

# An Overview of NIOSH Nanotechnology Research and an Update on the Efficacy of Personal Protective Equipment for Reducing Worker Exposure to Nanoparticles

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Workplace  
Safety and Health



**NPPTL** *Research to Practice  
through Partnerships*

Commercialization of Nanomaterials Conference Nov 12, 2007

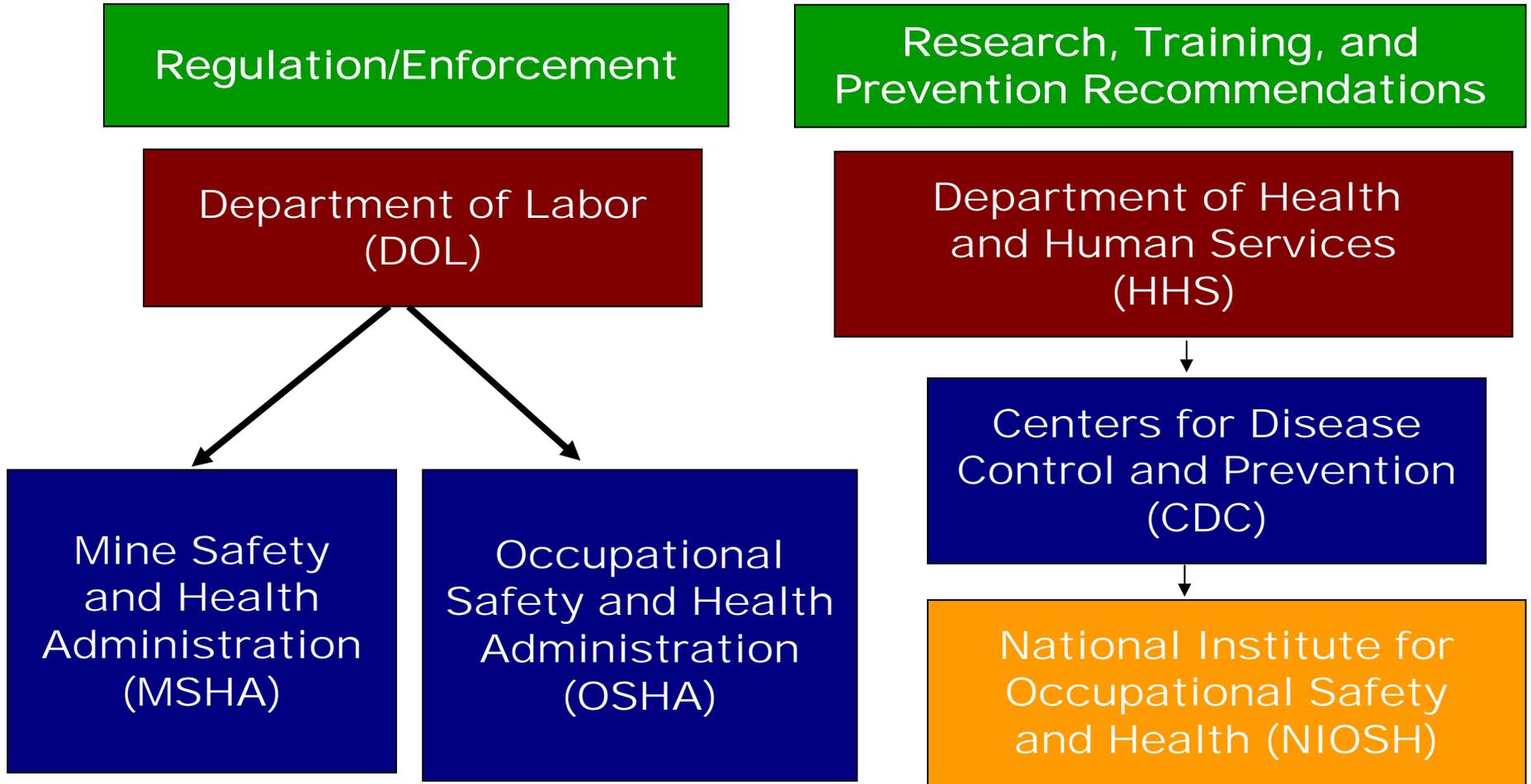
# Overview

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- **Introduce NIOSH**
- **Occupational Safety & Health Issues related to nanotechnology**
- **What is NIOSH doing?**
- **What have we learned?**
  - Filtration / Effectiveness of personal protective equipment (PPE)

**Occupational Safety & Health Act (1970) established OSHA & NIOSH - To assure safe and healthful working conditions for all working men and women.**

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# Nanotechnology - Background

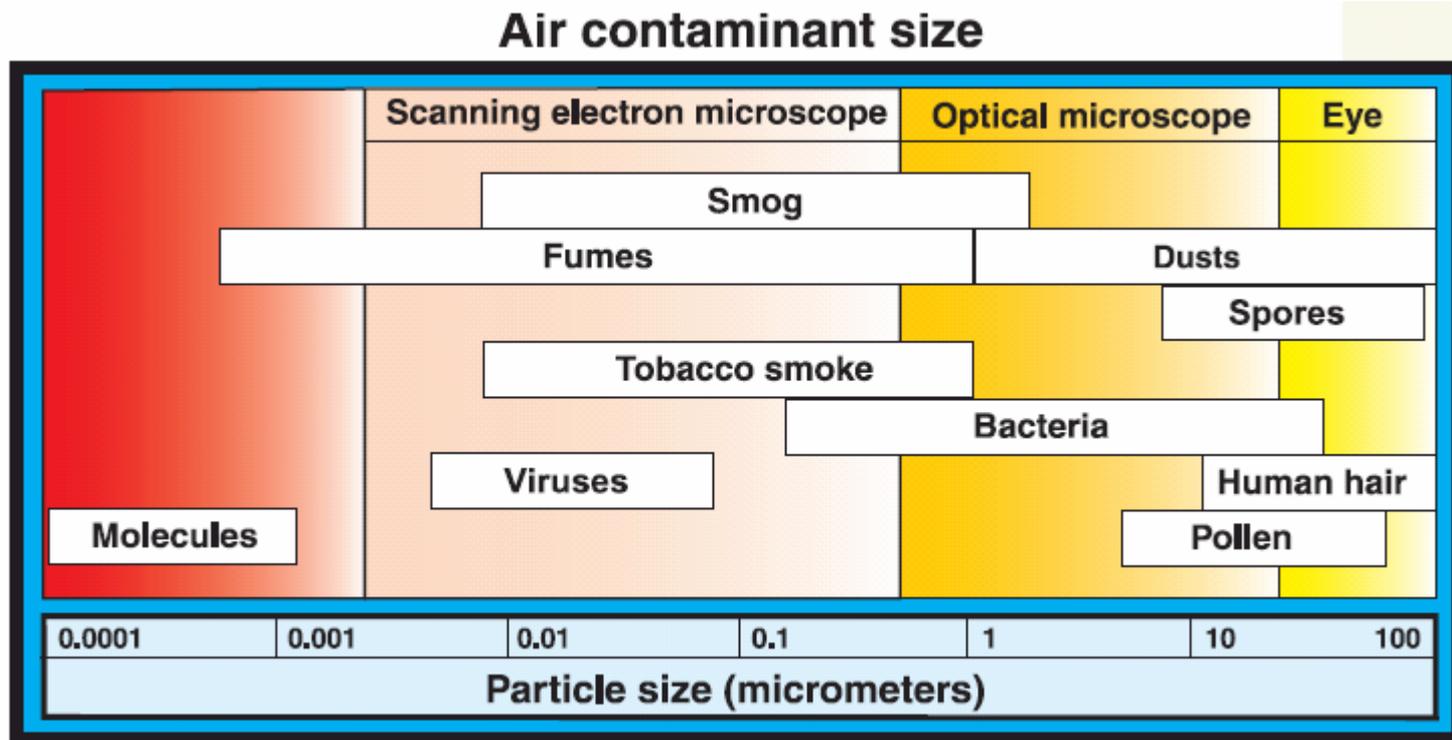
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- Nanotechnology - The Motivation
  - Purposely engineered nanostructured materials and devices demonstrate new, unique and size-dependent properties and behavior.
- Nanotechnology - The Challenge
  - Does the nature of engineered nanostructured materials present new **safety and health risks**?
  - How can the benefits of nanotechnology be realized while proactively **minimizing the potential risk**?
  - The broad extent of exposure: “Lab to Landfill”

***The focus for the Industrial Hygienist is the unbound nanoparticle.***

# What are Nanoparticles?

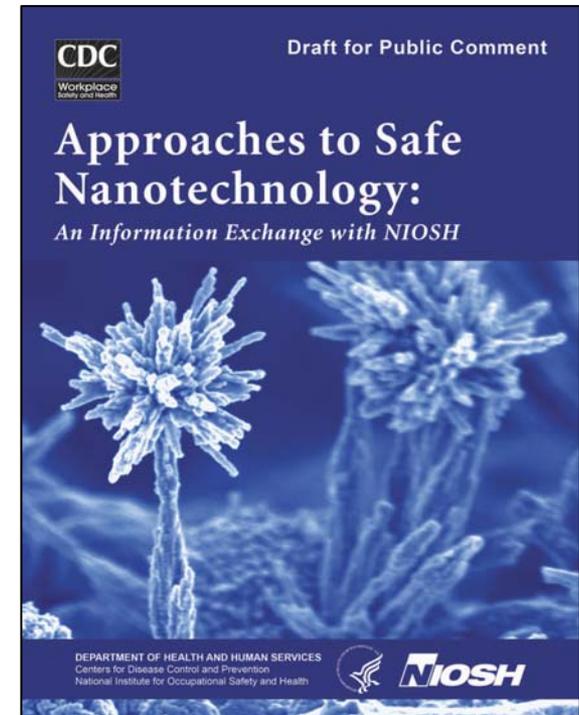
**Nanoparticles are particles having a diameter between 1 and 100 nm (0.001-0.1  $\mu\text{m}$ )**



Adapted from: Guidance for Filtration and Air-Cleaning Systems to Protect Building Environments from Airborne Chemical, Biological, or Radiological Attacks, DHHS (NIOSH) Publication No. 2003-136.

# Nanoparticles - Health Concerns

- Airborne nanomaterials can be inhaled and deposited in the respiratory tract
- Nanomaterials can enter the blood stream and translocate to other organs
- Mass doses of insoluble nanoparticles are more potent than larger particles of similar composition in causing pulmonary inflammation and lung tumors in laboratory animals
- Changes in the chemical composition, structure of the molecules, or surface properties can influence potential toxicity



<http://www.cdc.gov/niosh/topics/nanotech/>

# NIOSH NTRC

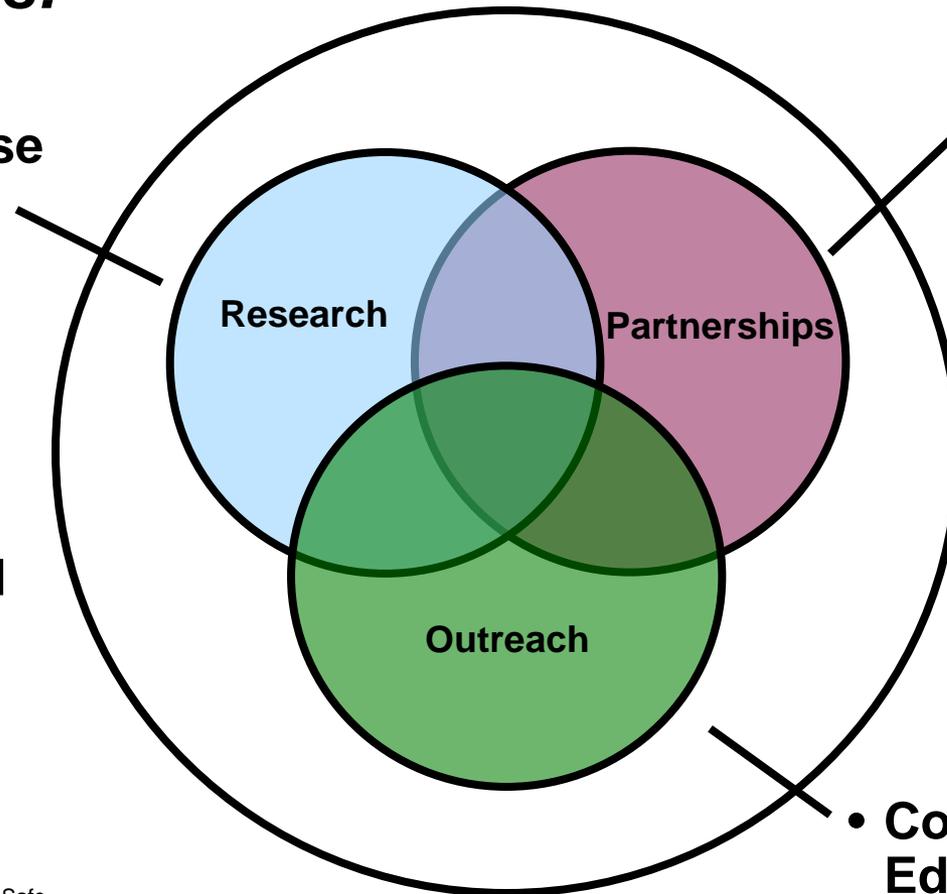
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- In 2004, NIOSH established the Nanotechnology Research Center & Steering Committee (NTRC)
- Vision of the NTRC: Safe nanotechnology by delivering on the Nation's promise—safety and health at work for all people through research and prevention.
- Mission of the NTRC: provide national and world leadership for research into the application of nanoparticles and nanomaterials in occupational safety and health and the implications of nanoparticles and nanomaterials for work-related injury and illness

# NIOSH NTRC

## 10 Critical Areas:

- Toxicity
- Exposure and Dose
- Risk Assessment
- Measurement Methods
- Controls
- Safety
- Epidemiology and Surveillance
- Application



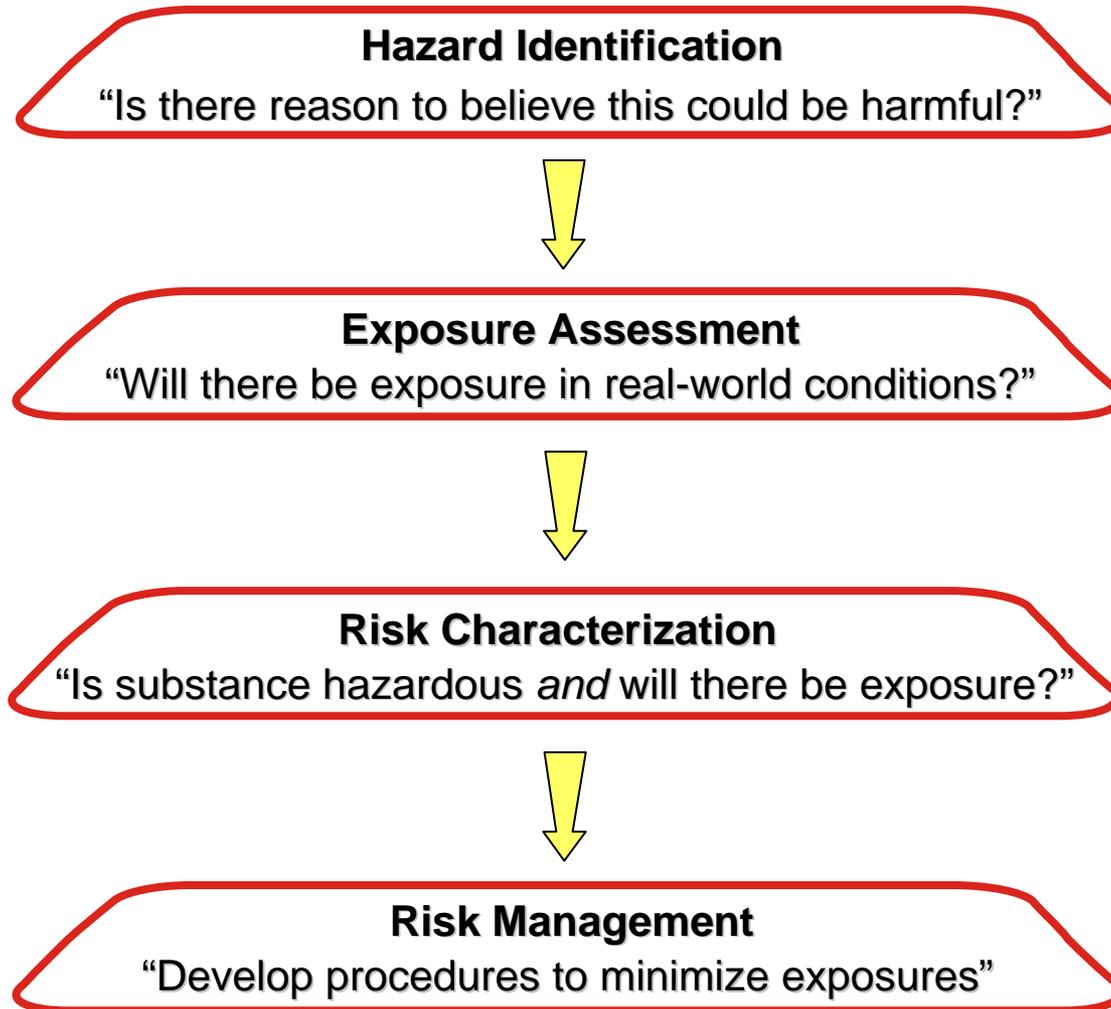
**Partners:**  
Government  
Academia  
Industry  
Labor  
International

- Communication and Education
- Recommendations

Adapted from Figure 2, Page 6 of "Progress Toward Safe Nanotechnology in the Workplace: A Report from the NIOSH Nanotechnology Research Center, DHHS (NIOSH) Publication No. 2007-123

# Steps to Protect Nanotechnology Workers

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Adapted from Figure 1, Page 5 of  
“Progress Toward Safe  
Nanotechnology in the Workplace: A  
Report from the NIOSH  
Nanotechnology Research Center,  
DHHS (NIOSH) Publication No. 2007-  
123

# Effectiveness of PPE for Workers Handling Unbound Nanomaterials

- **Effectiveness of personal protective equipment (PPE) against particulates is primarily a function of leakage around the sealing areas and direct penetration through the PPE**
- **Key question: do nanoparticles behave any differently than larger particles?**
- **Two NIOSH research projects are being conducted to address some of these issues**



Photo obtained from Health hazard evaluation report: HETA-2005-0291-3025, Methner-MM; Birch-ME; Evans-D; Hoover-MD

# Respirator Fit

- No specific data available to determine if nanoparticle face seal leakage is different
- However, WPF studies have validated effectiveness of current methods used to fit respirators for use against gases and vapors.
- TSI Portacount with N95 Companion uses ~40 nm particles
- NIOSH plans to conduct controlled laboratory studies using manikins to measure face seal leakage of 5 – 400 nm particles



# 42 CFR, Part 84 Air Purifying Particulate Respirator (APR) Certification



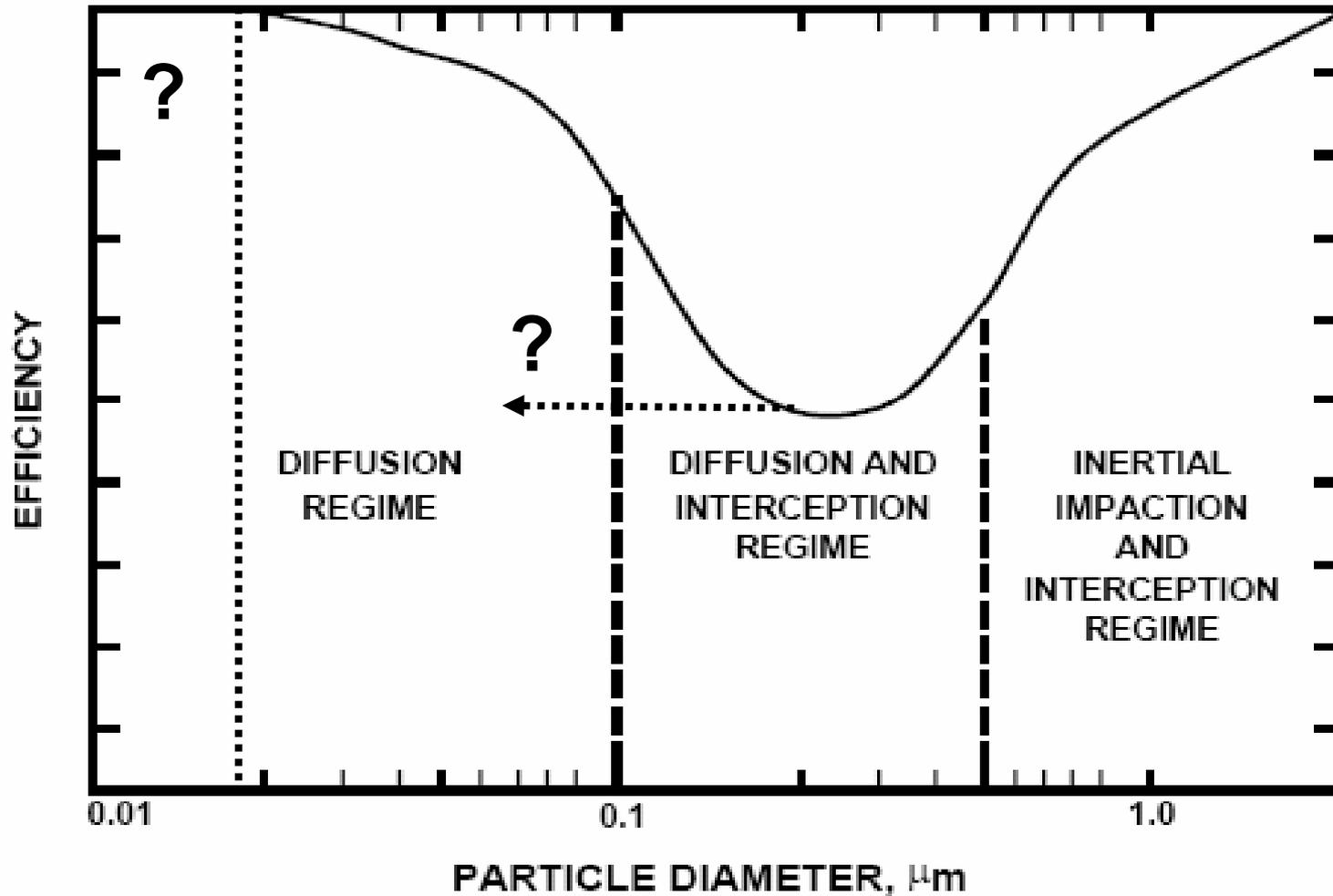
| Minimum Efficiency | NaCl Test | DOP oil Test | DOP oil Test |
|--------------------|-----------|--------------|--------------|
| 95%                | N95       | R95          | P95          |
| 99%                | N99       | R99          | P99          |
| 99.97%             | N100      | R100         | P100         |



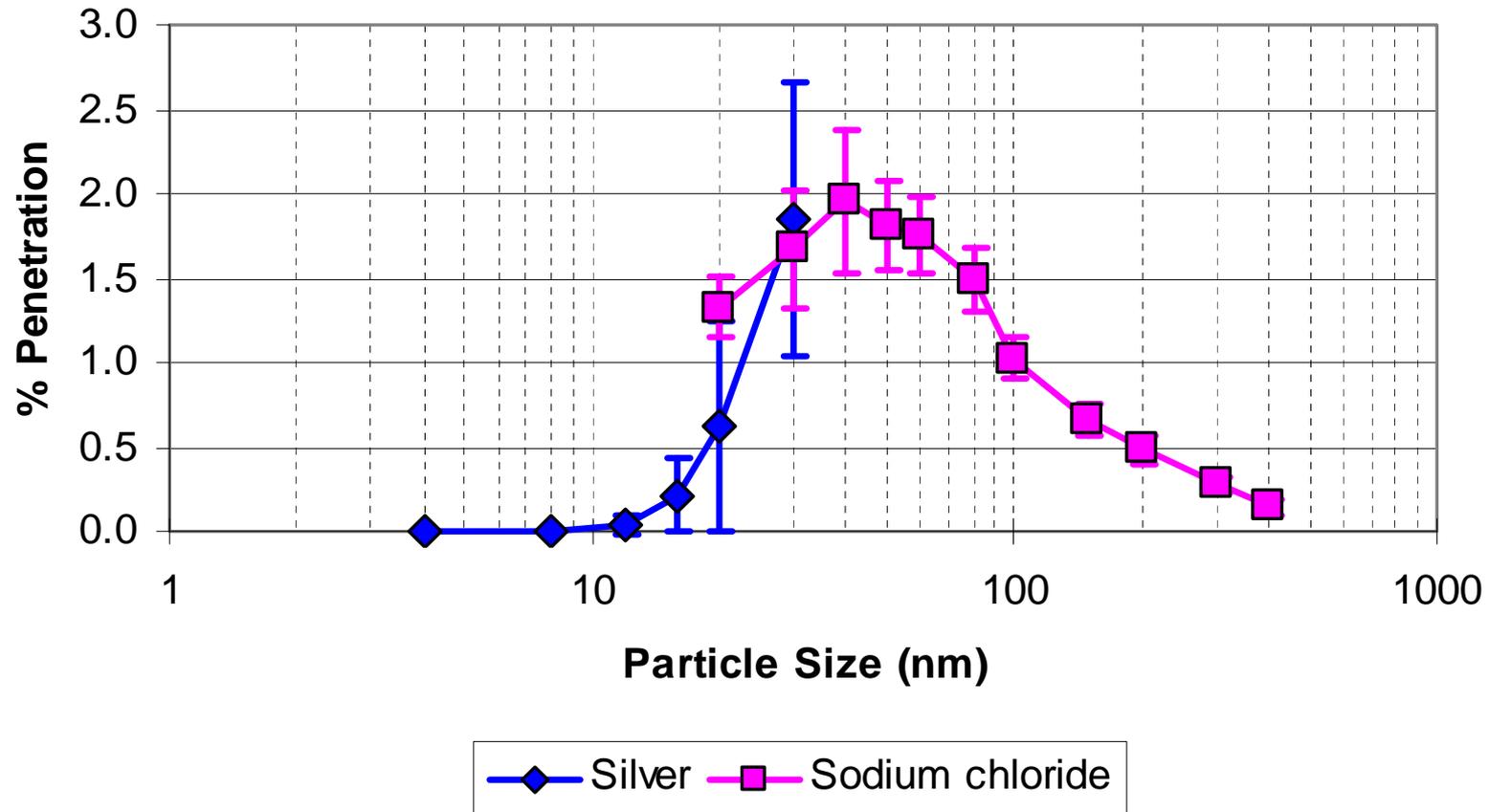
- N - not resistant to oil mist
- R - resistant to oil mist
- P - protective against oil mist
- 95, 99, 100 - minimum filter efficiency using certification test conditions



# Filtration Theory



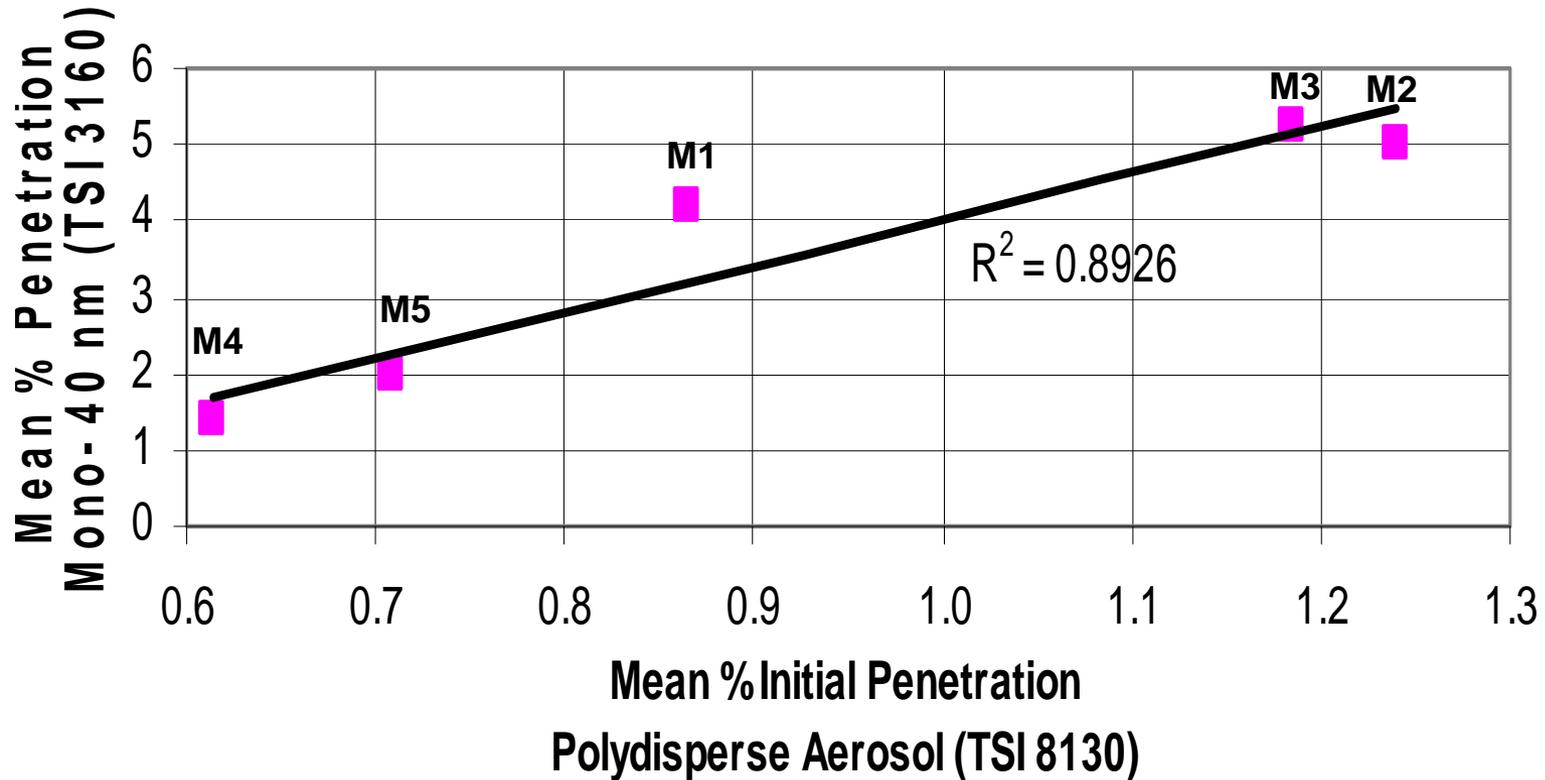
# Filtration Performance of an Example NIOSH Approved N95 Filtering Facepiece Respirator



n = 5; error bars represent standard deviations  
Sodium Chloride (TSI 3160); Silver (custom-built)  
Flow rate 85 L/min

Filtration performance of NIOSH-approved N95 and P100 filtering facepiece respirators against nanoparticles, S. Rengasamy, WP King, B. Eimer and R. Shaffer (in review)

# Correlation of Poly- and 40 nm Monodisperse Aerosol Penetrations



Rengasamy S, Verbofsky R, King WP and Shaffer R [2007]. Nanoparticle penetration through NIOSH-approved N95 filtering facepiece respirators. *Journal of International Society for Respiratory Protection*, 24:49-59.

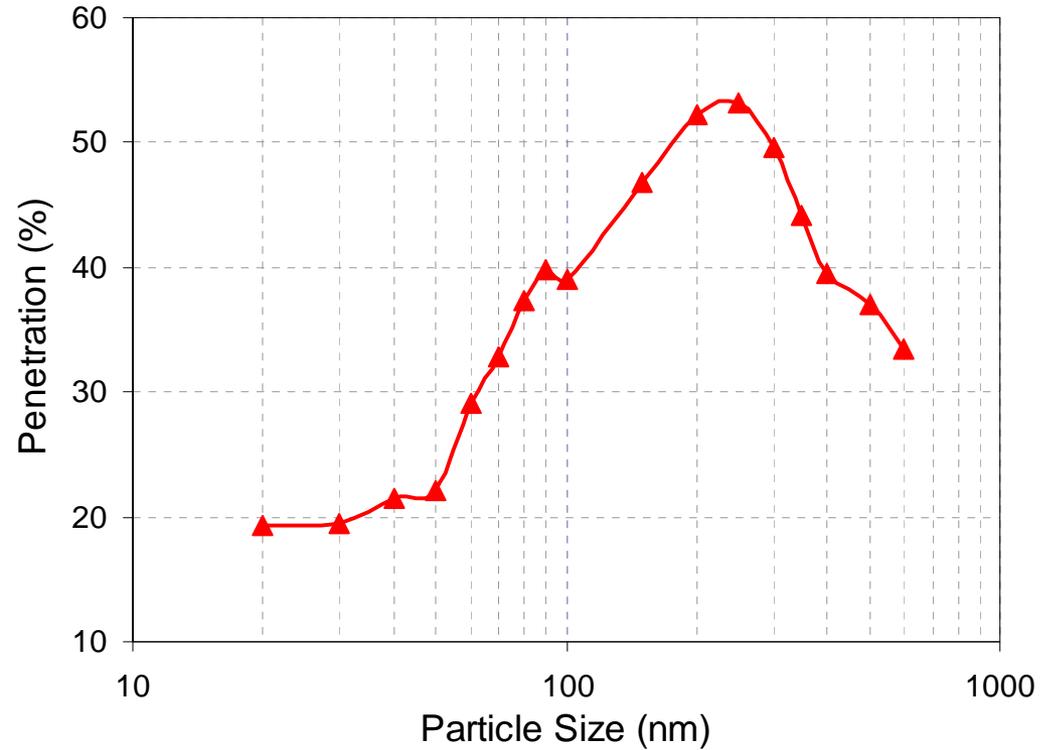
# Protective Clothing & Ensembles

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- **No guidelines available for proper selection, use, care, and maintenance of protective clothing & ensembles (PC&E) for protection against exposure to nanoparticles**
- **Some data on protection provided by PC&E against particulate hazards exist for military, clean-room, and asbestos remediation garments**
- **Data on the relative contribution of leakage around seams/closures vs. direct particle penetration is lacking**
- **NIOSH immediate focus is on assessing direct penetration through fabric swatches**

# Particle Penetration Through Clothing

- **Some fabric swatches behave like filter media**
- **Particle penetration driven by pressure differences**
- **Particle penetration is a function of the air permeability of the fabric**
- **FY09 NIOSH research project**



*10 cm diameter circular swatch  
Single layer of needle-punched Aramid material  
TSI 3160; Face velocity = 0.63 cm/sec; Flow rate 1L/min  
Data courtesy of Dr. Zhong-Min Wang (NPPTL)*

# NIOSH Information Resources

Nanotechnology topic page:

[www.cdc.gov/niosh/topics/nanotech](http://www.cdc.gov/niosh/topics/nanotech)

- NIOSH Position Statement – Jan 2005
- NIOSH Nano Strategic Plan – Oct 2005
- Nanoparticle Information Library – Oct 2005
- TiO<sub>2</sub> Current Intelligence Bulletin – Nov 2005
- Approaches to Safe Nanotechnology: 2<sup>nd</sup> version, Aug 2006
- Progress Toward Safe Nanotechnology in the Workplace: A Report from the NIOSH NTRC, Jun 2007
- NIOSH exposure field team site visits
- Ongoing research studies and publications

**CDC** **NIOSH** National Institute for Occupational Safety and Health

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**NIOSH Safety and Health Topic:**  
**Nanotechnology**

**Nanotechnology at NIOSH**

NIOSH is the leading federal agency conducting research and providing guidance on the occupational safety and health implications and applications of nanotechnology. This research focuses NIOSH's scientific expertise, and its efforts, on answering the questions that are essential to understanding these implications and applications:

- How might workers be exposed to nano-sized particles in the manufacturing or industrial use of nanomaterials?
- How do nanoparticles interact with the body's systems?
- What effects might nanoparticles have on the body's systems?

As part of this effort, NIOSH is conducting [strategic planning](#) and research, partnering with public and private-sector colleagues from the United States and abroad, and making the information and interim recommendations widely available. As observers generally agree, research to answer these questions is critical for maintaining U.S. competitiveness in the growing and dynamic nanotechnology market.

**Critical Topic Areas**

NIOSH has identified [10 critical topic areas](#) to guide in addressing knowledge gaps, developing strategies, and providing recommendations.

Each topic provides a brief description of the research that NIOSH is conducting in the area of nanotechnology and the applications and implications of nanomaterials in the workplace.

**Interim Recommendations**

In "Approaches to Safe Nanotechnology," NIOSH invites information and comment from stakeholders. This information exchange will advance our shared understanding of the current scientific knowledge related to occupational safety and health issues. This living document also makes recommendations for interim steps in employing the range of control technologies, work practices, and personal protective equipment demonstrated to be effective with other fine and ultrafine particles. These recommendations will be refined as more data become available.

# VOLUNTEER PARTNERS NEEDED FOR THE NIOSH NANOTECHNOLOGY FIELD RESEARCH EFFORT

NIOSH has a field research team available to visit and assess processes involving research, production, and use of nanomaterials. The team will characterize materials, processes, potential worker exposures, work practices, and control procedures. Information and recommendations will be shared with the business partner and will be used by NIOSH to update the guidance that appears on the Nanotechnology Topic Page. **There is no cost to participate.**

**If your organization is interested in volunteering to participate, please contact us.**

**Charles L. Geraci, PhD, CIH**

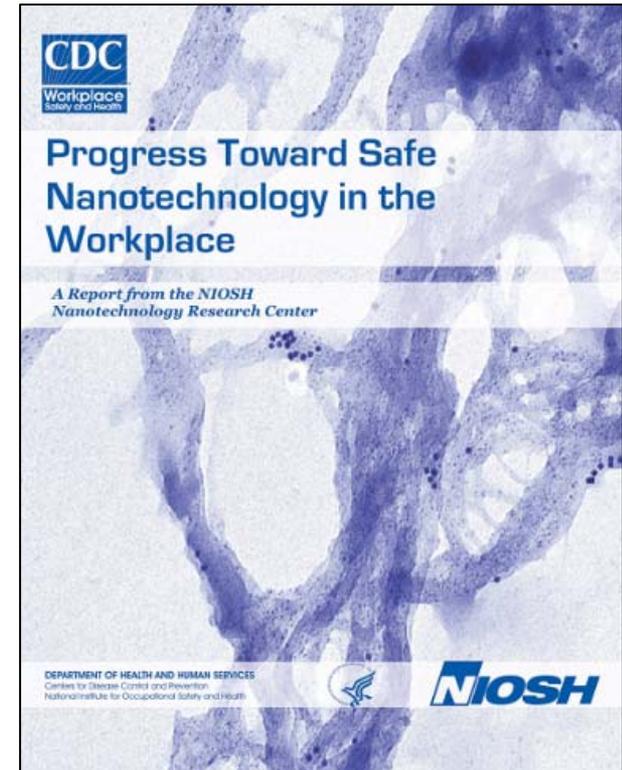
**E-mail: [CGeraci@cdc.gov](mailto:CGeraci@cdc.gov)**

**Phone: 513-533-8339**

**FAX: 513-533-8230**

# Summary

- NIOSH has an active research program on nanotechnology and PPE
- For respirator filter media there is no deviation from classical single-fiber theory for particulates as small as 4 nm in diameter
- It is likely that NIOSH approved APRs when used in a complete respirator program will be useful for protecting workers from nanoparticle inhalation and should provide levels of protection consistent with their OSHA assigned protection factor (APF)
- Research on effectiveness of protective clothing and gloves is just beginning



[www.cdc.gov/niosh/topics/nanotech](http://www.cdc.gov/niosh/topics/nanotech)

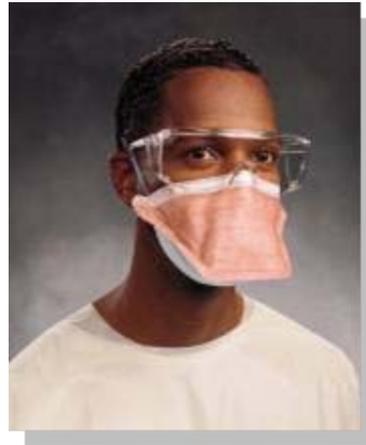
# Acknowledgements

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- **NIOSH NTRC**
- **Respiratory Protection Team: Samy Rengasamy (PI), Ben Eimer, Bill King**
- **Protective Clothing Team: Pengfei Gao (PI), Angie Shepherd, Zhong-Min Wang**

# Quality Partnerships Enhance Worker Safety & Health

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Visit Us at: <http://www.cdc.gov/niosh/npptl/default.html>

***Disclaimer:***

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Thank you