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Self-Assessment of
Engineered Nanomaterials Use
March 2016

Reviewed and Approved by:

Jim Floyd (EHS Division Director) — Date 4/11/16

Ravi Prasher (ESDR Division Director) — Date 4/20/16

Andrew Peterson (EHS) — Date 4/11/16

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Summary

The EHS Division, partnering with the Energy Technologies Area (ETA) assessed the requirements for and use of engineered nanomaterials (ENMs) in March 2016. Engineered nanomaterial use is an area of interest for the Department of Energy (DOE) and was the focus of several DOE assessments in 2015. This assessment was conducted to determine if use of these materials and the underlying requirements meets the requirements of DOE O 456.1, The Safe Handling of Unbound Engineered Nanoparticles. As part of the assessment, 15 researchers from three divisions were interviewed, six labs were inspected and the documents defining the program were reviewed. Of these, 5 researchers were Project Leads from ETA's Energy Storage and Distributed Resources (ESDR) division and four of the six labs were from ESDR. In general, the assessment found ENM use is well characterized and controlled and meets the requirements of DOE O 456.1.

This assessment noted one finding relating to programmatic requirements. LBNL does not have a nano-registry which is a requirement in DOE O 456.1. LBNL is actively working on implementing this within the Activity Manager database by June 30, 2016, and there is already a corrective action in place for this discrepancy. There were several minor observations noted during the assessment. Most notably, the hazard "unbound engineered nanomaterials" in Activity Manager was not always used appropriately, and it suggests some underlying confusion regarding requirements for ENMs and the distinction between ENMs and naturally occurring nanomaterials. This finding and observation along with several other observations are documented throughout this report.

Scope and Methodology

This assessment focused on the use of unbound "engineered" nanomaterials. This includes engineered nanomaterials used in solution but does not include naturally occurring or incidentally formed nanomaterials. The assessment only included those nanomaterials meeting the following DOE definitions:

- Engineered nanoparticle (hereafter referred to as engineered nanomaterials or ENMs) means intentionally created (in contrast with natural or incidentally formed) particle with one or more dimensions greater than 1 nanometer and less than 100 nanometers.
- Unbound engineered nanoscale particles, those nanoscale particles that are not contained within a matrix under normal temperature and pressure conditions 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 a practical matter of becoming airborne, would be "bound," while such a particle suspended as an aerosol would be "unbound."

As noted above, 15 researchers across three divisions were interviewed for this assessment. In addition, six labs were reviewed. The lines of inquiry used for the interviews and checklist used for the lab reviews is included in Appendix A.

For ETA, most of the work with nanomaterials occurs within Energy Storage & Distributed Resources (ESDR). There are currently 19 active activities with unbound engineered nanomaterials selected as a hazard in ETA (18 in ESDR and one in Cyclotron Road). Interviews covered 9 of the active activities (~47%). There are another 11 active activities with engineered nanomaterials bound to a substrate selected as a hazard in ETA (10 in ESDR and one in Cyclotron Road). Interviews covered 4 of these activities (~36%).

Requirements Documentation

LBNL has established policies and procedures for working with ENM. These include:

- PUB-3851, Worker Safety and Health Program, Appendix F, Section 11
- Chapter 45, Chemical Hygiene and Safety Plan, Work Process S (and several other work processes – C, E, I & J)
- Personal Exposure Air Monitoring Procedures for Unbound Engineered Nanoparticles
- PUB-3092, Generator Guidelines (note: LBNL does not have a specific waste handling procedure for engineered nanoparticles; rather this is included LBNL's general procedures for hazardous waste handling)

Collectively, these procedures address the documentation requirements of DOE O 456.1. While these documents meet DOE O 456.1 requirements, there were several opportunities for improvement noted during the assessment.

Observation: There seems to be a minor discrepancy between stated controls in the Chemical Hygiene and Safety Plan (CHSP) and currently enforced requirements for posting designated areas. The documented plan [Chapter 45, Work Process J(1)(b) and BB(3)] requires posting designated areas where handling ENMs, and this requirement is communicated through EHS0344, Safe Handling of Engineered Nanoscale Particulate Matter and EHS0356 Nano Safety for Crafts and Technical Work. However, per the subject matter expert (SME), posting a designated area is no longer a requirement, and posting designated areas is not a control in Work Planning and Control (WPC).

- *Recommendation:* Align the requirements around the posting of designated areas between Chapter 45 and WPC. Ensure applicable documents including training materials are updated appropriately.

Observation: Several LBNL documents list specific person's names as contacts. Personal Exposure Air Monitoring Procedures for Unbound Engineered Nanoparticles for example lists Rick Kelly as a contact.

- *Recommendation*: Update documents and training materials to remove references to specific persons.

Observation: DOE O 456.1 is changing, and the definition of ENM is changing slightly.

- *Recommendation:* Update LBNL documents to reflect the new definition.

Training

LBNL has established two training class (EHS0344, Safe Handling of Engineered Nanoscale Particulate Matter and EHS0356 Nano Safety for Crafts and Technical Work) geared toward the appropriate audience to meet training requirements in DOE O 456.1.

Staff working with ENMs are required to take EHS0344. Of the 567 workers required to take EHS0344, 98% have completed this training (as of 2/26/2016). EHS0356 has a similar completion rate of 98% (158 complete and 4 incomplete as of 3/8/2016).

While EHS0344 meets all of the specific requirements in DOE O 456.1, there are several areas where it communicates information that is not consistent with current policy. As noted above, EHS0344 (and EHS0356) includes designated area posting requirements, which according to the SME are no longer requirements. EHS0344 also instructs workers that the work "area needs to be wet wiped or HEPA vacuumed at least once per day when work is performed in it." This is not a documented requirement in Chapter 45 or a control in Activity Manager. Information on hazardous materials transportation is also outdated and does not accurately reflect current policy.

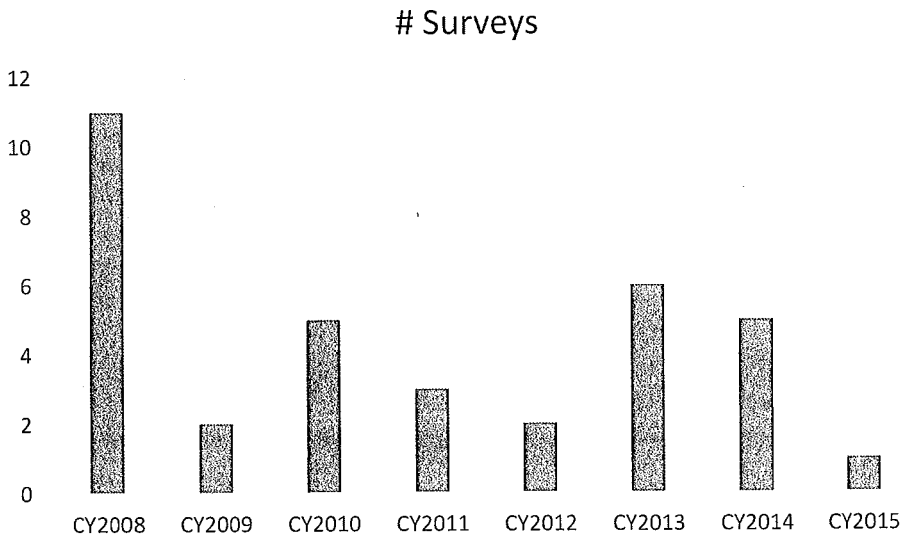
Observation: EHS0344 and EHS0356 include inaccurate or incorrect information for designated areas, daily cleaning requirements and hazardous materials transportation requirements.

- *Recommendation*: Update training materials to reflect current policy.

Exposure Assessment

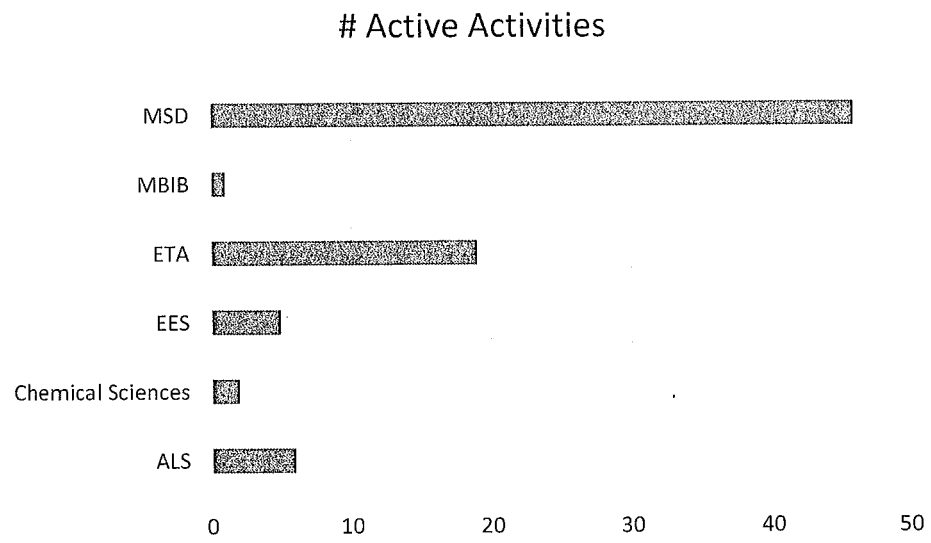
LBNL has established an air monitoring program for nanoparticles. Baseline exposure assessments are typically conducted when unbound ENMs are used outside of a fume hood. If determined to be necessary, air monitoring for "particles not otherwise specified - respirable" is performed.

Records of baseline exposure assessments and air monitoring are maintained in CHESS. The chart below shows the number of surveys performed over the previous few years specific to nanomaterials and demonstrates that exposure monitoring is being actively implemented.



Work Activities and Controls

Data from Activity Manager (collected 2/25/2016) identified 79 active work activities involving the use of unbound engineered nanomaterials. The majority of this work (58%) is occurring in Material Sciences. Energy Storage and Distributed Resources within Energy Technologies Areas accounts for another 24% of this work with 4 other divisions accounting for the remaining 18%.



Controls are documented as policy in ES&H Manual, Chapter 45 and have been transcribed and included in Activity Manager. The discrepancy with designated areas has already been discussed. Other controls are accurately represented in Activity Manager, but there are opportunities for improvement.

Observation: DOE O 456.1 has specific requirements to label containers "to plainly indicate the contents include ENM," and this control is reflected in Chapter 45. Activity Manager however only has a general requirement for labeling ("communicate chemical hazards through labeling and posting").

- *Recommendation:* Consider creating a new control for unbound ENMs to direct staff to label those containers as ENMs.

Observation: Activity Manager does not mention any specific controls for moving nano-containing containers out of a lab. There is a specific requirement in DOE O 456.1 and Chapter 45 for this.

- *Recommendation*: Consider adding a control in Activity Manager for additional labeling when moving or transferring ENM outside of a lab.

Observation: Activity Manager has a control to clean up residue or drips, but it does not mention or reference the need to use wet methods or vacuum with HEPA filtration.

- *Recommendation*: Consider modifying the control for wiping up residue or drips to reinforce the importance of using wet methods or other methods that don't involve dry sweeping/use of compressed air when cleaning up contaminated surfaces.

Field Observations and Interviews

As part of this assessment 15 researchers, primarily from ETA and MSD, were interviewed and six labs were inspected to understand how well nanomaterials are being controlled in the field. Interestingly, most research staff interviewed for this assessment are not using "engineered" nanomaterials, and are instead using naturally occurring nanomaterials such as carbon black or larger micron scale particles. The distinction between engineered and naturally occurring nanomaterials is important because the Department of Energy's order is specific to the use of "engineered" nanomaterials. If materials are not engineered nanoscale materials, then the order does not apply and the materials are treated as any other chemical hazard.

Specific to ETA, of the nine active activities under three of the Project Leads interviewed with unbound engineered nanomaterials selected as a hazard, none of them were actually using unbound "engineered" nanomaterials. Another Project Lead interviewed had identified working with engineered nanoscale materials bound in a substrate, but this person was also not working with engineered nanomaterials. The one researcher observed working with an *engineered* nanomaterial had not identified this as a hazard on the activity for the work.

In all cases, research staff were knowledgeable of the nanomaterials they were working with and controls were in place to minimize exposure. Controls included posting on doors, posting at points of use (designated area), use of fume hoods or gloveboxes, special labeling on a refrigerator, labeling of containers as nanomaterials (MSD had their own stickers for this), labelling of hazardous waste as nanomaterial containing, and use of ENM in solution. MSD reported using special ventilated weighing enclosures in some cases. In only one case, the controls did not meet the requirements in Chapter 45. In that case, the ENMs were being used in a glove box, so controls were in place to prevent exposure, but the container of ENM was not labelled as an ENM, the container was not in CMS, and unbound ENM was not identified as a hazard on the activity. This did lead to a discussion of when chemicals received from another research institution need to be entered into CMS.

Finally, in a few cases, researchers reported searching for the ENM "program" prior to this assessment. There is not an actual ENM "program." The requirements are just one component of the Chemical Hygiene and Safety Plan (CHSP) documented in Chapter 45. Collectively, these small discrepancies

suggest some confusion around the ENM "program" and when ENM hazards need to be selected in Activity Manager.

Observation: In one lab, a sample from a research institution was not labeled as ENM and was entered into CMS, and unbound ENMs was not identified as a hazard.

- *Recommendation 1:* Label the container as ENM and enter it into CMS. Add use of the materials to the activity.
- *Recommendation 2:* Review guidance for managing "research samples" from other institutions and clarify requirements if needed.

Observation: The selection of ENM hazards in Activity Manager is not consistently applied correctly.

- *Recommendation 1:* Review the wording of ENM hazards in Activity Manager and decide if the wording can be modified to clarify the intent of the hazard. This type of language could be reinforced in Chapter 45 and supporting training materials.
- *Recommendation 2:* Work with individual researchers to ensure ENMs are accurately reflected in their work activities and that the intent of the ENM requirements are understood.

Conclusions

Berkeley Lab appears to be in compliance with DOE requirements for engineered nanomaterials use, and research staff using ENMs use these materials in a manner that significantly reduces the risk of exposure. The one observation of note is that researchers seemed to be incorrectly applying hazards in Activity Manager to the work they were performing. In some cases, the Activity Lead selected "unbound engineered nanomaterials" as a hazard when the work did not involve work with "engineered" nanomaterials. Instead, the work involved either larger particles or naturally occurring nanomaterials. In both of these situations, the work falls outside of the scope of DOE O 456.1 and is not subject to additional controls. Unbound ENM should not be selected as a hazard in these cases. This however is not a finding. Several researchers indicated that they may use engineered nanomaterials in the future or that they simply wanted to ensure their staff received the training on engineered nanomaterials. In only one lab, a sample from a research institution was not labeled as an engineered nanomaterial, entered in CMS or identified as a hazard on the activity.

Appendix A: Engineered Nanoscale Particle Program: Field LOIs and Observation Checklist

High Level Question:

Do we have an effective nanomaterials program that is well understood and implemented in the field?

Introductory Comments (Optional):

- Conversation consists of the below questions and will be no more than 30 minutes in length.
- We'll be taking notes as part of the data collection. Responses will be reported by role.
- Limit response to experience with these materials.
- Please be honest with your responses. EHS is interested in finding areas for improvement in our safety program.
- For Group Interviews: If you have a different answer to a question than others in the room, we want to hear from you. Not looking for consensus.
- Do you have any questions before we get started?

Lines of Inquiry

1. What unbound nanoscale particles (ENM) do you work with and where?
   a. What activities authorize your ENM work?
2. What type of planning and preparation goes into work with ENMs?
   a. How about when conditions change (e.g., you begin working with different ENMs)?
3. What are the potential hazards of these ENMs and how are the risks communicated to yourself and others?
   a. What type of OJT is required, if any, before use of ENMs?
4. What control measures do you use to protect yourself and others from exposure to ENMs?
5. Do you have any questions, comments or feedback about working with ENMs or the ENM program?

Inspection Items (Field Observations)

1. Are entry portals to locations where nanomaterials are used clearly labeled?
2. Are chemical containers clearly labeled as ENP?
3. Are chemical containers in CMS?
4. Is equipment used for handling nanomaterials clearly labeled?
5. Are enclosures properly configured?
6. Is PPE available/used adequate?
7. Are surfaces free of contamination and debris?