No: P101-29
Revision: 0

Issued: 03/27/08
Effective Date: 07/31/08

Working with Nanotechnology Materials and Processes

1.0 PURPOSE

The purpose of this document is to:

- provide direction to ensure that work with engineered nanomaterials, as defined in Section 9.1 of this document, is conducted in a safe and responsible manner that protects workers, the public, and the environment, in accordance with Laboratory Integrated Work Management and Environmental Management Systems.
- provide direction in the development and application of the hierarchy of controls: (i.e., engineering, administrative, and Personal Protective Equipment [PPE]) that will protect workers and the environment.
- provide reasonable guidance for managing the uncertainty associated with engineered nanomaterials whose hazards have not been fully determined and reducing to an acceptable level the risk of worker injury, worker ill-health and negative environmental impacts.
- promote consistency in nanotechnology related Integrated Work Documents (IWDs) and other procedures across the Laboratory.

2.0 AUTHORITY AND APPLICABILITY

2.1 Authority

This document is issued under the authority of the Laboratory Director to direct the management and operation of the Laboratory, as delegated to the Associate Director for Environment, Safety, Health, and Quality (ADESH&Q) as provided in the Prime Contract. This document derives from the Laboratory Governing Policies, particularly the section on Safety.

- Issuing Authority (IA): Associate Director for Environment, Safety, Health, and Quality (ADESH&Q)
- Responsible Manager (RM): Industrial Hygiene and Safety (IHS) Division Leader
- Responsible Office (RO): Industrial Hygiene and Safety (IHS) Division

2.2 Applicability

This document applies to all engineered nanomaterial workers at the Laboratory, where such workers are defined as those who handle engineered nanomaterials that have the potential for inhalation or dermal exposure, routinely spend time in an area in which engineered nanomaterials have the potential to become dispersed in air, and/or work on equipment that might be contaminated with nanomaterials that could foreseeably be released during equipment servicing or maintenance. This document applies to all Research and Development (R&D), production, and facility operations that involve engineered nanomaterials. All other persons working at the Laboratory with engineered nanomaterials, but who are not employees, are expected to follow the requirements set forth in their contractual agreement or subcontract with the Laboratory.

3.0 PROCEDURE DESCRIPTION

This document sets forth practices for managing industrial hygiene, safety, and environmental concerns associated with engineered nanomaterials and associated processes. The document addresses the following topical areas:

- work planning,
- worker qualifications,
- work controls (i.e., engineering, administrative practices, and PPE),
- waste management,
- spill prevention and management, and
- transportation of nanomaterials.

3.1 Work Planning

Responsible Line Managers (RLMs) must ensure that all work involving engineered nanomaterial workers is reviewed for security, environment, safety and health, facility or equipment, and impact on facility safety basis concerns in accordance with *Integrated Work Management*. At a minimum, the following steps must be performed:

1. Initially categorize engineered nanomaterial work, involving engineered nanomaterial workers, as high-hazard.
2. Create a detailed description of the work involving engineered nanomaterials and engineered nanomaterial workers.
3. Assemble a hazard analysis review team in accordance with *Integrated Work Management*, and in accordance with requirements for high-hazard/complex work as detailed in *Integrated Work Management* (Appendix A, *Integrated Work Management Process for Research and Development*). In addition to the required members, include the deployed industrial hygienist(s), other industrial hygiene engineered nanomaterial safety Subject Matter Experts (SMEs).
4. Contact your deployed industrial hygienist to perform a qualitative exposure assessment in accordance with the Operations Support Tool (OST) 402-00-00, *Laboratory Industrial Hygiene and Safety Manual*, Chapter 64, *Nanotechnology Health and Safety,* and OST 400-00-00, *Laboratory Industrial Hygiene and Safety Manual*, Chapter 45, *Worker Protection Qualitative Exposure Assessment*, to evaluate the potential for worker exposure to engineered nanomaterials. Provide the following information to your deployed industrial hygienist for each activity that involves engineered nanomaterials:
   - Technical Area (TA)/Building/Room,
   - description of activity,
   - the engineered nanomaterials involved,
   - the engineering control methods employed, and
   - the Z numbers of employees that meet the definition of engineered nanomaterials worker.

Note: Your deployed industrial hygienist will work with SMEs and subcontractor IHS personnel to ensure that the potential for subcontractor worker exposure to nanomaterials is evaluated before removing, remodeling, servicing, maintaining, or repairing laboratory equipment and exhaust systems.

5. Specify hazard controls within the IWD using the following hierarchy of controls. See Section 3.3 for further details.
   a. Engineering Controls
   b. Administrative Controls:
      - qualifications,
      - formal procedures, and
      - work practices.
   d. Use of Personal Protective Equipment (PPE)
   d. Training
   e. Defined Criteria for Change Control

Notes: Guidance for Preparing IWDs:

- Consider chemical hazard information for bulk/raw materials when developing controls for engineered nanomaterials and any new information specific to the material at the size being used.
- Consider and understand the potential for generating new engineered nanomaterial-bearing waste streams. Work with Environmental Protection (ENV) Division and waste management personnel to define waste management procedures for wastes that contain engineered nanomaterials.
- Consider the recognized and foreseeable hazards of the precursor materials and intermediates as well as those of the resulting engineered nanomaterials.
- Consider the higher reactivity of some nanoscale materials (e.g., potential sources of ignition, accelerants, and fuel) that could result in fire or explosion.
- Consider the potential for reactions involving engineered nanomaterials already "captured" in exhaust air filters.

3.2 Worker Qualifications

3.2.1 Worker Medical Surveillance

At this time, there is no specific medical surveillance particular to engineered nanomaterials, other than that currently required for the material itself or its constituents, precursor material, intermediate material or product. Occupational Medicine will define any necessary specific medical surveillance procedures for engineered nanomaterial workers. It is suggested that visitors working with engineered nanomaterials be enrolled in the appropriate medical surveillance program at their respective institution.

3.2.2 Worker Competency

- RLMs must ensure that engineered nanomaterial workers complete the training requirements for authorized chemical worker, as outlined in *Chemical Management*, and additional awareness training for nanomaterials workers when available.
- RLMs must also ensure that employees and visiting researchers are aware of the health and safety concerns posed by engineered nanomaterials. At a minimum, visitors must be provided with facility specific awareness training.

Notes: Guidance for Controls:

- Follow a graded approach in specifying controls. Operations involving easily dispersed dry engineered nanomaterials deserve more attention and more stringent controls than those where the engineered nanomaterials are imbedded in solid or liquid matrices.
- The following represents the order of preference (most preferred to least preferred) for handling engineered nanomaterials:
  - solid macroscale materials or substrates with embedded nanostructures,
  - solid macroscale materials or substrates with nanostructures fixed to the material's or substrate's surface,
  - nanomaterials suspended in liquids, and
  - dry, dispersible engineered nanomaterials and their agglomerates or aggregates.
- Whenever possible, handle and store dispersible engineered nanomaterials, whether suspended in liquids or in a dry particle form, in closed (tightly sealed), and properly labeled containers.
- Consider the hazardous properties of the precursor materials as well as those of the resulting engineered nanomaterial. Engineered nanomaterial hazards might not be known or reliably anticipated.
- Consider the potential need to implement additional engineered or procedural controls to ensure workers are protected in areas where engineered nanomaterials will be handled.

3.3 Controls

3.3.1 Engineering Controls

- Engineering controls must be used to minimize the dispersal and environmental release of engineered nanomaterials. Where possible, and particularly for dispersible engineered nanomaterials, carry out manipulations of engineered nanomaterials in a glove box, glove bag, chemical fume hood, Type II biological safety cabinet, or other airborne contaminant control system. Whenever practical, remove the engineered nanomaterial from the effluent of such a control system before the effluent is released into the general environment (e.g., with High Efficiency Particulate Air [HEPA] filtration or other effective mechanism). Contact IHS personnel for assistance.
- Do not use horizontal laminar-flow hoods (clean benches) that direct a flow of HEPA-filtered air into the user's face to control exposure to engineered nanomaterials.
- Maintain and test the effectiveness of exhaust systems and components as specified by the manufacturer, and in accordance with *Local Exhaust Ventilation and HEPA Filtration Systems*.
- Evaluate laboratory equipment and exhaust systems before removing, remodeling, or repairing, if repair can reasonable be expected to result in exposure to engineered nanomaterials.

3.3.2 Administrative Controls

- Read and understand all IWDs associated with the work.
- Complete the training requirements for authorized chemical worker, as outlined in *Chemical Management*, nanomaterial worker awareness training, and any additional facility-specific training.
- Practice good housekeeping, paying particular attention to locations where dispersible nanomaterials are handled. In so far as practicable, maintain all working surfaces (i.e., benches, glassware, apparatus, exhaust hoods, support equipment, etc.) free of engineered nanomaterial contamination and otherwise limit worker exposure to engineered nanomaterials and associated hazards.
- Nanomaterials workers will ensure all signs and labels properly identify current chemical hazards. RLMs will verify posting accuracy. Hazard awareness signs and postings alert workers and emergency responders to the nature and degree of potential chemical, physical, and biological hazards within laboratory spaces. Signs and postings also alert workers and visitors to actions and precautions to be taken to reduce the risk of injury. Reference *Safety Signs, Labels, and Tags*, for signs and postings.

  Note: Where appropriate, label storage containers to plainly indicate that the contents are in engineered nanoparticulate form (e.g., “nanoscale zinc oxide particles) or other identifier specific nanomaterial label. Include the name of the owner on the container label. Where practical, transfer engineered nanomaterials samples between workstations (i.e., exhaust hoods, glove boxes, and furnaces) in closed, labeled containers.

- If engineered nanomaterial powders must be handled without the use of exhaust ventilation (i.e., laboratory exhaust hood, local exhaust) or enclosures (i.e., glove-box), evaluate hazards and implement alternative work practice controls to mitigate potential contamination and exposure hazards.

3.3.3 Personal Protective Equipment (PPE)

The Laboratory requires that suitable clothing and equipment be used to protect workers and others in Laboratory spaces from hazards in the workplace. Personal protective equipment is intended to protect the body (including eyes, face, feet, hands, head, hearing, and respiratory system) from hazards capable of causing injury, illness, or impairment of bodily function. No protective materials will provide full protection against all hazards. Personal protective equipment is used as a hazard control strategy only after it has been determined that elimination, substitution, engineered, and administrative controls are not feasible, or in the interim while engineered and administrative controls are being designed and implemented. Proper PPE will be identified in the IWD.

- The level of protection and type of PPE selected must match the applicable hazards. See *Personal Protective Equipment*, and OST 402-00-00, *Laboratory Industrial Hygiene and Safety Manual*, Chapter 49, *Personal Protective Equipment*.
- Protective clothing could include:
  - safety glasses with side shields,
  - closed-toed shoes,
  - long pants,
  - laboratory coat, and
  - nitrile gloves.

- If respirators are to be used for protection against engineered nanomaterials (determined after consultation with deployed industrial hygienist), select and use half-mask, P-100 cartridge-type respirators or respirators that provide a higher level of protection.
- Keep potentially contaminated personal protective equipment in the laboratory to prevent engineered nanomaterials from being transported into common areas.

3.4 Waste Management

Before disposing of any engineered nanomaterial waste, you must contact your waste management coordinator or ENV Division for disposal requirements. This applies to engineered nanomaterial-bearing waste streams consisting of:

- pure engineered nanomaterials (e.g., carbon nanotubes),
- items contaminated with, or containing engineered nanomaterials (e.g., wipes/personal protective equipment),
- liquid suspensions contaminated with, or containing engineered nanomaterials (e.g., hydrochloric acid containing carbon nanotubes); and waste waters from wet-processing of nanomaterials),
- solid matrixes with engineered nanomaterials that are friable or have a nanostructure loosely attached to the surface such that they can reasonably be expected to break free or leach out when in contact with air or water, or when subjected to reasonably foreseeable mechanical forces, and/or
- solid matrixes with engineered nanomaterials.

Generators of waste containing nanomaterials, including waste waters, must evaluate the waste to determine whether it is a hazardous waste or New Mexico special waste. These requirements apply to all wastes containing nanomaterials.[1]

3.4.1 Engineered Nanomaterials in Waste Streams

- Decontaminate equipment used to manufacture or handle nanomaterials before disposing of or reusing it. Treat wastes (e.g., cleaning solutions, rinse waters, rags, and personal protective equipment) resulting from decontamination as engineered nanomaterial-bearing waste.
- Do not put material from engineered nanomaterial-bearing waste streams into the regular trash without authorization from your waste management coordinator and ENV Division.
- Do not put nanomaterial-bearing waste down any drain without authorization from your waste management coordinator, ENV Division, and an approved waste profile.
- Do not permit engineered nanomaterial-bearing wastes to be shipped to off-site locations without first coordinating with waste management coordinator.
- ENV and Waste and Environmental Services will assist you in characterizing and managing engineered nanomaterial-bearing waste streams as either hazardous or nonhazardous waste based on the requirements in 40 Code of Federal Regulation (CFR) 261.10 to 38 and the New Mexico Environment Department.

[1] Neither the Environmental Protection Agency nor the State of New Mexico has promulgated environmental protection or waste management regulations specific to nanomaterials. However, waste containing nanomaterials in any form must be evaluated against currently applicable standards (e.g., State and federal hazardous waste regulations and water quality standards; and New Mexico special waste regulations).

- Package engineered nanomaterial-bearing wastes in containers that are compatible with the contents, in good condition, and that afford adequate containment to prevent the escape of the engineered nanomaterials. Minimally, all containers holding engineered nanomaterials must be labeled consistent with this document. Additional labeling may be required by applicable environmental protection and transportation regulations. Contact your waste management coordinator.

3.5 Spill Mitigation

- Contact the Laboratory Emergency Operations at 7-6211 in the event of a large spill (i.e., a spill that cannot be safely contained by the engineered nanomaterial worker).
- Engineered nanomaterial workers will determine the extent of the area affected, and demarcate it with barricade tape or use another reliable means to restrict entry into the area.
- Allow trained personnel to clean up smaller spills, following the approved cleanup procedures listed in the IWD.
- Refer personnel exposed to nanomaterials in the course of a spill to Occupational Medicine.
- Manage all debris and waste resulting from the clean up of a spill as though it contains engineered nanomaterials.

3.6 Transportation of Nanomaterials

3.6.1 Off-Site Shipping

Any nanomaterial that meets the definition of a hazardous material, or is suspected to be hazardous material according to 49 CFR Part 171.8 and can be classified as a hazardous material in accordance with 49 CFR 173.115–141 and 9 CFR 173.403–173.436 must be packaged, marked, labeled, shipping papers prepared and shipped in accordance with 49 CFR 100–185, *Department of Transportation*, and applicable Department of Energy (DOE) Orders by Department of Transportation (DOT) trained personnel. Contact Operations Support-Packaging and Transportation (OS-PT) for assistance.

Any nanomaterial being shipped by air that meets the definition of dangerous goods according to the International Civil Aviation Organization must be packaged, marked, labeled, and shipped, with an accompanying properly prepared dangerous goods declaration, in accordance with the International Civil Aviation Organization technical instructions. Contact OS-PT for assistance.

Nanomaterials that do not meet the DOT's criteria listed above still may pose health and safety issues to personnel handling the material if they are released during its transport. Therefore, all shipments of nanomaterials, regardless of whether they meet the definition for hazardous materials or not, should be consistently packaged using the equivalent of a DOT-certified Packing Group I (PG I) container and labeled as required by DOE. Contact OS-PT for assistance.

Wastes containing nanomaterials that are also New Mexico special wastes or hazardous wastes have additional shipping, placarding, manifesting, and training requirements. Contact your waste management coordinator.

3.6.2 On-Site Transfers of Engineered Nanomaterials

The on-site transfer of nanomaterials must follow the Laboratory Packaging and Transportation Manual. OS-PT is the authority having jurisdiction on the requirements for packaging, marking, and documentation necessary for on-site transfers. For nanomaterials, the following is required:

- Assess and record the hazards posed by the material(s) following a graded approach that takes into account the form of the material(s) (e.g., free particle vs. fixed on substrate).
- Use packaging consistent with the recommendations for off-site shipment or packaging that affords an equivalent level of safety.
- Include a Material Safety Data Sheet (MSDS), if available, in the package. If an MSDS is unavailable, supply material-specific knowledge.

4.0 RESPONSIBILITIES

Division Directors will:

- ensure that division activities involving engineered nanomaterials are conducted within the safety envelope and the scope of work identified in division and facility documents and
- ensure that adequate resources are provided to RLMs to identify, evaluate, and control hazards associated with existing and proposed engineered nanomaterial activities performed within their division.

Responsible Line Managers (RLMs) in coordination with the person in charge will:

- ensure that resource planning, funding, prioritizing, planning, scheduling, and implementation of engineered nanomaterial work conducted under their supervision addresses the necessary environmental, safety, and health evaluation and controls,
- inform visitors about Los Alamos National Laboratory's (LANL's) Environmental Safety and Health (ES&H) engineered nanomaterials policies and procedures and ensure that they are aware of the existence and availability of chemical hazard information and resources,
- ensure that IWDs are completed and approved for work with engineered nanomaterials by engineered nanomaterial workers, and
- ensure that all required training is completed by engineered nanomaterial workers before the engineered nanomaterial worker is authorized.

Engineered nanomaterial workers will:

- follow the requirements of this document,
- work safely by observing safety standards, guidelines, and procedures,
- implement all controls required by work authorization documentation,
- stop work that may pose an imminent danger to workers, and
- complete required training.

5.0 IMPLEMENTATION

The requirements in this document are in effect as of July 31, 2008.

6.0 TRAINING

RLMs must ensure that engineered nanomaterial workers, and support personnel with potential exposure to engineered nanomaterials, complete the training requirements for authorized chemical worker, as outlined in *Chemical Management*, and additional awareness training for nanomaterials workers when available.

7.0 EXCEPTION OR VARIANCE

To obtain an exception or variance to this document, see the following instructions:

- Managers may request an exception or variance from the ADESH&Q.
- At the request of the ADESH&Q, the IHS Division Leader will provide a recommendation or supporting information.
- The ADESH&Q or his designee will provide the requestor with a written response and copy the IHS Division Leader.

8.0 DOCUMENTS AND RECORDS

Office of Record

The Policy Office is the Laboratory Office of Record for this document and maintains the administrative record.

9.0 DEFINITIONS AND ACRONYMS

9.1 Definitions

See Definition of Terms, LANL *Policy and Procedures Manual*.

Engineered Nanomaterials—Are intentionally created (in contrast with natural or incidentally formed) nanoparticles. This definition excludes biomolecules (proteins, nucleic acids, and carbohydrates) covered by *Biological Safety*, and materials for which the Occupational Exposure Limit (OEL) documentation of national consensus, or regulatory standards has specifically addressed nanosized particles for that material.

Engineered Nanomaterial Worker—Handles engineered nanomaterials that have the potential for inhalation or dermal exposure. Routinely spends time in an area in which engineered nanomaterials have the potential to become dispersed in the air. Works on equipment that might be contaminated with engineered nanomaterials and that could foreseeably release engineered nanomaterials during servicing or maintenance.

Nanoparticles—Dispersible particles with two- or three-dimensions between 1 and 100 nanometers.

9.2 Acronyms

ADESH&Q	Associate Director for Environment, Safety, Health, and Quality
CFR	Code of Federal Regulation
DOE	Department of Energy
DOT	Department of Transportation
ENV	Environmental Protection
ES&H	Environmental Safety and Health
HEPA	High Efficiency Particulate Air
IA	Issuing Authority
IHS	Industrial Hygiene and Safety
IMP	Implementation Procedure
ISD	Implementation Support Document
IWD	Integrated Work Document
LANL	Los Alamos National Laboratory
LASO	Los Alamos Site Office
MSDS	Material Safety Data Sheet
NNSA	National Nuclear Security Administration
OEL	Occupational Exposure Limit
OS-PT	Operations Support-Packaging and Transportation
P	Procedure
PG	Packing Group
PPE	Personal Protective Equipment
R&D	Research and Development
RLM	Responsible Line Manager
RM	Responsible Manager
RO	Responsible Office
SME	Subject Matter Expert
TA	Technical Area

10.0 HISTORY

Revision History		
03/27/08	P101-29	Initial Issue

11.0 REFERENCES

Prime Contract:

- 10 CFR 851, *Worker Safety and Health Program*
- DEAR 970-5223-1, *Integration of Environment, Safety and Health into Work planning and Execution*
- DEAR 970.5204, *Laws, Regulations, and DOE Directives*; Appendix B 4.2, *Environment, Safety, and Health*
- DOE P 456.1, Secretarial Policy Statement on Nanoscale Safety

Other References:

- *Integrated Work Management*
- OST 402-00-00, *Laboratory Industrial Hygiene and Safety Manual*, Chapter 64, *Nanotechnology Health and Safety*
- OST 400-00-00, *Laboratory Industrial Hygiene and Safety Manual*, Chapter 45, *Worker Protection Qualitative Exposure Assessment*
- *Chemical Management*
- *Local Exhaust Ventilation and HEPA Filtration Systems*
- *Safety Signs, Labels, and Tags*
- *Personal Protective Equipment*
- OST 402-00-00, *Laboratory Industrial Hygiene and Safety Manual*, Chapter 49, *Personal Protective Equipment*
- 40 CFR 261.10 to 38
- 49 CFR Part 171.8
- 49 CFR 173.115–141
- 49 CFR 173.403–173.436
- 49 CFR 100–185, *Department of Transportation*
- *Biological Safety*
- Memorandum to Michael Anastasio, Director, LANL; from Donald L. Winchell, Manager NNSA: LASO SET: 9DD-007 Subject: *Worker and Environmental Protection at the Los Alamos National Laboratory, November 29, 2007*
- DOE Nanoscale Science Research Centers, *Approach to Nanomaterial ES&H*, Rev. 2 June 2007
- *International Civil Aviation Organization*

12.0 FORMS

N/A

13.0 ATTACHMENTS

N/A

14.0 CONTACT

Industrial Hygiene and Safety (IHS) Division Office
Telephone: (505) 606-0295
Fax: (505) 667-1945
Website: http://dev-y.lanl.gov/safety/nano/index.shtml