HEALTH AND SAFETY OF WORKING WITH NANOMATERIALS AT BROOKHAVEN

John Peters

July 30,2007

HEALTH AND SAFETY OF WORKING WITH NANOMATERIALS AT BROOKHAVEN

Recent Nanoscience Health and Safety Communication

- Today's Monday Memo
- Recent Nanoscience Forum
- Previous Bulletin Q&A Series
- This presentation

What's In The Future

- NSRC document may be revised again soon due to increased exposure/feedback - ORISE web site; may be posted on NANO.gov; NSRC member outreach & focus of BNL ISM assessment
- NSRC changes will drive BNL interim procedure changes - goal is to stay in sync
- Interim document will sunset when all applicable subject areas are updated (then become individual SME responsibilities)
- *HSS may develop a "Nano" Order - based on BNL's ISM assessment and other politics, this would supercede the interim procedure.*

HEALTH AND SAFETY OF WORKING WITH NANOMATERIALS AT BROOKHAVEN

- Nanoscale Science Research Centers (NSRCs) health and safety experts collaborated on
  - ***best-practice working guidelines and controls to assure that all work with nanomaterials is consistent, is safe, and does not harm the environment***.

- DOE Policy 456.1 “Secretarial Policy Statement on Nanoscale Safety

- BNL Implementation Plan for Policy 456.1
  - ISM : All work is planned: hazards identified, evaluated and controlled through ESR’s

- BNL Interim Procedure
  - **Approach to Nanomaterial ESH**

DOE Policy 456.1

Requirements

Incorporate both existing and future environment, safety and health best practices, National Consensus Standards and guidance

Control Through ISM

Identify and manage potential health and safety hazards and potential environmental impacts through ***existing Integrated Safety Management System****,*

Currency

stay abreast of current research and guidance relating to the potential hazards and impacts of nanomaterials, and ensure knowledge is reflected in the identification and control of these potential hazards and impacts at their facilities.

BNL Procedure Review

Institutional Nanoscience Safety Advisory Committee

(INSAC)

Chair: Doon Gibbs

The INSAC has been formed to act as an advisory body to the Laboratory for the implementation of this approach document. The INSAC will review and make recommendations where compliance to the approach document cannot be reasonably achieved and/or alternative approaches employing equivalent level of safety are proposed.

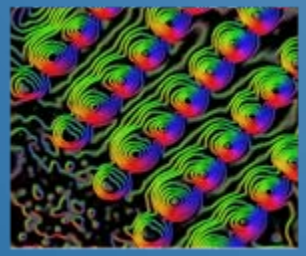
INSAC 7/23/07

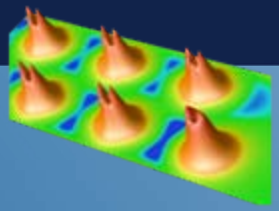
BNL Interim Procedure Update

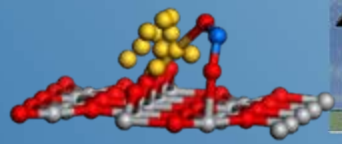
Center for Functional Nanomaterials

Brookhaven National Laboratory

AN INTERDISCIPLINARY ENVIRONMENT FOR NANOSCIENCE RESEARCH







BROOKHAVEN NATIONAL LABORATORY

Office of Science U.S. Department of Energy

Revised SBMS Interim Procedure

Brookhaven National Laboratory
SBMS Interim Procedure

- **Interim Procedure Number 2007- 001 Revision: 1**
- **Title: Approach to Nanomaterial ESH**
- **Point of Contact: John Peters**
- **Management System: Worker Safety and Health**
- **Effective Date: July 31, 2007**
- **Expiration Date: July 31, 2008**
- **Approved by (**line management & Management System Steward**): Patricia Williams**
- **Approved by (**Deputy Director, Science**) Doon Gibbs**
- **Applicability: All BNL management and staff**

Revision History

- **Revision 1: Incorporate changes from the Nanoscale Science Research Centers "Approach to Nanomaterial ESH" document Rev 1 and 2 and revisions from the BNL's Institutional Nanoscience Safety Advisory Committee.**

The significant revisions include:

- **Included a new definition of "nanoparticulates"**
- **Expanded section 3.4.2 "Housekeeping" to include guidance on laboratory cleaning protocol**
- **Section 3.5 modified to eliminate the requirement for lab coats in lieu of gautlet-type gloves**
- **Section 4 was added to include; the requirement to identify "nanoparticulate" workers; workplace characterization and worker exposure assessments; requirement to provide nanoparticulate workers with baseline medial evaluations and to check wastes for uncontrolled release of engineered nanomaterials.**
- **Section 5 was modified to allow the use of private vehicles to transfer small quantities of nanomaterials that do no fall into Department of Transportation hazard classifications.**
- **Section 6 was modified to reflect nanowaste management guidelines specific to BNL.**

Revised SBMS Interim Procedure

DRAFT Implementation Plan for Revision 1 "Approach to Nanomaterial ESH"

Task	Responsibility	Target Date
Post Revision 1 to SBMS	Hoey	7/31/07
Review Revision 1 Against Current Operations	Depts/Divisions conducting Nano-work	9/28/07
Submit to SME any non-compliances and corrective action plan	Depts/Division conducting Nano-work	10/31/07
Phase into compliance with Revision 1	Depts/Divisions conducting Nano-work	12/28/07
Submit to INSAC (if necessary) any	Depts/Division conducting Nano-work	9/28-11/30/07
Complete generic nanotraining module	Peters/Hoey	12/28/07
Complete Nanoparticle worker data base	Peters	12/28/07
Incorporate nano on Job Assessment Form	OMC	10/31/07
Include nano on ESR form	WP&C committee	11/30/07
Update interim procedure from feedback obtained during implementation phase and re-issue as Revision 2.	Peters	12/28/07

Table of Contents

New Procedure

Old Procedure

1.0 Introduction

- “Engineered” nanomaterials, i.e., materials consisting of, or containing structures of between 1- and 100-nanometers (nm) that use the properties unique to nanoscale forms of materials.

- Nanoparticles, i.e., dispersible particles having in two or three dimensions greater than 0.001 micrometers (1 nanometer) and smaller than about 0.1 micrometer (100 nanometers) and which may or may not exhibit a size-related intensive property.

- When any guidance contained herein that conflicts with any regulatory requirements or consensus standards, the more conservative approach should be used.

- **The Department of Energy has made it clear that the agency expects those engaged in the emerging field of nanotechnology to act responsibly in evaluating and controlling the associated environmental, health and safety risks.**

2.0 Brookhaven Laboratory Policy

- In conformance with the general principle in the National Research Council's *Prudent Practices for Handling Hazardous Chemicals in Laboratories*, nanomaterials will be treated as though they are a toxic and hazardous material until empirical-based evidence shows otherwise.

3.0 Routine R&D Laboratory Operations

- Review all work with nanomaterials for ES&H concerns following the Experimental Safety Review process contained within the Work Planning and Control Subject Area.

- Follow a graded approach in specifying controls. Operations involving easily ***dispersed dry nanomaterials deserve more attention*** and more stringent controls than those where the nanomaterials are imbedded in solid or liquid matrices.

- When applying hazard controls follow the standard hierarchy controls:
  - Engineered controls
  - Administrative controls
  - Personal protective equipment

- Implement additional controls to better ensure that nanomaterials are not brought out of the work area on clothing or other surfaces, e.g., install step-off pads, create a buffer area, and ensure the availability of decontamination facilities for workers.

3.0 Routine R&D Laboratory Operations

Ventilation Preferences

- **Conduct any work that could generate dispersible nanoparticles in an enclosure that operates at a negative pressure differential compared to the worker's breathing zone**
- **Do not directly exhaust effluent (air) that is reasonably suspected to contain nanoparticles.**
  - **HEPA filter it or otherwise clean it before release.**
- **Do not recirculate within the laboratory air from which nanoparticles have been removed.**
  - ***Table top HEPA units and BSCs must be tied into normal lab hood***

3.0 Routine R&D Laboratory Operations

- Maintain and test the effectiveness of exhaust systems and components as specified by the manufacturer and in accordance with *the SBMS Exhaust Ventilation Standard*

- Evaluate equipment previously used to synthesize or handle nanoparticles for contamination before reusing or disposing of it.

3.0 Routine R&D Laboratory Operations

Administrative Controls

- **Implement the BNL chemical hygiene plan (as required under 29 CFR 1910.1450) specific to the scope of activities as per the Chemicals, Working With Subject Area.**

- ***Practice good housekeeping in laboratories*** where nanomaterials are handled. Follow a graded approach paying attention where dispersible nanomaterials are handled.

- Insofar as practicable, maintain all working surfaces (i.e., benches, glassware, apparatus, exhaust hoods, support equipment etc.) free of engineered nanoparticle contamination and otherwise limit worker exposure to engineered nanoparticles and associated hazards.

- In areas where engineered nanoparticles might settle, perform precautionary cleaning, for example, wipe horizontal surfaces with a moistened disposable wipe, ***no less frequently than at the end of each shift.***

3.0 Routine R&D Laboratory Operations

Work Practices

- Transfer nanomaterial samples between workstations (such as exhaust hoods, glove boxes, furnaces) in closed, labeled containers.

- Take reasonable precautions to minimize the likelihood of skin contact with engineered nanoparticles or nanoparticle-containing materials likely to release nanoparticles (nanostructures).

3.0 Routine R&D Laboratory Operations

Marking, Labeling and Signage

- Signs: Post signs indicating hazards…at entry points into designated areas where *dispersible*, engineered nanoparticles are handled.

- Labels: Indicate on container labels that the contents are in nanoparticulate form, e.g., “nanoscale zinc oxide” or other identifier instead of just “zinc oxide.”

3.0 Routine R&D Laboratory Operations

Clothing & Personal Protective Equipment

- Conduct a hazard evaluation to determine the selection and use personal protective equipment (PPE) as per the Personal Protective Equipment Subject Area,
- Protective clothing that would typically be required for a wet-chemistry laboratory would be appropriate … ***Lab Coats vs gauntlet gloves working at hood***
- Wear polymer (e.g., nitrile rubber) gloves when handling engineered nanomaterials and particulates in liquids. Choose gloves only after considering the resistance of the glove to the chemical attack by both the nanomaterial and, if suspended in liquids, the liquid. ***(eg. DMSO)***
- Wear eye protection, e.g., (spectacle type) safety glasses, face shields, chemical splash goggle, or other safety eyewear appropriate to the type and level of hazard. ***Do not consider face shields or safety glasses to provide sufficient protection against unbound, dry materials that could become airborne. (use goggles)***

3.0 Routine R&D Laboratory Operations

Monitoring and Characterization

- In consultation with SHSD Industrial Hygiene Group, use a direct-reading particle measuring device to *screen for suspect emissions.*

- Use more sophisticated techniques, to collect samples to characterize emissions and determine if a control is needed or must be upgraded or serviced.

- Link environmental data to potentially exposed personnel using the Laboratory's data-management system.

3.0 Routine R&D Laboratory Operations

Worker Competency

- Do not assume that staff members and visiting researchers are aware of the health and safety concerns posed by nanomaterials.

- Alert all personnel in each group to concerns and to the Laboratory policies about nanomaterials via an ***awareness-level orientation and /or reading of this interim procedure.***

- Incorporate specific procedural requirements into the ESR to better assure understanding and competence.

4.0 Verifying program effectiveness

verify the absence of unusual health effects in exposed workers.

- Identifying staff (hereafter “nanoparticle workers”) potentially exposed to engineered nanoparticles of unknown health effects.
- Conduct workplace characterization and worker exposure assessments
- Provide nanoparticle workers with “baseline” medical evaluations and include them in a nonspecific routine health monitoring program
- Check wastes for evidence of uncontrolled release of engineered nanomaterials
- Effluent monitoring -reserved

4.0 Verifying program effectiveness

Nanoparticle Worker Identification

- Handles engineered nanoscale particulates that have the potential to become dispersed in the air
- Routinely spends time in area with *potential* engineered nanoparticle release
- Works on contaminated equipment with foreseeable release during servicing or maintenance

4.0 Verifying program effectiveness

Department Responsibilities

- Identify Workers: Record e*ngineered nanoparticle workers* in the appropriate Experimental Safety Review. SHSD also developing a data base to relate people with ESR's

- Training: Ensure workers take the BNL nanomaterial hazards awareness and/or lab standard training and are familiar with this Interim Procedure

- Workplace Characterization: Characterize workplace conditions and exposures of *engineered nanoparticle workers*

- Medical Evaluations: Ensure workers are offered periodic medical evaluations that may include routine tests such as pulmonary, renal, liver, and hematopoietic function and pulmonary function testing.

4.0 Verifying program effectiveness

Workplace Characterization and Exposure Assessments

Although there is ***no validated or consensus approach*** for characterizing worker exposure, this document recommends a good faith effort to characterize the exposures of personnel exposed to engineered nanoparticles and to link the resulting data to those nanoparticle-exposed personnel.

Conduct “baseline” monitoring

- use ***direct-reading particle-measuring devices*** to screen for suspect emissions and atypical conditions that deserve further investigation.

- use ***more sophisticated techniques***, to collect and analyze samples that will be used to characterize emissions and potential exposures

4.0 Verifying program effectiveness

Worker Health Surveillance

OMC is responsible to define health monitoring for workers engaged in nanoscale science research and support activities

- BNL staff and other Laboratory employees (identified as Engineered Nanoparticle Workers) with jobs involving the potential for respiratory or skin exposure to engineered nanomaterials be offered a baseline medical evaluation and periodic medical monitoring

- Have BNL employees involved in any incident that results in an unexpected and/or unusually high exposure to nanomaterials, through any route of entry, examined by the Occupational Medical Clinic for a post-incident evaluation as per OSHA 1910.1450(g)(1)(i).

- Exempting non-resident (e.g., user facility) personnel from medical surveillance.

4.0 Verifying program effectiveness

Domestic Waste Surveys

- BNL staff members visually inspect domestic wastes periodically and report instances involving the appearance of suspect nanomaterial, including contaminated wipes, in domestic trash containers.

Effluent Monitoring

[Reserved]

5.0 Transportation of Nanomaterials

- Personnel who prepare and package nanomaterials for shipment off-site must have current HazMat Employee training in compliance with 49 CFR Subpart H.

5.0 Transportation of Nanomaterials

Categories of Materials

- **Recognized HazMat**
- **Suspected DOT HazMat**
  - **materials that have known hazardous properties (e.g., toxic, reactive, flammable), but are not recognized in the DOT regulations**
- **Other Nanomaterials**
  - **packaged using the equivalent of a DOT-certified Packing Group I (PG I) container and labeled as described below, but need not be shipped by a commercial carrier.**

5.0 Transportation of Nanomaterials

Off-site Shipments

Recognized HazMat and
Suspected DOT HazMat

- All transportation should be performed using a low cost, qualified carrier for whom DOE or GSA has a tender on file and all transportation services must be made in compliance the Federal Acquisition regulations (FAR).

Other Materials

- most expeditious method ***(e.g., private vehicle)*** Driver and car must meet all state safety regulations

- possess basic hazard information on the commodity being transported, i.e., material name, quantity, form and material safety data sheet if available

5.0 Transportation of Nanomaterials

Off-site Shipments

Packaging

Package Group I (PG I)

Labeling

CAUTION

Nanomaterials Sample
Consisting of (Technical Description Here)
Contact: (POC)
at (Contact number)
in Case of Container Breakage.

5.0 Transportation of Nanomaterials

Off-site Shipments

For *Dry Dispersible Particles* Add wording:

Nanoparticulates can exhibit unusual reactivity and toxicity. Avoid breathing dust, ingestion, and skin contact.

5.0 Transportation of Nanomaterials

On-Site Transfers of Nanomaterials

- The on-site transfer of nanomaterials should follow the Transfer of Radiological and Hazardous Material On-site Subject Area.
- Use packaging consistent with off-site shipment or packaging that affords an equivalent level of safety.
- Mark the transfer containers in accordance with (above) recommendations for off-site shipments.
- An MSDS if available (or a similar form) detailing possible hazards associated with the material; otherwise, if an MSDS is unavailable, the Principal Investigator should supply material-specific knowledge.
- Notify the receiving facility of the incoming shipment

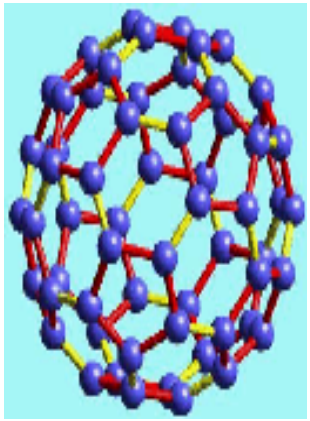
6.0 Management of Nanomaterial-bearing waste streams

- In addition to meeting the other requirements in the Hazardous or Industrial Waste Subject Area, as applicable, the following is also required for nanowastes:

6.0 Management of Nanomaterial-bearing waste streams

- **Collect all nanowaste and contaminated waste** for transfer to Waste Management for proper off-site disposal.
- Do not dispose of hazardous nanowaste in the sanitary drain or in the regular trash.
- **Liquid nanowaste** must be placed into a container with a top that can be firmly secured. (Note: friction fit e.g., rubber or glass stoppers are not acceptable)
- **Solid particulate nanowastes** must be placed inside a sturdy/suitable bag (6 mil thick minimum) or a container with a sealing lid.
- Accumulate wastes in a hazardous waste satellite area as per the sections on "Generating Wastes" and "Operating a Satellite Accumulation Area (SAA)" of this Subject Area.
  - ***SAA's used for particulate nanowastes must be located in an exhausted fume hood.***
- In addition to the use of hazardous waste labels, label the outermost bag/container with the words "Contains Nanomaterials". See example on next slide

6.0 Management of Nanomaterial-bearing waste streams



Contains Nanomaterials

6.0 Management of Nanomaterial-bearing waste streams

- Any waste material, such as PPE, wipes, blotters, glassware, cleaning solutions, rinse waters, pads etc. potentially in contact with hazardous nanoparticles is hazardous nanowaste.

- Complete the Nonradioactive Waste Control Form as per “Completion of Nonradioactive Waste Control Form and Process Knowledge Form” and add nanomaterial information content as required.

- Transfer the waste to the 90-Day Accumulation Area in accordance with the section entitled “Operating a Satellite Accumulation Area “ and “Operating a 90-Day Area”.

7.0 Management of Nanomaterial Spills

Control and clean up supplemental to the Spill Response Subject Area.

- Determine the extent of the area and **restrict entry**
- Large spills, **call x2222**
- Small spills: **trained personnel from the facility** may clean
- **Refer personnel** exposed to nanomaterials in the course of a spill **to the OMC**

7.0 Management of Nanomaterial Spills

Dry Materials

- Position a walk-off mat (e.g., Tacki-Mat®) where clean-up personnel will exit the access- controlled area.

- **No dry sweeping or use of compressed air. Use wet wipes or a tested and certified HEPA vacuum.**
  - Characterize, collect and dispose of spill clean-up materials as nanomaterial-bearing waste.

- When feasible, use only “dedicated” HEPA vacuums used for nanomaterial clean up. Label the units accordingly, e.g., “Use only for nanomaterial spill clean up.” Use a “log” to record the type of material collected and avoid mixing potentially incompatible materials in the vacuum or filters.

- Characterize, collect and dispose of used HEPA filters as nanomaterial-bearing waste.

7.0 Management of Nanomaterial Spills

Liquids

- Employ normal hazmat response based on the spilled material’s known hazards.
- Mitigate nanomaterials left behind once the liquids have been removed using the dry material procedures

7.0 Management of Nanomaterial Spills

Cleanup Wastes

- Manage all debris resulting from the clean up of a spill as though it contains sufficient nanomaterials to be managed in accordance with Section 6 of this procedure.

Back to the Future

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- Interim document will sunset when all applicable subject areas are updated (then become individual SME responsibilities)
- *HSS may develop a “Nano” Order - based on BNL’s ISM assessment and other politics, this would supercede the interim procedure.*