FESHM 4310: NANOMATERIALS

Revision History

Author	Description of Change	Revision Date
Ruthe	• Updated respiratory usage authorization form	June 2018
Rich Ruthe	• Initial Release	April 2018

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1.0 INTRODUCTION

Nanoscale particles, often referred to as nanomaterials, have unique properties that may pose serious health hazards that are greater than the same material of the same chemical composition in a non-nanoscale form. When nanomaterials become airborne, they are particularly hazardous since they can enter the deepest tissues of the lung. Although the exact health effects this may have in humans is not known, animal studies have shown adverse lung effects, including pulmonary inflammation and rapidly developing, persistent fibrosis. Several animal studies have shown a possible cancer link. The results from animal research therefore indicate that human exposure needs to be minimized until further information is available on human health effects. This chapter specifically addresses the handling of intentionally produced unbound engineered nanoscale particles (defined below) at the Fermilab site in Batavia, Illinois and all Fermilab leased spaces.

2.0 DEFINITIONS

Engineered nanoparticle – Intentionally created material, in contrast to natural or incidentally formed, with one or more dimensions greater than 1 nanometer (nm) and less than 100 nm.

Recommended Exposure Limit (REL) – A maximum airborne concentration for a workplace hazard that is recommended by the National Institutes of Occupational Safety and Health (NIOSH) of the Centers for Disease Control and Prevention (CDC). A REL is based on risk evaluations using human or animal health effects data, and on an assessment of what levels can be feasibly achieved by engineering controls and measured by analytical techniques. At publication time for this chapter, NIOSH has established an REL for two nanomaterials as follows:

a. Carbon nanotubes and nanofibers: an eight-hour time-weighted average (TWA) of 1 $\mu g/m^3$ as respirable elemental carbon
b. Titanium dioxide (ultrafine): an eight-hour TWA of 0.3 mg/m^3 for up to 10 hours per day during a 40-hour work week

Unbound Engineered Nanoscale Particle (UNP) – Those nanoscale particles that are not contained within a matrix that would reasonably be expected to prevent the particles from being separately mobile and a potential source of exposure. An engineered primary nanoscale particle dispersed and fixed within a polymer matrix, incapable as practical matter of becoming airborne, is considered bound. A particle suspended in any liquid that then could become an aerosol would be unbound.

UNP Worker – A person who:

1) Has the potential for inhalation or dermal exposure to UNPs due to working with UNPs; or

2) Routinely spends time in an area due to performance of regular duties in which UNPs have the potential to become dispersed in the air or onto surfaces; or

3) Works on equipment that might contain or bear UNPs and that could release UNPs during servicing or maintenance.

3.0 RESPONSIBILITIES

3.1 Division/Section Heads and Project Managers (D/S/Ps)

D/S/Ps will ensure that the requirements of this chapter are fulfilled regarding the hazards of handling UNPs, including assessments, hazard mitigation, health surveillance and training.

3.2 Managers and Supervisors

- Ensure that exposures to UNPs are mitigated using control measures, which shall be reflected in a written Hazard Analysis (FESHM Chapter 2060, *Work Planning and Hazard Analysis*) for a one-time activity or a written standard operating procedure for periodic or continuous activities.
- Request that ESH&Q Section Industrial Hygiene personnel conduct a workplace exposure assessment to provide initial and periodic exposure evaluations that address any concerns or uncertain hazards.
- Ensure that UNP workers, identified via their Individual Training Needs Assessment (ITNA), are provided information and training about the hazards of UNPs and the steps that have been implemented to protect them from exposure.

3.3 Chief Safety Officer and ESH&Q Section

- Conducts exposure assessments, including workplace monitoring if possible, in areas where UNPs are handled. Report findings of surveys to supervisors and exposure results, if applicable, to supervisors and employees.
- Serve as a general support resource to managers and supervisors on safe work practices for mitigating airborne exposures to UNPs.
- Maintain site-wide records of exposure assessments and monitoring results that might be generated.
- Communicate to the Occupational Medical Office the findings of any exposure assessments and the possible need for medical screening.
- Oversee and provide appropriate nanomaterial handling training to personnel.
- Manage the proper disposal of Unbound Engineered nanomaterial waste.

3.4 Occupational Medical Office

The Occupational Medical Office shall provide a medical surveillance program for Fermilab employees that may be exposed to UNPs if the need arises.

4.0 PROGRAM DESCRIPTION

Personnel working with UNPs will be protected from the potential hazards of exposure to these materials by following established procedures at Fermilab and by those described in this section.

4.1 Purchase of Nanomaterials

The purchase of any nanomaterials shall be handled in the same manner as the purchase of chemicals in general, i.e. the purchase must be reviewed and approved by the Division Safety Officer (DSO).

4.2 Use of Nanomaterials

The Operational Readiness Clearance (ORC) process as described in FESHM 2005 shall be completed prior to the commencement of operation for any new activity that utilizes any nanomaterials. The ORC process is initiated by the Activity Owner through completing the appropriate online form (https://fermipoint.fnal.gov/service/tsworc). The Activity Owner must select *New ORC – No beam*:

Create *New ORC No Beam* Form:

https://fermipoint.fnal.gov/service/tsworc/Lists/tsworc/NewForm.aspx?Source=/service/tsworc/&Beam=0&orc=1

The Activity Owner should develop written standard operating procedures for the activity if it will be a periodic process or an ongoing process, ensuring that all potential hazards are addressed within the procedure(s). If the activity is a one-time event, a Hazard Analysis per FESHM 2060 will be needed. The documents should be developed prior to a review of the activity by subject matter experts to prevent any delay in the ORC approval process.

4.3 Engineering Controls

The handling of UNPs in powder form shall take place in a ventilated hood or glove box, or some other ventilated enclosure. Ventilated air from these devices shall not be recirculated into the building interior.

4.4 Personal Protective Equipment (PPE)

a. The use of P100 respiratory protection shall be used when engineering controls are not available or are ineffective in mitigating an inhalation risk. Examples include handling UNPs in powder form in a non-ventilated area, or cleaning up spilled, dried UNPs. Handling UNPs in some type of suspension would not be expected to pose an inhalation hazard. The use of respiratory protection shall comply with FESHM 4150.
b. Protective disposable gloves shall be chosen based on the chemical in which the nanomaterial is suspended. Gloves that protect the wrist shall be chosen, and all wrist jewelry (e.g. watches, bracelets, etc.) shall be removed. In some instances, double gloving may be required, as repeatedly handling UNPs may cause the glove material to degrade and/or abrade. Disposable nitrile gloves shall be worn when handling dry UNP powders.
c. Closed laboratory coats (elastic at the wrists preferred) to prevent contamination of street clothes shall be worn. Cotton or cotton-polyester lab coats are sufficient for low hazard materials or when handling small quantities of UNPs. These lab coats shall remain in the area where UNPs are handled. Lab coats of non-woven material shall be worn when handling high hazard UNPs or UNPs in large quantities.
d. Eye protection shall be worn that is based on the hazard of the UNPs that are handled. Safety glasses with side shields are a minimum requirement. Tight-fitting goggles shall be worn when airborne dispersion of dry UNPs is likely, such as when handling dry powders or cleaning up dried spills.

4.5 Posting

Areas where airborne dispersions of UNPs may be present or could be generated (e.g. cleaning up a dried spill) shall be posted with a warning. This could be an area such as a lab hood, or a room if that is the primary activity within the room. If the nanomaterial activity is periodic, and the area is used for other activities, the posting can be removed after a thorough cleaning of the area where the nanomaterial activity took place. The posting shall include the statements "CAUTION: Unbound Engineered Nanoscale Particles May Be Present on Surfaces. Avoid skin contact. Unbound Engineered Nanoparticles can become hazardous when airborne."

4.6 Spills

Spills of UNPs shall be cleaned up immediately. Wipe up spills of liquid UNPs with paper towels or rags. Wipe up spills of dry UNPs with wetted paper towels or rags, commercially available wet towelettes or a HEPA vacuum. The appropriate PPE shall be used depending on the state of the spill:

a. For a dry spill, including a dispersion that has dried, the following PPE shall be used: P100 respirator, disposable gloves, closed lab coat, tight fitting goggles.
b. For a wet spill, i.e. one in a dispersion, the following PPE shall be used: disposable gloves, closed lab coat, safety glasses.

4.7 Waste Management

Materials from cleaning up spills of UNP, or unwanted UNP, shall be placed in a closed container or sealed bag and marked as "Unbound Engineered Nanomaterial Waste." Contact the Hazard Control Technology Team for disposal.

4.8 Training

"Nanomaterial Handling Training" (FN000577/CR/00) is an awareness-level course required for all workers who may handle nanomaterials in any form (both UNP and bound), and therefore have the potential to be exposed. This training shall include information on the potential health effects of nanomaterials, safe work practices, proper handling, and the control of nanomaterial exposures. The need for the training is initiated by a question on the ITNA.

4.9 Exposure Assessments

An Industrial Hygiene (IH) Assessment is required as part of an ORC for any new use of nanomaterials. For nanomaterials already in use, contact the ESH&Q Section IH Group for an IH Assessment if there are any concerns regarding potential exposure to UNPs.

4.10 Medical Surveillance

Personnel who may be exposed to engineered nanomaterials shall be placed in the existing Fermilab health surveillance program that is provided for respirator users. Individuals will be identified through the Workplace Activities Analysis Form (WAAF). If personnel will wear respiratory protection that is required by Section 4.4 (PPE) and/or Section 4.6 (Spills) of this

chapter, the Medical Surveillance Request for Respiratory Protection Usage form shall be completed. A detailed description of the work and/or potential exposure to engineered nanomaterials, including the chemical name of the primary nanomaterial, shall be included on the form, which is then forwarded to the Fermilab Medical Office.

5.0 REFERENCES

DOE Order 456.1A dated July 15, 2016

Approaches to Safe Nanotechnology, Managing the Health and Safety Concerns Associated with Engineered Nanomaterials, DHHS (NIOSH) Publication No. 2009-125, March 2009

Occupational Exposure to Titanium Dioxide, Current Intelligence Bulletin 63, DHHS (NIOSH) Publication No. 2011-160, April 2011

General Safe Practices for Working with Engineered Nanomaterials in Research Laboratories, DHHS (NIOSH) Publication No. 2012-147, May 2012

Occupational Exposure to Carbon Nanotubes and Nanofibers, Current Intelligence Bulletin 65, DHHS (NIOSH) Publication No. 2013-145, April 2013

Engineered Nanomaterials in the Workplace, Fact Sheet Sponsored by the AIHA® Nanotechnology Working Group, July 9, 2015

Personal Protective Equipment for Engineered Nanoparticles, Fact Sheet Sponsored by the AIHA® Nanotechnology Working Group, October 24, 2015

Nanoparticle Sampling and Analysis, Fact Sheet Sponsored by the AIHA® Nanotechnology Working Group, May 6, 2016

WHO Guidelines on Protecting Workers From Potential Risks of Manufactured Nanomaterials, World Health Organization, December 12, 2017.