# General Considerations for Engineering Controls for Nanomaterials

The information below is intended to guide engineers and health professionals in the understanding and application of exposure control strategies and technologies. The understanding of biologic properties and specific health effects of nanoparticulates is evolving along with the ability to communicate significant properties and behaviors of these materials.

## General

Opportunities for both personal exposure and work-site contamination to nanoparticulate materials should be minimized by design through a hierarchy of controls beginning with physical or chemical containment, proceeding through ventilation or other extraction methods, and ending with standard work practices, administrative procedures, personal protective equipment and personal hygiene.

The following address specific issues.

## Physical or chemical containment

Some examples of physical and chemical containment would include working with dispersions of nanoparticles in liquids, gels, or bulk solids as opposed to dry powders and preventing such materials from drying out and dispersing beyond the intended application. Chemical binding and overcoating are other methods to contain nanoparticles.

Closed and ventilated compartments should be considered for material transfer operations where nanoparticulates may be easily lost to the work environment. Store and process nanoparticulate materials in closed containers as much as possible.

## Ventilation and flow extraction

Smaller particles have slower settling rates and tend to remain suspended in air longer than larger particles of similar density. Thus, local and general exhaust ventilation can effectively reduce exposure to nanoparticle-containing aerosols and minimize exposure beyond the handling site. Ventilation should be considered as a supplement to physical or chemical containment and a requirement whenever containment is not possible for exposure control.

To control process or experimental spaces with small volumes, vacuum pumps and venturi aspirators, eductors, or other flowing fluids may be used to collect and extract nanoparticles in certain situations.

If ventilation or vacuum exhaust is discharged into a workspace, effective HEPA filtration should be maintained. The discharging air from such exhaust should not re-suspend particles from surfaces or interfere with the effectiveness of exhaust capture flows.

Positive-pressure, laminar-flow hoods are designed to protect work materials in the hood from environmental contamination. They can transport materials generated inside the hood into the workroom or into the air breathed by operators. Particulate nanomaterials, like any potentially hazardous material, should be sufficiently contained or controlled by other mechanisms if they are used in such hoods.

**HEPA filtration**

High-efficiency particle arresting respirator filters have been tested [1] with particles ranging from 30 to over 1000 nanometers in diameter. Simulations [2] of the fundamental physics have extended the filtration efficiency curve for particles down to 4 nanometers in diameter. Government standards are set so that the filters are tested with particles of a diameter that would most easily penetrate the filter. Particles in the 100 to 400-nanometer diameter size range are most likely to penetrate the filters. Manufacturers are required to assure that filters are at least 99.97 % effective with particles 300 nanometers in diameter. HEPA filters are more than 99.97 % effective with both particles smaller and larger than 300 nanometers in diameter. [3] HEPA filters are not effective for gases or with liquids after they have saturated the filter media.

With filtering devices, consider manufacturers' operating guidelines for flow rates and change-out schedules to optimize performance.

**References/Citations**


[1] Gregory A. Stevens & Ernest S. Moyer, "Worst Case" Aerosol Testing Parameters: I Sodium Chloride and Dioctyl Phthalate Aerosol Filter Efficiency as a Function of Particle Size and Flow Rate, *American Industrial Hygiene Association Journal*, 1989, 50(5), 257-264.

[2] A. Latz & A. Wiegmann, Simulation of Fluid Particle Separation in Realistic Three Dimensional Fiber Structures, Fraunhofer Institut fur Techno- und Wirtschaftsmathematik, Gottlieb-Daimler Str. 67663 Kaiserslauten, Germany, July 16, 2003, http://www.itwm.fhg.de/sks/employees/wiegmann/References/filtex.pdf.

[3] William C. Hinds, Chapter 9, *Aerosol Technology: Properties, Behavior, and Measurement of Airborne Particles*, 2nd edition, 1999, John Wiley & Sons, Inc.