

- Cleanup and disposal of nanoparticles may result in exposure if not properly handled.
- Maintenance and cleaning of production systems or dust collection systems may result in exposure if deposited nanoparticles are disturbed.
- Machining, sanding, drilling, or other mechanical disruptions of materials containing nanoparticles may lead to aerosolization of nanoparticles.

3. Can nanoparticles be measured?

Traditional industrial hygiene sampling methods can be used to measure airborne nanoparticles. However, these methods are limited and require careful interpretation. Scientists are developing more sensitive and specific sampling techniques to evaluate occupational exposures to nanoparticles.

Sampling in the workplace should include background measurements and measurements before, during, and after production or handling of nanoparticles. These measurements can determine if emissions and possible exposures are occurring.

4. Can worker exposures be controlled?

Engineering controls. Employers should use engineering controls to reduce worker exposures to nanoparticles. These controls include source enclosure (isolating the generation source from the worker) and local exhaust ventilation systems. Exhaust ventilation systems that use high-efficiency particulate air (HEPA) filters are very effective in removing nanoparticles.

Engineering controls have been designed to reduce worker exposures to other particles with sizes similar to those of nanoparticles. Examples include controls for welding fume. These controls are also effective for the manufacturing and fabrication of nanoparticles.

Respirators. Respirators should be considered if engineering and administrative controls do not control worker exposures to nanoparticles. The decision to use respirators should be based on professional judgment and an assessment of worker exposures and the health risks they pose.

Training. Worker training should be part of any complete safety and health program. To reduce nanoparticle exposures, workers should learn how to safely handle nanoparticles, use personal protective equipment, handle work clothes, clean contaminated surfaces, and dispose of spilled nanoparticles.

Where can I get more information?

Refer to the following sources for more information about safe nanotechnology in the workplace:

Approaches to Safe Nanotechnology: An Information Exchange with NIOSH [www.cdc.gov/niosh/topics/nanotech/safenano/]

NIOSH Nanotechnology Website:
www.cdc.gov/niosh/topics/nanotech/

NIOSH
Telephone: 1-800-CDC-INFO (1-800-232-4636)
TTY: 1-800-232-6348 ■ E-mail: cdcinfo@cdc.gov

or visit the NIOSH Web site at www.cdc.gov/niosh

For a monthly update on news at NIOSH, subscribe to NIOSH *eNews* by visiting www.cdc.gov/niosh/eNews

For general information about nanotechnology, visit www.nano.gov

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Safe Nanotechnology in the Workplace

An Introduction for Employers, Managers, and Safety and Health Professionals

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

Introduction

Nanotechnology is the engineering and manipulation of materials at the molecular level. This new technology creates materials with dimensions ranging from 1 to 100 nanometers (1 nanometer is 1 billionth of a meter). Particles created at the nanoscale have different chemical and physical properties than larger particles of the same material. These manufactured nanoparticles are known as *engineered nanoparticles*.^{*} Scientists and manufacturers can use nanoparticles to create new products that would be impossible with larger particles.

This brochure addresses the following questions:

1. Are nanoparticles hazardous to workers?
2. How can workers be exposed?
3. Can nanoparticles be measured?
4. Can worker exposures be controlled?

1. Are nanoparticles hazardous to workers?

Little information is available about the hazards of nanoparticles in the workplace. The National Institute for Occupational Safety and Health (NIOSH) is conducting research to determine whether they pose a health threat to exposed workers.

Different types of nanoparticles are made or used in various industrial processes. To determine whether these nanoparticles pose a hazard to workers, scientists must know the following:

- Types and concentrations of nanoparticles in the workplace
- Properties of nanoparticles that could affect the body
- Concentrations of nanoparticles that could produce adverse effects

^{*}Engineered nanoparticles are referred to as nanoparticles throughout this brochure.



A nanoparticle production worker wearing a personal air sampler and hearing, respiratory, and dermal protection during a pouring operation.

Effects in animals. Laboratory studies in animals have shown that some types of nanoparticles may reach the blood, brain, and other organs of laboratory animals when they are inhaled. Some studies have shown adverse effects such as inflammation and fibrosis in the lungs and other organs of animals.

Effects in humans. Human studies of exposure and response to engineered nanoparticles are not currently available.

Safety issues in the workplace. Fire and explosion are the main safety hazards associated with nanoparticles in the workplace. Some materials at the nanometer scale may unexpectedly become chemical catalysts and result in unanticipated reactions.

Current exposure standards. No U.S. or international exposure standards have been established for nanoparticles.

Recommendations. Although more research is needed to predict the effects of nanoparticle exposures in humans, sufficient information is available to provide

interim recommendations and guidance about occupational exposures to nanoparticles. NIOSH recommends a prudent approach for manufacturing and using nanoparticles in industry. Employers should take steps to minimize worker exposures until more information is available.

2. How can workers be exposed?

Workers may be exposed by three routes:

Inhalation—The most common route of exposure is by inhalation.

Ingestion—Workers can be exposed by unintentional hand-to-mouth transfer of materials or swallowing particles cleared from the respiratory tract.

Skin—Some studies mention that nanoparticles may penetrate the skin. This possibility is being investigated.

Several factors affect worker exposure to nanoparticles:

- Concentration, duration, and frequency of exposure all affect exposure.
- The ability of nanoparticles to be easily dispersed as a dust (e.g., a powder) or an airborne spray or droplets may result in greater worker exposure.
- Use of protective measures such as engineering controls can reduce worker exposure.

Job-related activities may also influence worker exposure:

- Active handling of nanoparticles as powders in non-enclosed systems pose the greatest risk for inhalation exposure.
- Tasks that generate aerosols of nanoparticles from slurries, suspensions, or solutions pose a potential for inhalation and dermal exposure.