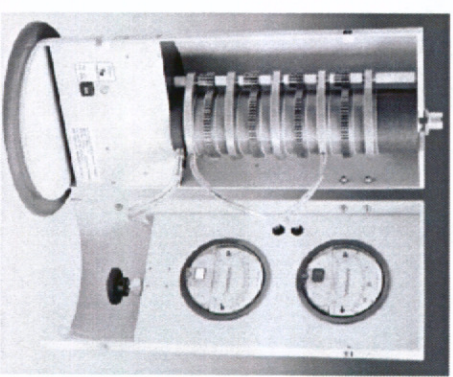
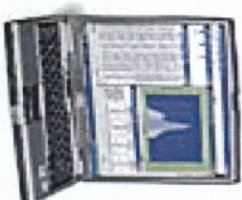
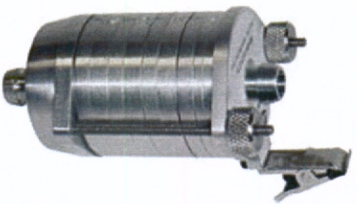
- TSI 3007: particle size range of 10 – 1000 nm with a concentration range of 0 to 100,000 particles/cc.

Optical Particle Counter/Sizer (OPC)



ART Instruments (ARTI) HHP-C-6: 300 nm to >10 μm in six size ranges simultaneously (particles/L)

More Complex (research) Measurement Methods for Nanoparticles



Exposure Metrics used for Nanoparticles

- “Gross” Particle Number Concentration
- Particle Number Concentration by Size
- Mass
- Respirable Mass

Add Some Sophistication With:

- Detailed Size Distribution
- Real-time Mass and Size Distribution
- Surface area
- Electron Microscopy Characterization

Assessment of Exposure:

Advantages and Disadvantages

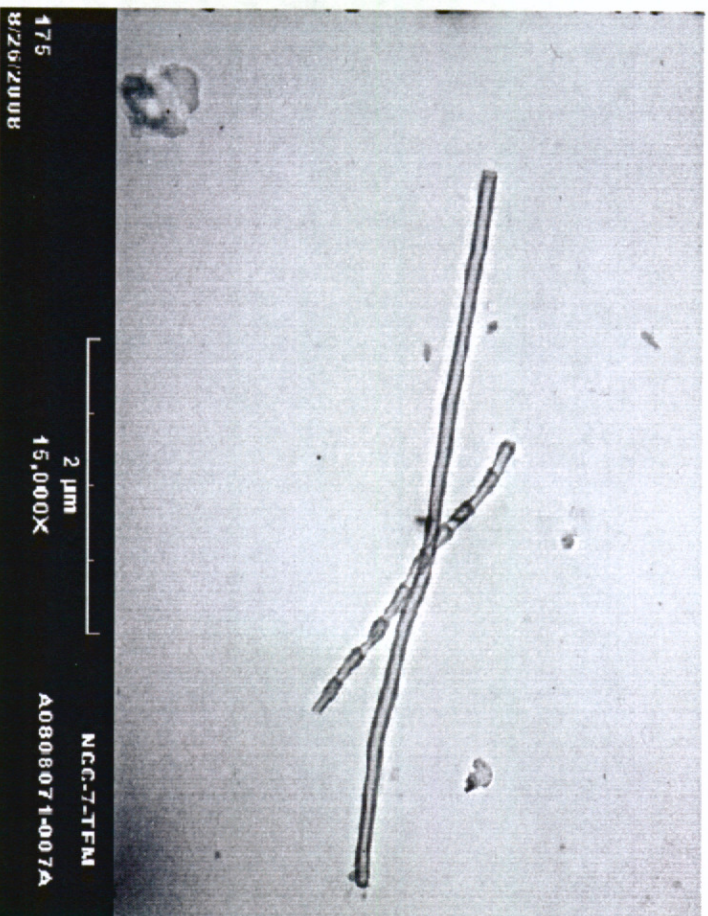
- ❑ **Mass:** Links to historical data, generally lacks sensitivity and specificity; however can be made specific (e.g., metals)
- ❑ **Size distribution:** More information, not always easy, not specific to particle type
- ❑ **Number Concentration:** Fairly simple with real time monitors, not specific to particles, recent correlation of particle number in ambient air to biomarkers of coronary heart disease
- ❑ **Surface area:** Some relevance based on toxicology; technology available but results difficult to interpret
- ❑ **Electron microscopy characterization:** can provide information on particle morphology, size, count and elemental analysis (metals, carbon); resource intensive

Occupational Exposure

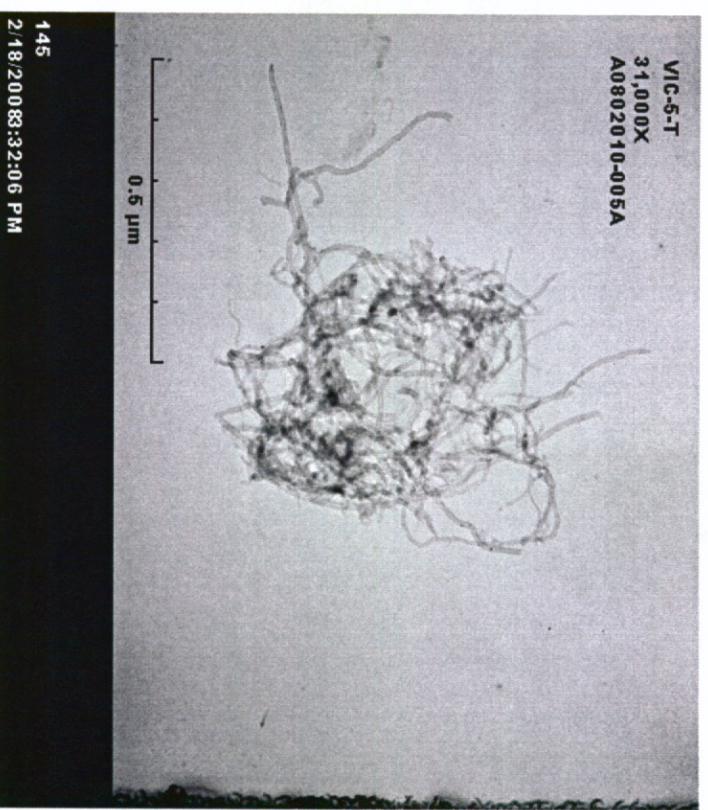
Carbon Nanotubes and Nanofibers

- Potential for carbon nanotube and nanofiber exposure at job tasks and processes during research application, production, and use
- Worker exposure observed to be task specific and short-term during research application and production. Likelihood and frequency of exposure during “down stream” use is unknown
- Limited Exposure Data: Exposures reported as particle or mass concentrations with minimal descriptive information on the characteristics of airborne exposure

Occupational Exposure: TEM Images from Filter Samples



Carbon Nanotube and Nanofiber
15,000X



MWCNT's Collected During
Sonication

Measurement of Occupational Exposure

Carbon Nanotubes and Nanofibers

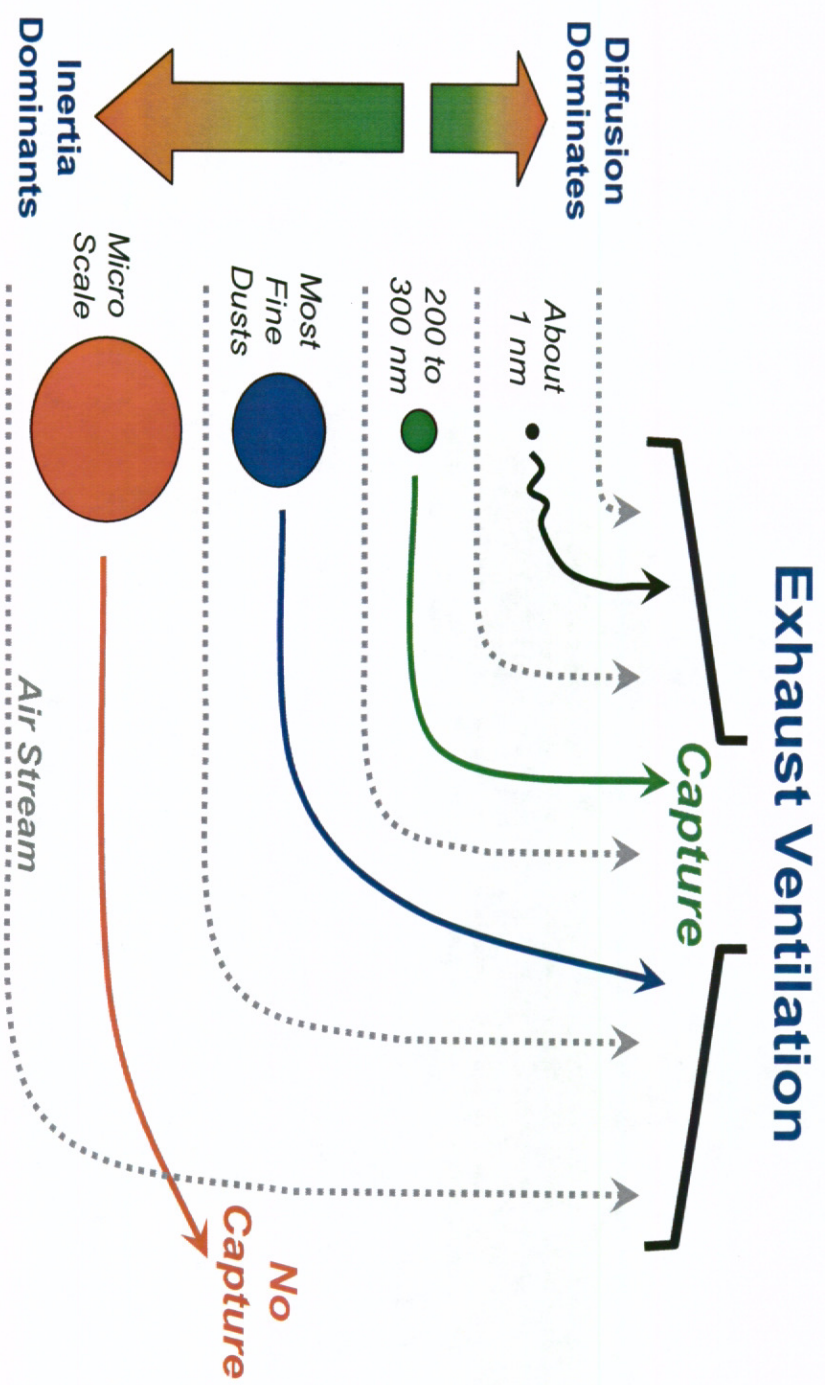
- ❑ NIOSH Recommended Exposure Limit (REL): $7\mu\text{g}/\text{m}^3$ 8-hour TWA for a 40-hour workweek. Best correlation to date with animal toxicology data.
- ❑ REL established at the estimated upper limit of quantitation (LOQ) for Method 5040. Lower LOQ possible.
- ❑ Personal respirable mass exposure measurements using NIOSH Method 5040 for elemental carbon.

Measurement of Occupational Exposure

Carbon Nanotubes and Nanofibers

- ❑ **Limit of detection (LOD) and LOQ depends on the air volume, filter size, sample portion analyzed (usually 1.5 cm²) and media blank variability**
- ❑ **Appendix C of ClB provides guidance on how to optimize the collection of samples using NIOSH Method 5040**

Conventional Controls Should Work for Carbon Nanotubes and Nanofibers



Control of Occupational Exposure

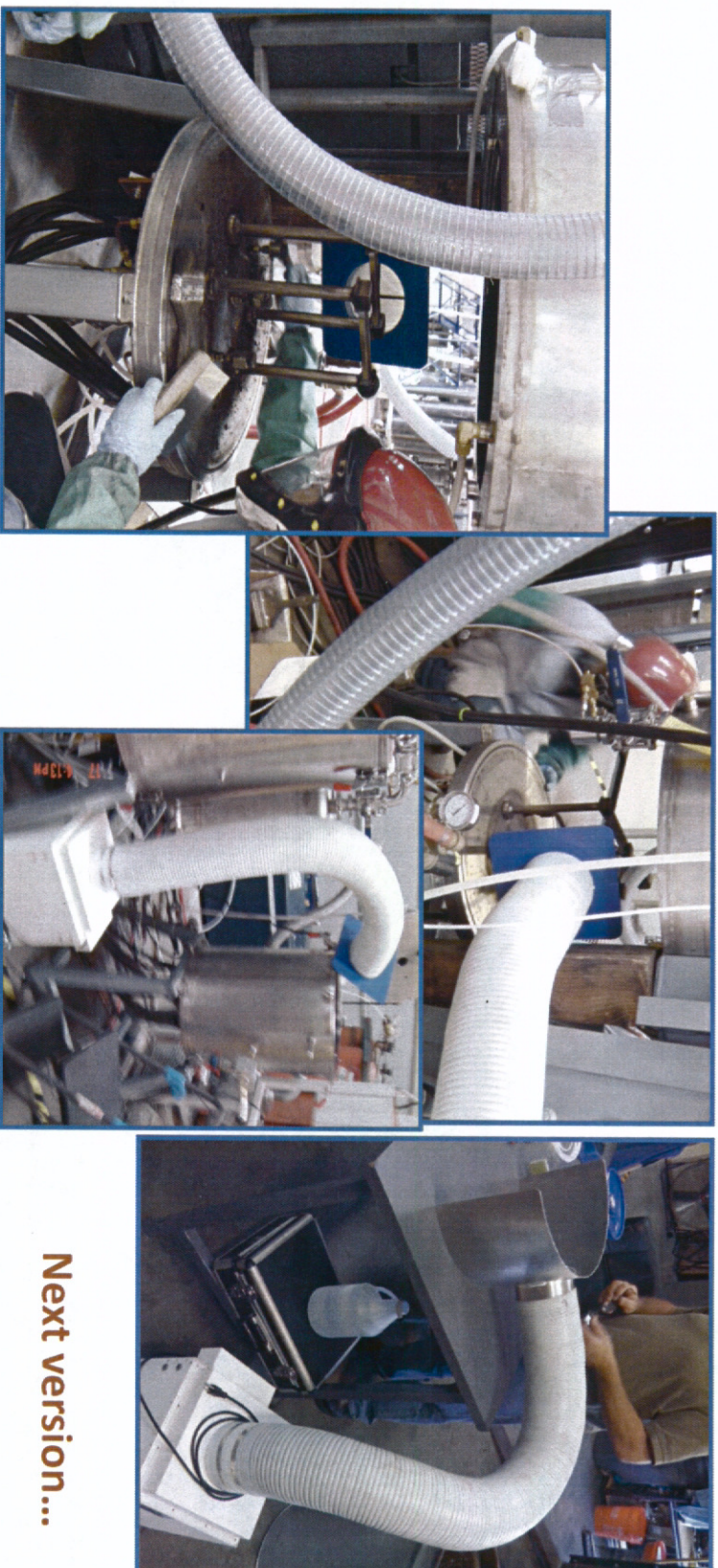
Carbon Nanotubes and Nanofibers

Engineering controls (e.g., enclosure, local exhaust ventilation) shown to be effective in reducing airborne exposures below NIOSH REL of 7 $\mu\text{g}/\text{m}^3$, 8-hour TWA

Selection of exposure controls should take into account:

- Physical form of material (bulk or encapsulated in a solid)
- Job task duration and frequency of workers coming into contact with material

Case Study: Use of LEV during reactor cleanout



Next version...

Average percent reduction from the use of a local exhaust ventilation unit
96 +/- 6% based on particle counts
88 +/- 12% based on mass

Mark Methner, PhD, CIH; JOEH June 2008

Larger Scale: Use of LEV and Enclosure



Mixing of carbon nanofibers inside ventilated enclosure (face of opening is covered in plastic strips for easy access). Air is drawn underneath plastic strips and up to ceiling exhaust vents.

Exposure Assessment and Control

Carbon Nanotubes and Nanofibers

Summary

- Respirable mass sampling using Method 5040 should provide reasonable estimates of worker exposure for implementing appropriate risk management practices.
- Engineering controls typically used for reducing exposures to fine powders and ultrafine aerosols should be effective in reducing exposures to carbon nanotubes and nanofibers.

Exposure Assessment and Control

Research Needs

- Quantify worker airborne exposure to CNT and CNF.
- Develop improved sampling and analytical methods for CNT and CNF that more closely align with the health endpoints observed in animals studies.
- Evaluate the effectiveness of engineering controls to reduce worker exposures below NIOSH REL of $7\mu\text{g}/\text{m}^3$ at different job tasks and processes.
- Determine the effectiveness of gloves and other PPE barrier materials in preventing dermal exposure.