

LOOKING TO THE PAST AND THE FUTURE OF NIOSH NANOTECHNOLOGY GUIDANCE

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The National Institute for Occupational Safety and Health (NIOSH) has been at the forefront of research on engineered nanomaterials since the early 2000s. As the NIOSH Nanotechnology Research Center (NTRC) celebrates its 20th anniversary, we look back over two decades of NIOSH NTRC published guidance to help reduce worker exposures to engineered nanomaterials (ENMs).

Both companies and workers use this guidance to keep workers safer. NTRC research has led to improved recommendations for controlling exposures during advanced manufacturing processes. Organizations have also used our guidance to base global standards.

Here, we reflect on how our guidance and publications have evolved through decades of research. We also discuss the needs for future research efforts.

THE NTRC STRATEGIC PLAN

In 2005, NIOSH became the first government agency to publish a strategic plan as a roadmap for nanotechnology research. This work, titled *Approaches to Safe Nanotechnology: An Information Exchange with NIOSH*, led to seminal guidance for the nanotechnology industry.

The strategic plan served multiple purposes. It offered a chance to collect safety and health concerns about nanomaterial exposures. It also outlined research needs and gave recommendations for workplace practices. International organizations and others used those workplace practices to create guidance documents. In 2009, the strategic plan was updated and published as "Approaches to safe nanotechnology: Managing the health and safety concerns associated with engineered nanomaterials."¹

It's A Matter Of Choice



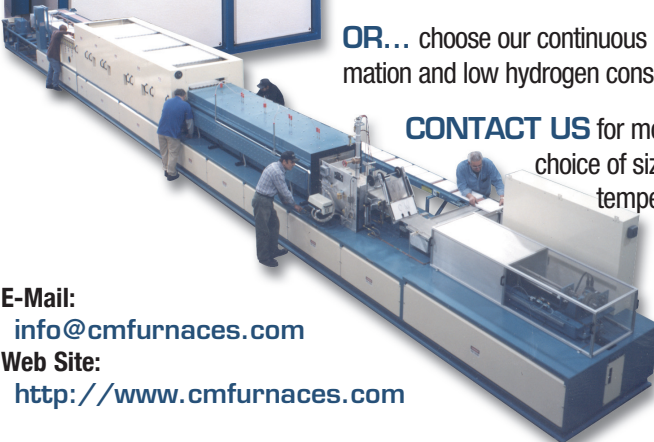
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Examples of Current Intelligence Bulletins providing guidance on workplace exposure to engineered nanomaterials. Credit: National Institute for Occupational Safety and Health

To protect the nanotechnology workforce, NIOSH published the "Strategic Plan for NIOSH Nanotechnology Research and Guidance" in 2010.² Updated in 2014 and 2019, the plan currently describes the NTRC strategy into 2025.³

The strategic plan includes filling knowledge gaps in these priority areas:

- Researching the toxicology of available nanoparticles on the market
- Studying long-term effects of carbon nanotubes
- Developing exposure limits and control recommendations for fine and ultrafine titanium dioxide and carbon nanotubes
- Finding new nanomaterials coming into the market for mass production

ESTABLISHING WORKPLACE EXPOSURE LIMITS AND RECOMMENDATIONS

Occupational exposure limits are the "gold standard" for those working in occupational safety and health. NIOSH recommended exposure limits (RELs) are intended to prevent adverse health effects in workers from occupational inhalation exposures for up to a 10-hour shift, 40-hour work week, over a working lifetime. Researchers develop RELs from the best science available for a given material.

NIOSH was the first U.S. government agency to establish RELs for ENMs. In 2011, for the first time in its history, NIOSH released two RELs for the same chemical based on fine and ultrafine sizes. These were published in "Current Intelligence Bulletin 63: Occupational exposure to titanium dioxide."⁴ Workplace guidance recommendations were also provided in this Current Intelligence Bulletin.

NIOSH also published two other ENM-related guidance documents:

- "Current Intelligence Bulletin 65: Occupational exposure to carbon nanotubes and nanofibers" (2013): <https://www.cdc.gov/niosh/docs/2013-145/pdfs/2013-145.pdf>

- "Current Intelligence Bulletin 70: Health effect of occupational exposure to silver nanomaterials" (2021): <https://www.cdc.gov/niosh/docs/2021-112/pdfs/2021-112.pdf>

TARGETED GUIDANCE FOR EMPLOYERS

In addition to exposure limits, employers need to know the best workplace practices to meet exposure targets. NIOSH has published guidance documents for these employers:

- "Medical screening and hazard surveillance for workers potentially exposed to engineered nanoparticles" offers interim guidance on controlling exposures with practical measures, conducting hazard surveillance, and using established medical surveillance methods (2009): <https://www.cdc.gov/niosh/docs/2009-116/pdfs/2009-116.pdf>
- "General safe practices for working with engineered nanomaterials in research laboratories" addresses ENM handling in research laboratory settings (2012): <https://www.cdc.gov/niosh/docs/2012-147/pdfs/2012-147.pdf>
- "Strategies for engineering controls in nanomaterial production and downstream handling processes" helps to find and describe methods for controlling ENM exposures using engineering controls (2014): <https://www.cdc.gov/niosh/docs/2014-102/pdfs/2014-102.pdf>
- "Building a safety program to protect the nanotechnology workforce" is targeted to small- and medium-sized businesses (2016): <https://www.cdc.gov/niosh/docs/2016-102/default.html>
- "Occupational exposure sampling for engineered nanomaterials" offers workplace sampling guidance for carbon nanotubes and nanofibers, silver, titanium dioxide, and other ENMs without exposure limits (2022): <https://www.cdc.gov/niosh/docs/2022-153>

TARGETED GUIDANCE FOR EMPLOYEES

Ultimately, NIOSH aims to protect the health of the worker. When workers understand why and how to manage their exposures, they are more likely to take actions to protect their health. NIOSH published clear, concise, one-page guidance documents specifically for workers.

For example, three NIOSH posters present safety questions workers should ask before working with nanomaterials⁵ and when 3D printing with filament⁶ or metal powders.⁷ The posters can help workers in recognizing possible hazards. The posters include the types of controls and personal protective equipment workers could use to protect themselves.

NIOSH also published an infographic on reducing exposures when 3D printing with plastic filament.⁸ It highlights easy ways to reduce exposures during fused filament fabrication, fused deposition modeling, and fused layer modeling.

LOOKING AHEAD TO THE FUTURE

NIOSH NTRC remains committed to offering research-based guidance to meet the needs of the ever-changing field of nanomaterials and related emerging technologies. Researchers recently published "Approaches to safe 3D printing: a guide for makerspace users, schools, libraries, and small business to help control exposures."⁹

They are also laying the groundwork to develop additional occupational exposure limits for ENMs.

NIOSH continues to seek and gather feedback from the advanced manufacturing industry and provide guidance. The aim is to bridge knowledge gaps and make actionable recommendations. If you have input or suggestions about guidance or research needs, contact nano@cdc.gov.

You can find a full list of NIOSH nanotechnology publications at Nanotechnology Guidance and Publications.¹⁰

To celebrate the 20th anniversary of the Nanotechnology Research Center, the National Institute for Occupational Safety and Health will focus on nanomaterials in its 2024 science blog posts. View the NIOSH Science Blog at <https://blogs.cdc.gov/niosh-science-blog>.

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How to Reduce Exposures When 3D Printing with Plastic Filament

It is important to know how to reduce or avoid exposures when printing by:

- Fused Filament Fabrication (FFF)
- Fused Deposition Modeling (FDM™)
- Fused Layer Modelling (FLM)

Heating plastics during these types of printing processes releases small particles and gases that might raise concerns for health risks to the lungs, eyes, and skin. Several basic precautions can help minimize risks.

Easy Ways to Reduce Exposures



Use ventilation.



Print at lowest recommended temperature.



Keep the nozzle clean.



Air it out if the printer malfunctions.



Heat nozzle then load filament.



Wait before opening a closed printer.

Wear Appropriate Personal Protective Equipment



Eye protection to prevent damage to the eyes.



N95* respirator to avoid breathing particles.



Gloves to protect hands from hot surfaces.

Avoid Touching



Moving parts



Loose or frayed wires




Go to 3D Printing with Filaments for more information.



NIOSH is a certification mark of the U.S. Department of Health and Human Services (HHS) registered in the United States and several international jurisdictions.

Example of a one-page guidance document published by NIOSH to help workers understand why and how to manage their exposure to engineered nanomaterials. *Credit: National Institute for Occupational Safety and Health*