NTRC | NANOTECHNOLOGY RESEARCH CENTER

Exposure Scenario: Workplace Exposures

Kevin L Dunn, MS, CIH

National Institute for Occupational Safety and Health

Nano and Advanced Materials and Manufacturing Field Team

2nd Quantifying Exposure to Engineered Nanomaterials from Manufactured Products Work Shop

October 9-10, 2018

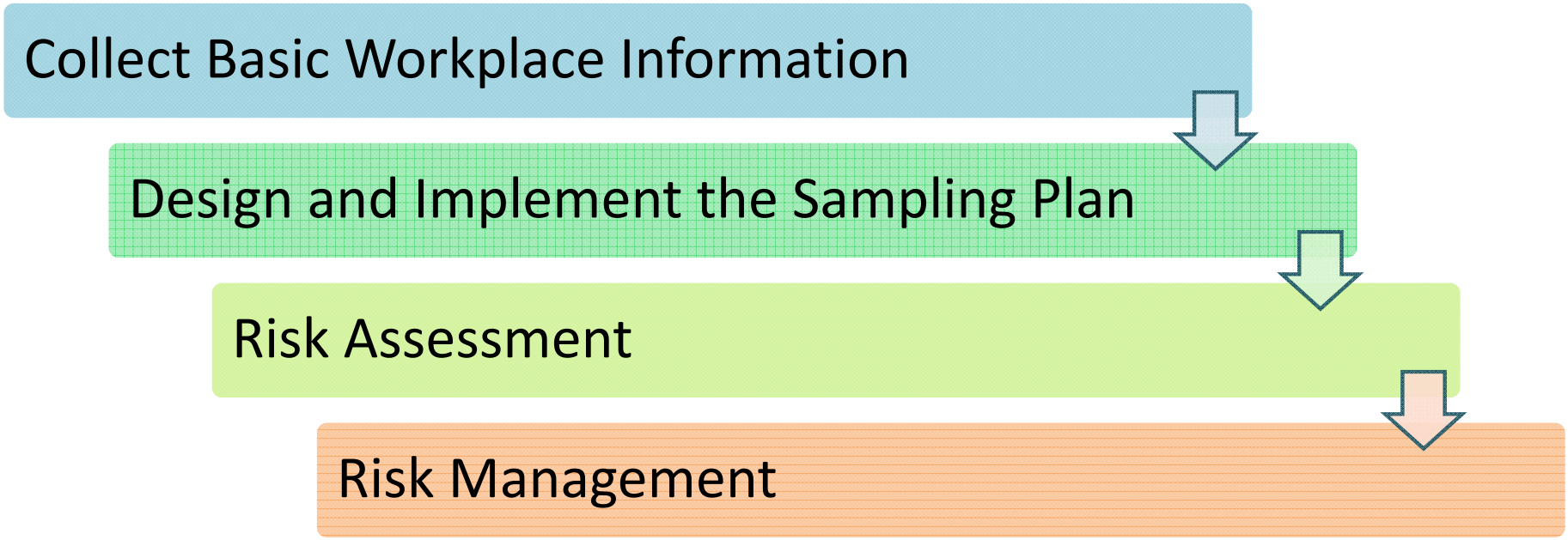
CDC Workplace Safety and Health NIOSH

12 years in and what do we know?

- Traditional industrial hygiene methods can be used to assess potential occupational exposures,
  - However be careful with data interpretation!
- Form matters- Wet is preferred over dry when possible
- Engineering control options are available but proper design, installation and maintenance are key in their effective use
- Work practices play a large role in exposure potential
- PPE is effective against fine and ultrafine particulate
- Little evidence of release by mechanical means down stream
- Supply chain is a potential weak point in understanding hazard potential

Exposure assessment process

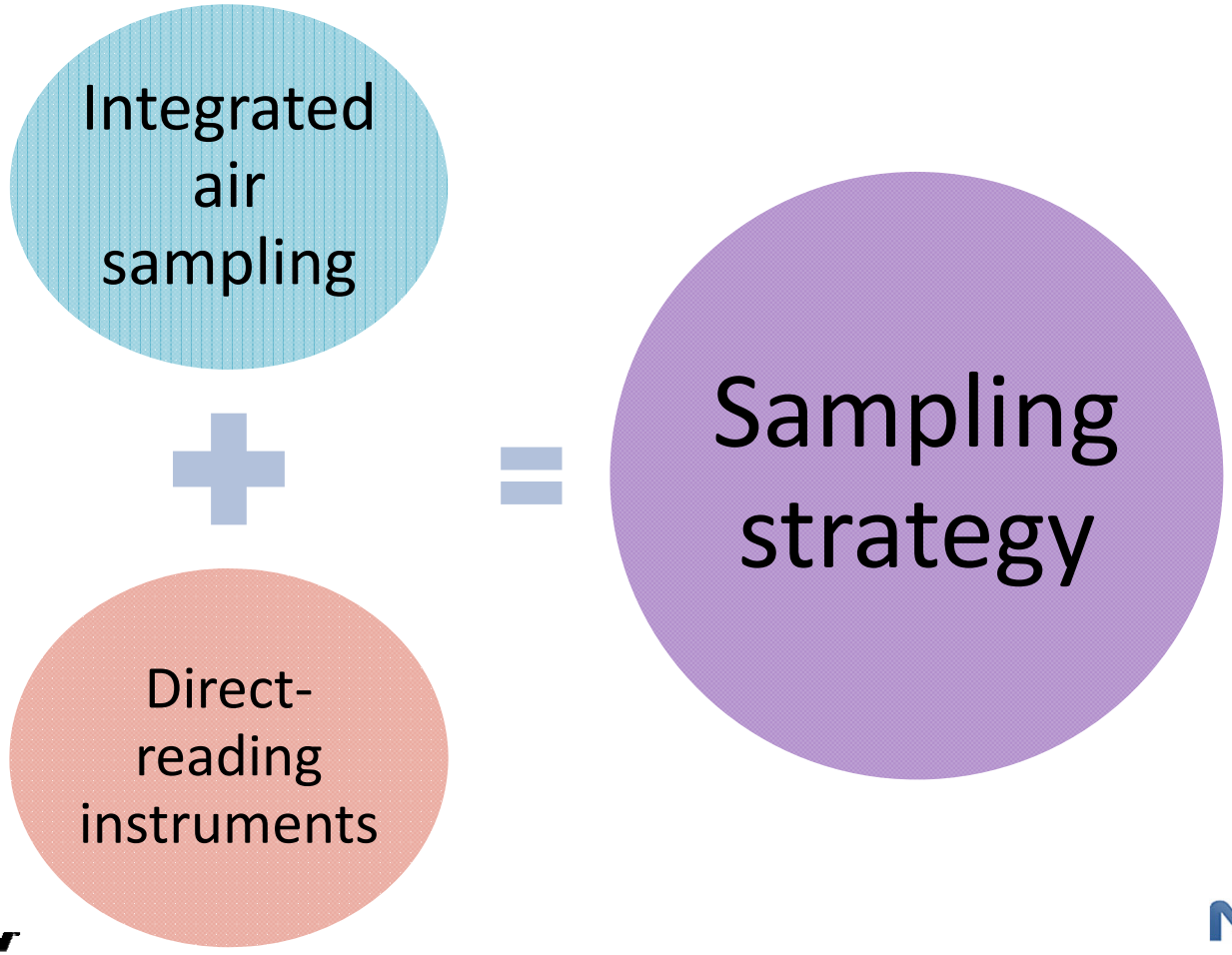
Based on Nanomaterial Exposure Assessment Technique (NEAT) 2.0



CDC Workplace Safety and Health NIOSH

NTRC NANOTECHNOLOGY RESEARCH CENTER

Design and Implement the Sampling Plan



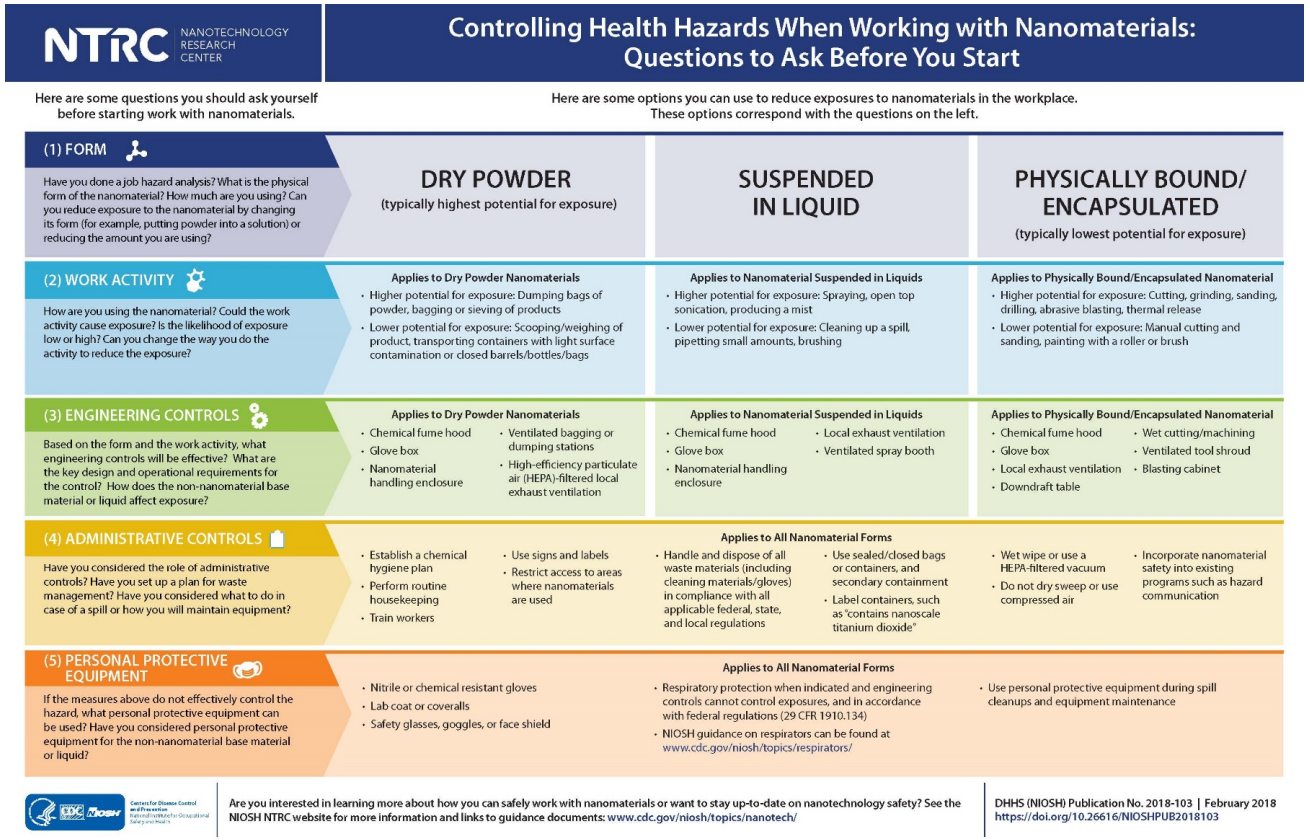
Nano Risk Assessment Tool

Poses questions that employers and workers should consider before starting work with a nanomaterial

For each question, the poster provides options to reduce exposures to nanomaterials based on the physical form

Can be displayed in a lab or work environment

Reminder of the important health and safety considerations for working with nanomaterials



NTRC NANOTECHNOLOGY RESEARCH CENTER

Controlling Health Hazards When Working with Nanomaterials: Questions to Ask Before You Start

Here are some questions you should ask yourself before starting work with nanomaterials.

Here are some options you can use to reduce exposures to nanomaterials in the workplace. These options correspond with the questions on the left.

	DRY POWDER (typically highest potential for exposure)	SUSPENDED IN LIQUID	PHYSICALLY BOUND/ ENCAPSULATED (typically lowest potential for exposure)
(1) FORM Have you done a job hazard analysis? What is the physical form of the nanomaterial? How much are you using? Can you reduce exposure to the nanomaterial by changing its form (for example, putting powder into a solution) or reducing the amount you are using?			
(2) WORK ACTIVITY How are you using the nanomaterial? Could the work activity cause exposure? Is the likelihood of exposure low or high? Can you change the way you do the activity to reduce the exposure?	**Applies to Dry Powder Nanomaterials** • Higher potential for exposure: Dumping bags of powder, bagging or sieving of products • Lower potential for exposure: Scooping/weighing of product, transporting containers with light surface contamination or closed barrels/bottles/bags	**Applies to Nanomaterial Suspended in Liquids** • Higher potential for exposure: Spraying, open top sonication, producing a mist • Lower potential for exposure: Cleaning up a spill, pipetting small amounts, brushing	**Applies to Physically Bound/Encapsulated Nanomaterial** • Higher potential for exposure: Cutting, grinding, sanding, drilling, abrasive blasting, thermal release • Lower potential for exposure: Manual cutting and sanding, painting with a roller or brush
(3) ENGINEERING CONTROLS Based on the form and the work activity, what engineering controls will be effective? What are the key design and operational requirements for the control? How does the non-nanomaterial base material or liquid affect exposure?	**Applies to Dry Powder Nanomaterials** • Chemical fume hood • Glove box • Nanomaterial handling enclosure • Ventilated bagging or dumping stations • High-efficiency particulate air (HEPA)-filtered local exhaust ventilation	**Applies to Nanomaterial Suspended in Liquids** • Chemical fume hood • Glove box • Nanomaterial handling enclosure • Local exhaust ventilation • Ventilated spray booth	**Applies to Physically Bound/Encapsulated Nanomaterial** • Chemical fume hood • Glove box • Local exhaust ventilation • Downdraft table • Wet cutting/machining • Ventilated tool shroud • Blasting cabinet
(4) ADMINISTRATIVE CONTROLS Have you considered the role of administrative controls? Have you set up a plan for waste management? Have you considered what to do in case of a spill or how you will maintain equipment?	**Applies to All Nanomaterial Forms** • Establish a chemical hygiene plan • Perform routine housekeeping • Train workers • Use signs and labels • Restrict access to areas where nanomaterials are used	• Handle and dispose of all waste materials (including cleaning materials/gloves) in compliance with all applicable federal, state, and local regulations • Use sealed/closed bags or containers, and secondary containment • Label containers, such as "contains nanoscale titanium dioxide"	• Wet wipe or use a HEPA-filtered vacuum • Do not dry sweep or use compressed air • Incorporate nanomaterial safety into existing programs such as hazard communication
(5) PERSONAL PROTECTIVE EQUIPMENT If the measures above do not effectively control the hazard, what personal protective equipment can be used? Have you considered personal protective equipment for the non-nanomaterial base material or liquid?	• Nitrile or chemical resistant gloves • Lab coat or coveralls • Safety glasses, goggles, or face shield	**Applies to All Nanomaterial Forms** • Respiratory protection when indicated and engineering controls cannot control exposures, and in accordance with federal regulations (29 CFR 1910.134) • NIOSH guidance on respirators can be found at www.cdc.gov/niosh/topics/respirators/	• Use personal protective equipment during spill cleanups and equipment maintenance

Are you interested in learning more about how you can safely work with nanomaterials or want to stay up-to-date on nanotechnology safety? See the NIOSH NTRC website for more information and links to guidance documents: www.cdc.gov/niosh/topics/nanotech/

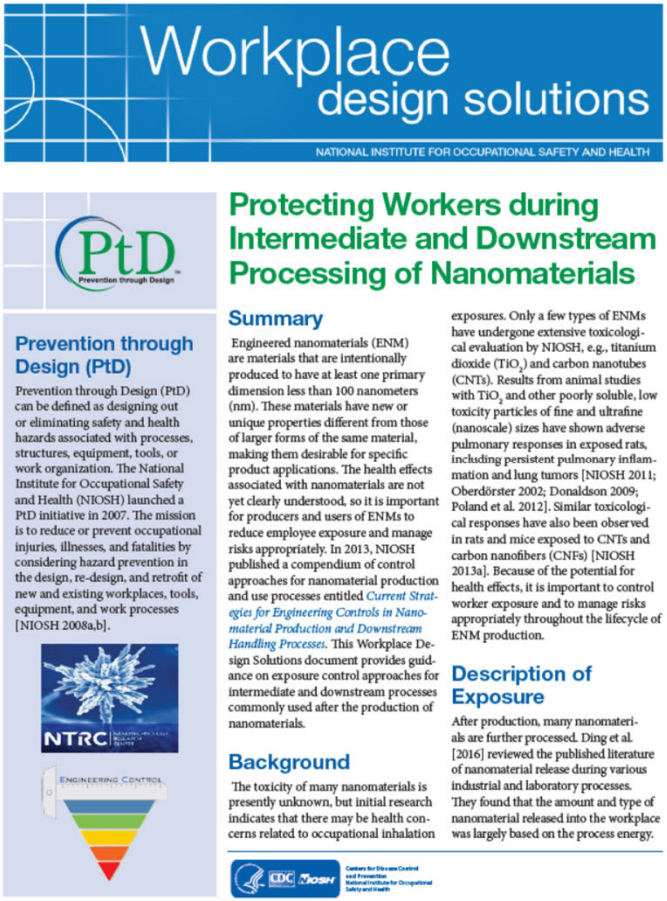
DHHS (NIOSH) Publication No. 2018-103 | February 2018
https://doi.org/10.26616/NIOSHPUB2018103

Nano Workplace Design Solutions

Each workplace design solutions document provides key tips on the design, use, and maintenance of exposure controls for nanomaterial production, post processing, and use.

1. Protecting Workers during the Handling/Weighing of Nanomaterials
2. Protecting Workers during Nanomaterial Reactor Operations
3. Protecting Workers during Intermediate and Downstream Processing of Nanomaterials

https://www.cdc.gov/niosh/updates/upd-03-12-18.html



Workplace design solutions

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

PtD Prevention through Design

Prevention through Design (PtD)

Prevention through Design (PtD) can be defined as designing out or eliminating safety and health hazards associated with processes, structures, equipment, tools, or work organization. The National Institute for Occupational Safety and Health (NIOSH) launched a PtD initiative in 2007. The mission is to reduce or prevent occupational injuries, illnesses, and fatalities by considering hazard prevention in the design, re-design, and retrofit of new and existing workplaces, tools, equipment, and work processes [NIOSH 2008a,b].

NTRC

ENGINEERING CONTROL

Protecting Workers during Intermediate and Downstream Processing of Nanomaterials

Summary

Engineered nanomaterials (ENM) are materials that are intentionally produced to have at least one primary dimension less than 100 nanometers (nm). These materials have new or unique properties different from those of larger forms of the same material, making them desirable for specific product applications. The health effects associated with nanomaterials are not yet clearly understood, so it is important for producers and users of ENMs to reduce employee exposure and manage risks appropriately. In 2013, NIOSH published a compendium of control approaches for nanomaterial production and use processes entitled *Current Strategies for Engineering Controls in Nanomaterial Production and Downstream Handling Processes*. This Workplace Design Solutions document provides guidance on exposure control approaches for intermediate and downstream processes commonly used after the production of nanomaterials.

Background

The toxicity of many nanomaterials is presently unknown, but initial research indicates that there may be health concerns related to occupational inhalation exposures. Only a few types of ENMs have undergone extensive toxicological evaluation by NIOSH, e.g., titanium dioxide (TiO_2) and carbon nanotubes (CNTs). Results from animal studies with TiO_2 and other poorly soluble, low toxicity particles of fine and ultrafine (nanoscale) sizes have shown adverse pulmonary responses in exposed rats, including persistent pulmonary inflammation and lung tumors [NIOSH 2011; Oberdörster 2002; Donaldson 2009; Poland et al. 2012]. Similar toxicological responses have also been observed in rats and mice exposed to CNTs and carbon nanofibers (CNFs) [NIOSH 2013a]. Because of the potential for health effects, it is important to control worker exposure and to manage risks appropriately throughout the lifecycle of ENM production.

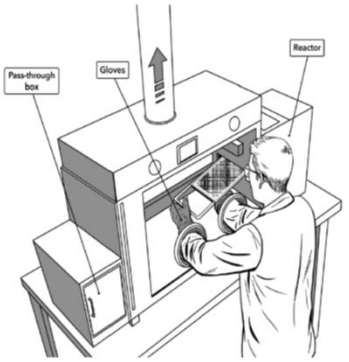
Description of Exposure

After production, many nanomaterials are further processed. Ding et al. [2016] reviewed the published literature of nanomaterial release during various industrial and laboratory processes. They found that the amount and type of nanomaterial released into the workplace was largely based on the process energy.

CDC NIOSH Centers for Disease Control and Prevention National Institute for Occupational Safety and Health

Chemical Fume Hood

- Common control used in many settings, including with nanomaterials.
- Effectively contains nanomaterials for a range of activities.
- Should include design features such as airfoils at all edges and baffles inside the unit to reduce turbulence and improve containment.
- Older versions with constant airflow were found to leak even at the design face velocity [Tsai et al. 2009].
- Exhausts directly out of facility—not recirculated into workplace.
- Larger size, higher and potentially disruptive airflows compared with the nanomaterial handling enclosure.
- Higher energy costs for both fan motor and tempered replacement air than for low flow units such as the nanomaterial handling enclosure.



Small Reactor Harvest Enclosure

- Ventilated enclosure for capturing emissions during the harvesting of ENMs from a reactor.
- Enclosure design must account for operator access needs and process visibility to be effective.
- A low exhaust flowrate should be sufficient to maintain negative pressure in the enclosure and contain emissions.
- After ENMs are harvested, they should be placed in a sealed container to minimize contamination during removal from the enclosure.
- A pass through box allows for the removal of nanomaterials from the enclosure with minimal potential for release of materials to the workplace.

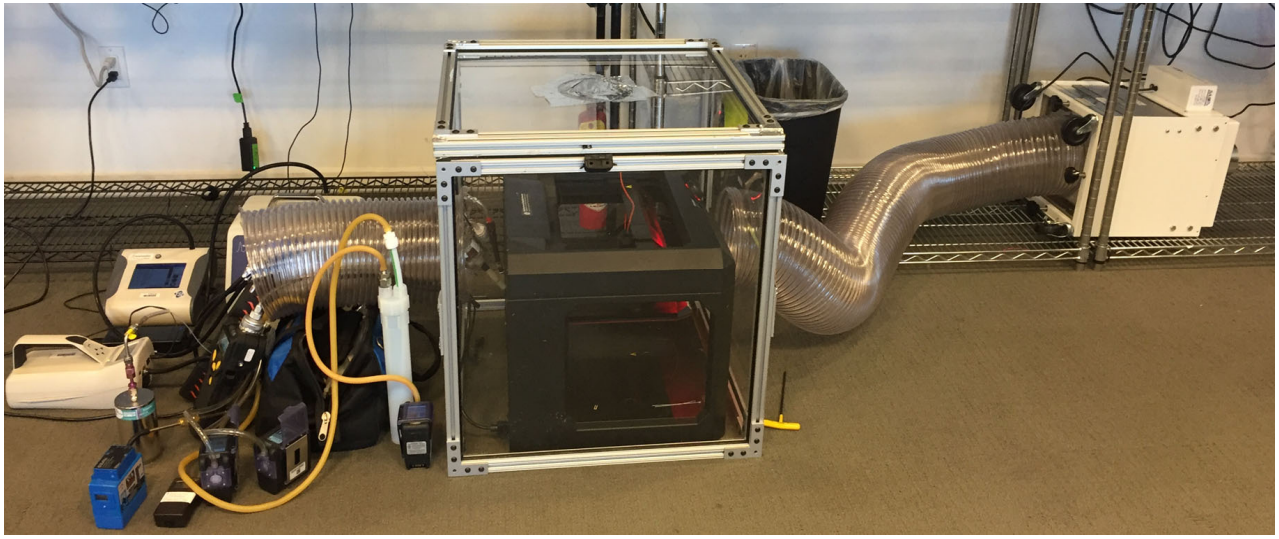
Follow up study at MakerBot Sept 2018

20 MakerBot 3D printers with and without LEV controls

NTRC NANOTECHNOLOGY RESEARCH CENTER

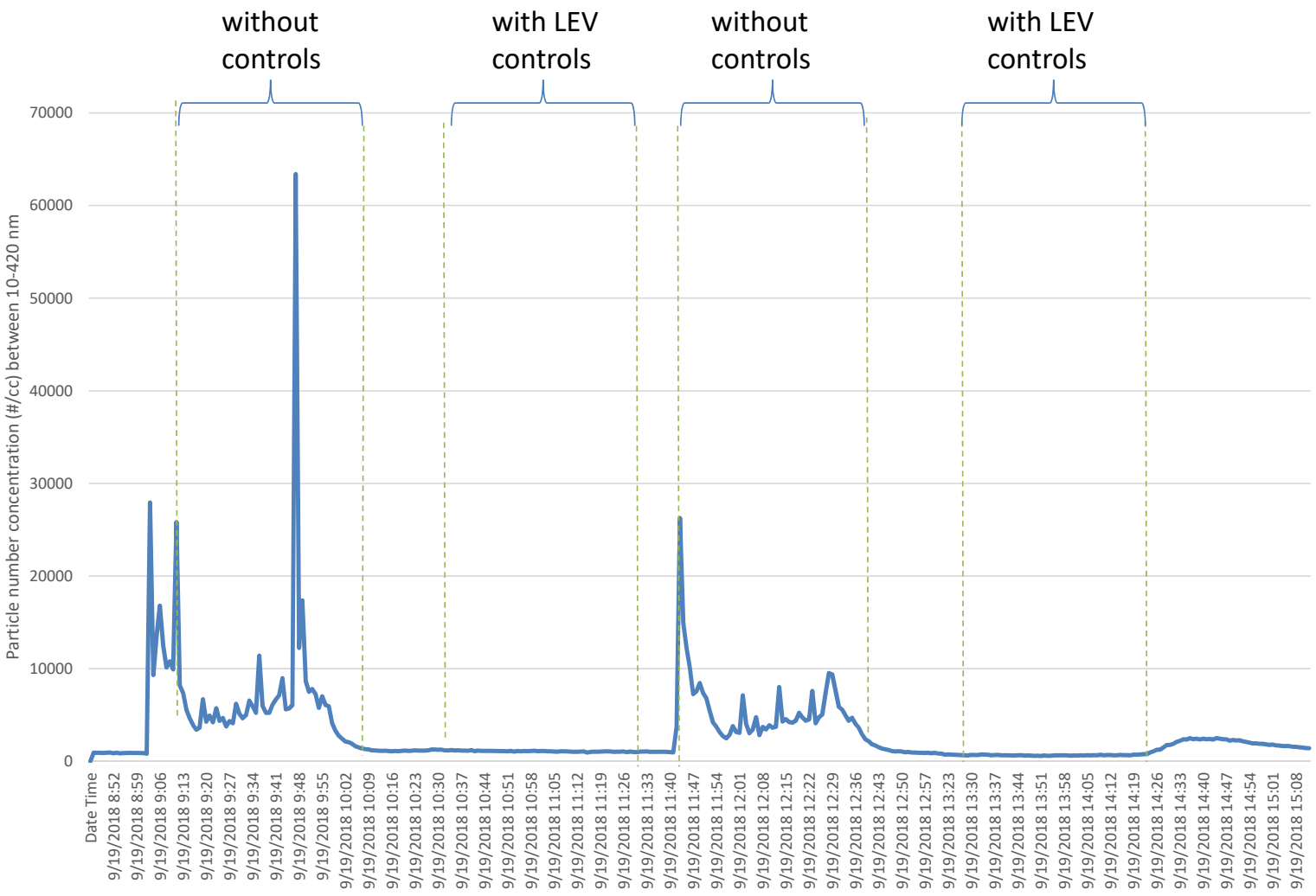
Portable chamber

- 8 cubic foot (ft^3) portable chamber
- HEPA-filtered portable floor fan (Model SS-300-PYT, Sentry Air Systems Inc.)
- Chamber ventilated at 52 to 55 cubic feet per minute of air (CFM)
- Used CPC, DustTrak, OPS, and Nanoscan real-time monitoring instruments as well as filter-based and VOC sampling techniques



CDC Workplace Safety and Health NIOSH

NTRC NANOTECHNOLOGY RESEARCH CENTER

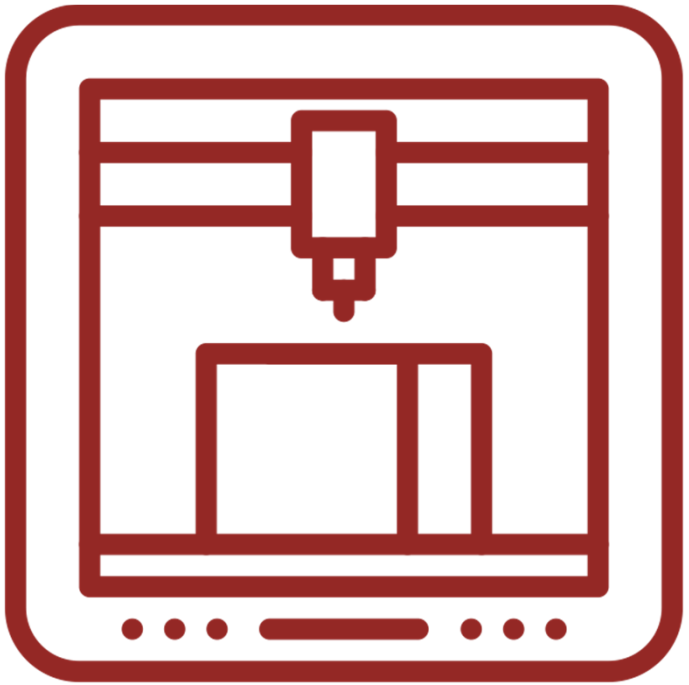


CDC Workplace Safety and Health NIOSH

NTRC NANOTECHNOLOGY RESEARCH CENTER

Acknowledgements

- NIOSH NTRC
- Charles Geraci
- Kevin H. Dunn
- Duane Hammond
- Gary Roth
- Laura Hodson
- Aleks Stefaniak
- Jennifer Tyrawski



Created by lastspark
from Noun Project