



U.S. Department of Energy
Office of Inspector General
Office of Audit Services

Audit Report

Nanoscale Materials Safety at the Department's Laboratories




Department of Energy

Washington, DC 20585

February 28, 2008

MEMORANDUM FOR THE SECRETARY

FROM:


Gregory H. Friedman
Inspector General

SUBJECT:

INFORMATION: Audit Report on "Nanoscale Materials Safety at the Department's Laboratories"

BACKGROUND

The National Nanotechnology Initiative was established as a multi-agency research and development program in 2001. As a part of the Initiative, the Department of Energy (Energy) is in the process of constructing Nanoscale Science Research Centers at six national laboratories. In addition to funding the construction and operation of these facilities, the Department funds nanotechnology projects at six other national laboratories.

Since the field of nanoscale materials research is relatively new, the health and safety risks associated with these materials are still emerging. Health and safety risks include possible pulmonary inflammation and lung tumors resulting from the inhalation of nanoscale materials as well as an increased potential for explosion and fire due to nanoscale attributes that are not present in the same materials at larger sizes.

The Department established DOE P 456.1, *Secretarial Policy Statement on Nanoscale Safety* in September 2005. This policy stipulates that the Department and its contractors should use best practices and national consensus standards when establishing safety policies to protect workers. National consensus standards have not yet been established as the scientific community studies safety and health risks posed by nanoscale materials. The Centers for Disease Control and the National Institute of Occupational Safety and Health (CDC/NIOSH) have taken a leading role among Federal agencies conducting research on the safe handling of nanoscale materials. In October 2005, CDC/NIOSH distributed, for peer review, information regarding precautionary measures for the safe conduct of nanoscale work, including medical surveillance, workplace monitoring, training, and engineering controls. Given the absence of consensus standards, we used the CDC/NIOSH information to determine whether the Department's laboratories were employing appropriate safety measures specifically tailored for working with nanoscale materials.

RESULTS OF AUDIT

We found that the Department and its laboratory contractors had not always employed precautionary measures as outlined by the CDC/NIOSH. While some laboratories had established work practices concerning the safe handling of nanoscale materials, the Department's laboratories we reviewed generally had not:



- Performed medical surveillance on individuals working with these materials;
- Monitored the workplace environment for exposure to airborne nanoscale materials;
- Provided specific training in the safe handling of nanoscale materials; and,
- Required that nanoscale materials research be performed in facilities equipped with all of the suggested engineering health and safety controls.

In addition, the Department had not established a mechanism to disseminate nanoscale materials safety information. Management told us that existing mechanisms, such as Departmental working groups, adequately performed the dissemination function for nanoscale safety information. However, at the time of our audit, neither the Department nor the working group had disseminated lessons learned and other information developed by the group to other laboratories working with nanoscale materials.

Department officials indicated that they were waiting for the development of national consensus standards before issuing additional guidance in the areas of medical surveillance, exposure rate monitoring, training, and use of engineering controls. Similarly, officials at several laboratories indicated that they were waiting for more definitive agency standards to be available before establishing specific safety policies locally. However, CDC/NIOSH has encouraged the establishment of interim standards until more definitive consensus standards are developed for nanotechnology.

We concluded that the Department should adopt a proactive approach to ensuring that its laboratories follow best practices in conducting nanoscale-related work. In this way, the Department increases the chance that workers will be protected from potential health and safety risks, some of which experts acknowledge may not be fully understood for years.

During our review, an Environment, Health and Safety (ES&H) working group representing the Department's Nanoscale Science Research Centers (NSRC), issued safety guidance for nanotechnology, entitled *Approach to Nanomaterial ES&H*. The policy suggestions in this guide conform to the CDC/NIOSH precautionary measures on medical surveillance, exposure rate monitoring, worker training, and engineering controls. Management stated that all of the Directors of the national laboratories have accepted the guidance and endorsed them as the best collection of safety and health information concerning nanoscale activities. While the development of this guidance is a positive development, the use of the guide is voluntary on the part of the laboratories. Accordingly, we recommended the Department adopt and issue the NSRC working group's guidance until national consensus standards can be established.

MANAGEMENT REACTION

Management did not concur with our recommendation. Management felt it was unnecessary to develop any additional policy or guidance in this area at this time.

Management also stated that it had asked Laboratory Directors to provide an update on their progress in the development and implementation of requirements for nanotechnology activities.

We disagree with management's position. After we received management's response, we followed up with several laboratories and found varying degrees of action on the policy suggestions in the NSRC guidance. Our review found that none of the laboratories had fully adopted the NSRC suggestions. One official stated that his laboratory was awaiting formal direction from the Department before acting.

During the course of our audit, we noted a concern regarding the Department being overly prescriptive about how contractors should achieve mission objectives and its impact on economy and efficiency. However, the disparity in precautionary measures we found warrants that the Department clearly establish expectations for such measures at its laboratories. In addition, the Department's adoption of the NSRC guidance would not involve the establishment of new requirements since the laboratory directors have agreed to adopt and operate in a manner consistent with them.

Given the potential health consequences, we believe it is important that the Department adopt and disseminate the best available guidance on nanoscale safety in order to protect workers in this important and emerging field of research. Management's comments and our response are discussed in more detail in the body of the report.

Attachment

cc: Deputy Secretary
Under Secretary of Energy
Under Secretary for Science
Administrator, National Nuclear Security Administration
Chief of Staff
Chief Health, Safety and Security Officer
Director, Policy and Internal Controls Management, NA-66

REPORT ON NANOSCALE MATERIALS SAFETY AT THE DEPARTMENT'S LABORATORIES

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NANOSCALE MATERIALS SAFETY POLICES

Best Practices

The Department of Energy (Department) established DOE P 456.1, *Secretarial Policy Statement on Nanoscale Safety* in September 2005. This policy stipulates that the Department and its contractors should use best practices and national consensus standards when establishing safety policies to protect workers. Although consensus standards have not been established, we benchmarked the safety practices of the Department's laboratories against the Centers for Disease Control and National Institute for Occupational Safety and Health (CDC/NIOSH) guide *Approaches to Safe Nanotechnology* (issued in October 2005 and reissued in July 2006 for peer review). CDC/NIOSH are the leading Federal agencies conducting research on health and safety issues of nanoscale materials.

While 12 of the Department's laboratories reviewed had established some work practices concerning the safe handling of nanoscale materials, they generally had not implemented all of the procedures suggested in the CDC/NIOSH guide. These procedures were in the areas of medical surveillance, exposure rate monitoring, worker training, and engineering controls. In addition, the Department had not established a mechanism to disseminate nanoscale materials safety information.

Medical Surveillance

Of the 12 labs, 11 did not perform medical surveillance of individuals working with nanoscale materials. Medical surveillance involves establishing an initial health baseline of those who work with hazardous materials and scheduling subsequent periodic medical examinations. These subsequent exams track deviations from the baseline and help identify any adverse health effects arising from exposure to nanoscale materials. CDC/NIOSH guidelines state that the unique properties of nanoscale materials, together with information suggesting these materials may pose health and safety hazards to workers, underscore the need for medical surveillance.

Workplace Exposure Monitoring

Nine of the 12 laboratories had not initiated monitoring for exposure rates in the workplace. Exposure monitoring involves the sampling of air at various locations in the workplace to measure the amount of airborne particles. Although the toxicity of nanoscale materials is unknown, the CDC/NIOSH suggests monitoring the workplace environment for exposure to nanoscale materials. CDC/NIOSH states that it is critical that background

exposure measurements be conducted in order to determine whether there has been an increase in exposure due to production and processing activities.

Training

Only two of the laboratories required that workers receive training specific to handling nanoscale materials. Since nanoscale materials can have different qualities than the same materials at a larger size, and since knowledge of the safety aspects of the nanoscale materials is largely unknown, it is important that workers receive more specific training in working with these materials. Accordingly, CDC/NIOSH suggests educating and training workers in the safe handling of nanoscale materials. Most of the laboratories we reviewed relied on standard chemical safety training provided to laboratory workers, as well as training on the hazards of the specific materials led by principal investigators. However, standard chemical safety training usually did not include content related to potential hazards of working with nanoscale materials. Further, the training led by principal investigators was not standardized and was limited to the hazards of the specific materials being used on a particular experiment. While both types of training are useful, they should be used in tandem with specific training in the safe handling of nanoscale materials to ensure workers are aware of potential hazards and good work practices. Finally, two principal investigators at one laboratory told us that they did not require students who were part of their research teams to take the standard chemical safety training required of laboratory personnel.

Engineering Controls

Only two laboratories required that nanoscale materials research be performed in facilities equipped with all of the suggested engineering health and safety controls. For example, one laboratory identified a potential inhalation hazard with an experiment but did not require use of available HEPA filtered exhaust ventilation because very little particle loss was anticipated. Another laboratory without HEPA filtered ventilation systems stated they may allow on-site preparation of nanomaterials samples. Such action could increase the inhalation risk of nanomaterials. Engineering controls such as exhaust ventilation systems which include high efficiency particulate air (HEPA) filters can effectively remove nanoscale particles. CDC/NIOSH

suggests the use of engineering controls, including exhaust ventilation systems with HEPA filters, to remove nanoscale particles.

Management pointed out engineering controls should be tailored to the potential hazard. It stated that high-efficiency particulate air filters such as HEPA filters are appropriate when nanomaterials might become airborne, but may not be necessary in all areas where nanomaterials research is being conducted. We agree that engineering controls should be tailored to potential hazards. As noted in the above examples, potential inhalation hazards exist that may require the use of engineering controls.

Dissemination of Information

The Department also had not established a formal process for disseminating nanoscale materials safety information to all of the laboratories. Although several Departmental working groups had been formed to discuss issues related to nanoscale materials research, none of these groups had been tasked with disseminating safety and health information or lessons learned throughout the Department. For example, the Department encouraged the six Nanoscale Science Research Centers (NSRC) to establish an Environment, Health and Safety working group. Management told us that existing mechanisms, such as Departmental working groups, interagency working groups, and various websites, adequately performed the function of dissemination for nanoscale safety information. However, neither the Department nor the working group had disseminated lessons learned and other information developed by the group to the other laboratories working with nanoscale materials. Such information is useful to organizations in ensuring that the best current knowledge is reflected in the identification and control of potential hazards, as required by the Secretarial Policy Statement and encouraged by the CDC/NIOSH.

Departmental Guidance

The Department relied upon each separate laboratory to develop and implement protective measures and had not provided its laboratories with guidance on what specific procedures should be followed to meet the *Secretarial Policy Statement on Nanoscale Safety*. Based on our discussions, Department officials were waiting for definitive standards to be established by consensus standard setting organizations before issuing guidance on medical surveillance, exposure rate monitoring, and training; ensuring laboratories have the suggested engineering controls; or

establishing a method of disseminating information. Similarly, officials at several laboratories indicated that they were waiting for more definitive agency standards to become available before establishing specific safety policies locally. Nonetheless, the CDC/NIOSH has encouraged the establishment of interim standards until the development of more definitive consensus standards.

During our review, the NSRC working group issued suggested safety guidance for nanotechnology, entitled *Approach to Nanomaterial ES&H*. The policy suggestions contained in the guidance are similar to the CDC/NIOSH guidance in the areas of medical surveillance, exposure rate monitoring, worker training, and the appropriate use of engineering controls as suggested by CDC/NIOSH's guide. Management stated that all of the national laboratories have accepted the guidelines and endorsed them as the best collection of safety and health information and guidance concerning nanoscale activities. However, use of the NSRC working group guidance, as well as the CDC/NIOSH guidance, are voluntary on the part of the Department's laboratories involved in nanotechnology.

Risk to Worker Health and Safety

One of the Department's stated goals is the safety of its employees, the public, and the environment. The Department faces many uncertainties about whether nanotechnology materials pose occupational health and safety risks as it pursues nanotechnology research. Health and safety risks include possible pulmonary inflammation and lung tumors resulting from the inhalation of nanoscale materials as well as an increased potential for explosion and fire due to nanoscale attributes that are not present in the same materials at larger sizes. Given the uncertainties about the occupational health and safety risk posed by nanotechnology particles, it is prudent for the Department to take precautionary measures to minimize worker exposure as suggested by the CDC/NIOSH and the NSRC guidance.

RECOMMENDATIONS

We recommend that the Chief, Office of Health, Safety and Security (HSS), adopt and disseminate the Nanoscale Science Research Centers working group's guidance as the Department's expectation of safety policies and procedures at the laboratories in these areas:

- Performing medical surveillance on individuals working with or around nanoscale materials;

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- Performing exposure rate monitoring in the laboratories where nanoscale materials research is performed;
 - Training employees in the safe handling of nanoscale materials when working with and around these materials; and,
 - Using appropriate engineering controls, such as HEPA filtered external exhaust systems, while performing nanoscale materials research.

MANAGEMENT REACTION

The Office of HSS did not concur with our recommendation. Specifically, management felt it was unnecessary to develop any additional policy or guidance in this area at this time. Management found that the NSRC working group's guidance addressed the existing Secretarial Policy Statement and provided an appropriate approach to health and safety concerns when working with nanomaterials. Management also stated that it has asked Laboratory Directors to provide HSS with an update on their progress in the development and implementation of requirements for nanotechnology activities.

AUDITOR COMMENTS

Management's comments were not responsive to our recommendation. While we agree that development of the NSRC guidance is a positive first step, compliance with the guidelines remains voluntary by the laboratories. For example, one national laboratory official pointed out that the guidelines were not part of the laboratory's contract with the Department, although they were applicable to nanotechnology-related work at the laboratory. Additionally, although the guidelines have been accepted by the Laboratory Directors, subsequent discussions with several laboratories found varying degrees of action had been taken on the policy suggestions in the NSRC guidance. None of the laboratories we contacted had fully adopted the NSRC suggestions. One non-NSRC laboratory official responded that the guidance was not mandatory and intended for the NSRCs only.

We also noted that, in at least two cases, responses to the HSS request for an update on nanotechnology safety requirements, which were available to us, did not provide assurance that proper requirements were in place. Specifically, two laboratories responded that they were either still developing procedures or reviewing the additional program requirements needed to establish strict adherence to the NSRC guide.

Accordingly, we believe it is important for the Department to adopt and disseminate the guidelines in order to clearly establish its expectations for measures that all laboratories need to take in order to satisfy the Secretarial Policy Statement on nanotechnology safety.

Appendix 1

OBJECTIVE

The objective of this audit was to determine whether the Department of Energy's (Department) laboratories were employing appropriate measures specifically tailored for working with nanoscale materials.

SCOPE

This audit was performed between January and August 2007 at Department Headquarters in Washington, DC, and Germantown, Maryland; Ames Laboratory in Ames, Iowa; and Sandia National Laboratory in Albuquerque, New Mexico. Information was also received from Lawrence Berkeley National Laboratory in Berkeley, California; Brookhaven National Laboratory in Upton, New York; Argonne National Laboratory in Argonne, Illinois; Oak Ridge National Laboratory in Oak Ridge, Tennessee; Pacific Northwest National Laboratory in Richland, Washington; Lawrence Livermore National Laboratory in Livermore, California; Los Alamos National Laboratory in Los Alamos, New Mexico; Idaho National Laboratory in Idaho Falls, Idaho; the National Renewable Energy Laboratory in Golden, Colorado; and the Stanford Linear Accelerator Center in Menlo Park, California. The scope of the audit included policies and procedures related to nanoscale materials safety in effect during Fiscal Year 2007.

METHODOLOGY

To accomplish the audit objective, we:

- Reviewed applicable laws and regulations pertaining to nanoscale materials safety;
- Reviewed industry and governmental standards related to industrial hygiene;
- Reviewed Departmental policies and procedures related to nanoscale materials safety;
- Performed site visits at Ames Laboratory, and Sandia National Laboratory;
- Reviewed safety policies and requirements in effect at 12 Departmental Laboratories;
- Reviewed the Government Performance and Results Act of 1993 and determined if performance measures had been established; and,

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- Held discussions with officials and personnel from the Office of Health, Safety and Security; the National Nuclear Security Administration's Environment, Safety and Health Program; Ames Laboratory; Sandia National Laboratory; Lawrence Berkeley National Laboratory; Brookhaven National Laboratory; Argonne National Laboratory; Oak Ridge National Laboratory; Pacific Northwest National Laboratory; Lawrence Livermore National Laboratory; Los Alamos National Laboratory; Idaho National Laboratory; the National Renewable Energy Laboratory; and the Stanford Linear Accelerator Center.

This performance audit was conducted in accordance with generally accepted Government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objective. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objective. The audit included tests of controls and compliance with laws and regulations necessary to satisfy audit objectives. Because our review was limited, it would not necessarily have disclosed all internal control deficiencies that may have existed at the time of the audit. We did not rely on computer processed data to accomplish our audit objective. Performance measures were not established for nanoscale materials safety; however, our recommendations were directed at the Department to establish its expectations in this area.

An exit conference was held with Department Officials for the Office of Health, Safety and Security, and the Office of Science on January 22, 2008.



Department of Energy
Washington, DC 20585

December 18, 2007

MEMORANDUM FOR GREGORY H. FRIEDMAN
INSPECTOR GENERAL *Greg Friedman*

FROM: GLENN S. PODONSKY
CHIEF HEALTH, SAFETY AND SECURITY OFFICER
OFFICE OF HEALTH, SAFETY AND SECURITY *Glenn S. Podonsky*

SUBJECT: COMMENTS FOR IG DRAFT AUDIT REPORT: "Nanoscale
Materials Safety at the Department's Laboratories"
(AO7CH050)

The Office of Health, Safety and Security (HSS) has reviewed the Nanoscale Science Research Centers, "Approach to Nanomaterials Environment Safety and Health." HSS feels that this document addresses the policy established in the existing DOE P 456.1, "Secretarial Policy statement on Nanoscale Safety" and provides the Department with the appropriate approach to the health and safety concerns when working with nanomaterials. A letter has been sent to the Laboratory directors asking them to provide HSS with an update on the progress of the laboratories' development and implementation of requirements for nanotechnology activities based on DOE P 456.1 and the November 8, 2007, Executive Office of the President, Office of Science and Technology Policy memorandum.

As the laboratories are developing requirements for the use of nanomaterials on their sites, HSS feels that it is unnecessary to develop additional policy or guidance at this time.

If you have any questions, you may contact me at (301) 903-3777, or have a member of your staff contact Patricia Worthington at (301) 903-5926.

cc: Frank Russo, NA-1
Marcus Jones, SC-31
Michael Kilpatrick, HS-1
Lesley Gasperow, HS-1.2
Patricia Worthington, HS-10



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