

1
2
3
4
5
6
7
8
9
10
11
12
13

FESHM 4310: NANOMATERIALS

Revision History

Author	Description of Change	Revision Date
Rich Ruthe	• Initial Release	March 2018

TABLE OF CONTENTS

14			
15			
16	1.0	INTRODUCTION.....	2
17	2.0	DEFINITIONS	2
18	3.0	RESPONSIBILITIES.....	3
19	3.1	Division/Section Heads; Project Managers (D/S/Ps)	3
20	3.2	Managers and Supervisors.....	3
21	3.3	Chief Safety Officer and ESH&Q Section	3
22	3.4	Occupational Medical Office	3
23	4.0	PROGRAM DESCRIPTION	3
24	4.1	General Description.....	3
25	4.2	Purchase of Nanomaterials	3
26	4.3	Use of Nanomaterials	4
27	4.4	Engineering Controls.....	4
28	4.5	Personal Protective Equipment (PPE).....	4
29	4.6	Posting.....	4
30	4.7	Spills.....	5
31	4.8	Waste Management	5
32	4.9	Training	5
33	4.10	Exposure Assessments	5
34	4.11	Medical Surveillance.....	5
35	5.0	REFERENCES.....	5
36			
37			
38			

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).

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. NIOSH has established an REL for two nanomaterials as follows:

- a. Carbon nanotubes and nanofibers: an eight-hour time-weighted average (TWA) of $1 \mu\text{g}/\text{m}^3$ as respirable elemental carbon
- b. Titanium dioxide (ultrafine): an eight-hour TWA of $0.3 \text{mg}/\text{m}^3$ 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, which 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 performing work 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.

85 **3.0 RESPONSIBILITIES**

86

87 **3.1 Division/Section Heads; Project Managers (D/S/Ps)**

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

90

91 **3.2 Managers and Supervisors**

92 • Ensure that exposures to UNPs are mitigated using control measures, which shall be
93 reflected in a written Hazard Analysis ([FESHM Chapter 2060](#), Work Planning and
94 Hazard Analysis) for a one-time activity or a written standard operating procedure for
95 periodic or continuous activities.

96 • Request that ESH&Q Section Industrial Hygiene personnel conduct a workplace
97 exposure assessment to provide initial and periodic exposure evaluations that address
98 any concerns or uncertain hazards.

99 • Ensure that UNP workers are identified through the ITNA, and provided
100 information and training about the hazards of UNPs and the steps that have been
101 implemented to protect them from exposure.

102

103 **3.3 Chief Safety Officer and ESH&Q Section**

104 • Conducts exposure assessments, including workplace monitoring if possible, in areas
105 where UNPs are handled. Report findings of surveys to supervisors, and exposure
106 results if applicable to supervisors and employees.

107 • Serve as a general support resource to managers and supervisors on safe work
108 practices for mitigating airborne exposures to UNPs.

109 • Maintain site-wide records of exposure assessments and monitoring results that might be
110 generated.

111 • Communicate to the Occupational Medical Office the findings of any exposure
112 assessments and the possible need for medical screening.

113 • Oversee and provide training to Fermilab employees that meets Section 4.9.

114

115 **3.4 Occupational Medical Office**

116 The Occupational Medical Office shall provide a medical surveillance program for Fermilab
117 employees that may be exposed to UNPs. (Refer to Section 4.11.)

118

119 **4.0 PROGRAM DESCRIPTION**

120

121 **4.1 General Description**

122

123 The handlers of UNPs will be protected from the potential hazards of exposure to these materials
124 by following established procedures at Fermilab and by those described in this section.

125

126 **4.2 Purchase of Nanomaterials**

127

128 All nanomaterial purchases shall be handled in the same manner as the purchase of chemicals in
129 general, i.e. the purchase must be reviewed and approved by the Division Safety Officer (DSO).

130

4.3 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.

4.4 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.

4.5 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. In the case of handling dry powders, disposable nitrile gloves shall be worn.
- c. Closed laboratory coats (elastic at the wrists preferred) to prevent contamination of street clothes shall be worn.
- d. Tight-fitting goggles shall be worn when airborne dispersion of dry UNPs is likely.

4.6 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:

177 Unbound Engineered Nanoscale Particles May Be Present on Surfaces. Avoid skin contact.
178 Unbound Engineered Nanoparticles can become hazardous when airborne.”

179 **4.7 Spills**

181
182 Spills of UNPs shall be cleaned up immediately. Wipe up spills of liquid UNPs with paper towels
183 or rags. Wipe up spills of dry UNPs with wetted paper towels or rags, commercially available wet
184 towelettes or a HEPA vacuum. The appropriate PPE shall be used depending on the state of the
185 spill:

- 186
- 187 a. For a dry spill, including a dispersion that has dried, the following PPE shall be used: P100
188 respirator, disposable gloves, closed lab coat, tight fitting goggles.
- 189 b. For a wet spill, i.e. one in a dispersion, the following PPE shall be used: disposable gloves,
190 closed lab coat, safety glasses.

191 **4.8 Waste Management**

192
193
194 Materials from cleaning up spills of UNP, or unwanted UNP, shall be placed in a closed container
195 or sealed bag and marked as “Unbound Engineered Nanomaterial Waste.” Contact the Hazard
196 Control Technology Team for disposal.

197 **4.9 Training**

198
199
200 “Nanomaterial Handling Training” (FN000577/CR/00) is an awareness-level course required for
201 all workers who may handle nanomaterials in any form (both UNP and bound), and therefore have
202 the potential to be exposed. This training shall include information on the potential health effects
203 of nanomaterials, safe work practices, proper handling, and the control of nanomaterial exposures.
204 The need for the training is initiated by a question on the Individual Training Needs Assessment
205 (ITNA).

206 **4.10 Exposure Assessments**

207
208
209 An Industrial Hygiene (IH) Assessment is required as part of an ORC for any new use of
210 nanomaterials. For nanomaterials already in use, contact the ESH&Q Section IH Group for an IH
211 Assessment if there are any concerns regarding potential exposure to UNPs.

212 **4.11 Medical Surveillance**

213
214
215 Personnel who may be exposed to UNPs shall be placed in the existing Fermilab health surveillance
216 program that is provided for respirator users. Individuals will be identified through the Workplace
217 Activities Analysis Form (WAAF) and the form titled Medical Surveillance Request for Unbound
218 Engineered Nanoscale Particle Worker and Respiratory Protection Usage.

219 **5.0 REFERENCES**

220
221
222 DOE Order 456.1A dated July 15, 2016

- 223
224 *Approaches to Safe Nanotechnology, Managing the Health and Safety Concerns Associated with*
225 *Engineered Nanomaterials*, DHHS (NIOSH) Publication No. 2009-125, March 2009
226
227 *Occupational Exposure to Titanium Dioxide*, Current Intelligence Bulletin 63, DHHS (NIOSH)
228 Publication No. 2011-160, April 2011
229
230 *General Safe Practices for Working with Engineered Nanomaterials in Research Laboratories*, DHHS
231 (NIOSH) Publication No. 2012-147, May 2012
232
233 *Occupational Exposure to Carbon Nanotubes and Nanofibers*, Current Intelligence Bulletin 65,
234 DHHS (NIOSH) Publication No. 2013-145, April 2013
235
236 *Engineered Nanomaterials in the Workplace*, Fact Sheet Sponsored by the AIHA[®] Nanotechnology
237 Working Group, July 9, 2015
238
239 *Personal Protective Equipment for Engineered Nanoparticles*, Fact Sheet Sponsored by the AIHA[®]
240 Nanotechnology Working Group, October 24, 2015
241
242 *Nanoparticle Sampling and Analysis*, Fact Sheet Sponsored by the AIHA[®] Nanotechnology Working
243 Group, May 6, 2016
244
245 *WHO Guidelines on Protecting Workers From Potential Risks of Manufactured Nanomaterials*, World
246 Health Organization, December 12, 2017.