

A.J. Eggenberger, Chairman  
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# DEFENSE NUCLEAR FACILITIES SAFETY BOARD

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April 25, 2007

The Honorable Samuel Bodman  
Secretary of Energy  
1000 Independence Avenue, SW  
Washington, DC 20585-1000

Dear Secretary Bodman:

On April 25, 2007, the Defense Nuclear Facilities Safety Board (Board), in accordance with 42 U.S.C. § 2286a(a)(5), unanimously approved Recommendation 2007-1, *Safety-Related In Situ Nondestructive Assay of Radioactive Materials*, which is enclosed for your consideration. This Recommendation addresses the measuring of radioactive material holdup at defense nuclear facilities in the Department of Energy (DOE) complex.

After you have received this Recommendation and as required by 42 U.S.C. § 2286d(a), the Board will promptly make it available to the public. The Board believes that this Recommendation contains no information that is classified or otherwise restricted. To the extent that this Recommendation does not include information restricted by DOE under the Atomic Energy Act of 1954, 42 U.S.C. §§ 2161-68, as amended, please arrange to have it placed promptly on file in your regional public reading rooms. The Board will also publish this Recommendation in the *Federal Register*. The Board will evaluate DOE's response to this Recommendation in accordance with the Board's Policy Statement 1, *Criteria for Judging the Adequacy of DOE Responses and Implementation Plans for DNFSB Recommendations*.

Sincerely,

A handwritten signature in black ink, appearing to read "A. J. Eggenberger".

A. J. Eggenberger  
Chairman

c: Mr. Mark B. Whitaker, Jr.

Enclosure

**RECOMMENDATION 2007-1 TO THE SECRETARY OF ENERGY**  
***Safety-Related In Situ Nondestructive Assay of Radioactive Materials***  
**Pursuant to 42 U.S.C. § 2286(a)(5)**  
**Atomic Energy Act of 1954, As Amended**

Dated: April 25, 2007

**Overview**

There are many situations in which the quantity and composition of radioactive material must be determined. In some instances, access to the material is impossible or undesirable, and consequently, weighing, laboratory analysis, and calorimetry are not viable options. In these cases, *in situ* nondestructive assay (NDA), based on the measurement of signature emissions from a specific isotope of interest, is used to provide an estimate of the type and quantity of radioactive material present. However, large uncertainties and inaccuracies have occurred in estimating the type and quantity of radioactive material using *in situ* NDA. These uncertainties and inaccuracies include incorrect assumptions about shielding and the spatial distribution of radioactive material, as well as poor measurement techniques. Measurement errors, in turn, lead to potential criticality accident conditions, unexpected radiation exposure to workers, and underestimation of radioactive material available for release in accident scenarios.

In most nuclear safety areas, the Department of Energy (DOE) has captured required elements for robust site programs through its Directives system. These elements include requirements necessary for proper functioning of the program, training and qualification standards for personnel, assessment criteria to ensure proper implementation of requirements, and feedback mechanisms for lessons learned and continuous improvement. However, DOE has not established programmatic requirements for NDA, even though this method is heavily relied upon for nuclear safety throughout the complex and is key to many DOE activities. The capability to perform accurate measurements and use the results to determine compliance with nuclear safety limits is absolutely essential.

Research and development efforts for NDA have historically focused on the areas of material control and accountability and nuclear material safeguards; advances in these areas have peripherally benefitted *in situ* NDA measurement capabilities. Current research and development efforts appear to hold little promise for addressing needed improvements for *in situ* NDA measurement. For example, development of instrumentation and measurement techniques is needed to reduce overall measurement uncertainties.

**Examples**

Three notable instances of recent errors associated with *in situ* NDA measurement of radioactive material holdup are discussed below. These errors resulted from the use of inaccurate correction factors regarding material geometry assumptions or failure to perform measurements

at locations where the material was accumulating. In each of these cases, the amount of radioactive material was initially underestimated, resulting in a smaller-than-expected safety margin and violations of criticality safety limits.

- Material holdup in 6-inch diameter vacuum system pipe at the Hanford Site's Plutonium Finishing Plant was assumed to be in the form of a 0.25 inch layer at the bottom of the pipe. Using a correction factor for this geometry, the initial estimate of material was about 1 kg. When workers then proceeded to remove the piping, it was found to be filled with a solid plug of material, and the actual amount of material present was nearly twice as high as the initial estimate.
- Measurement of an exhaust filter at the Y-12 National Security Complex assumed that fissionable material was loaded only on the face of the filter. An estimate of a few hundred grams of material was obtained using correction factors for this geometry. Subsequent investigation showed that material was loaded throughout the filter, and not just on the face. The actual amount of fissionable material present was several times the initial estimate.
- A second exhaust filter at the Y-12 National Security Complex was measured periodically using NDA, but the measurement point was not where the fissionable material was accumulating. Once this error was discovered, follow-up measurements showed significant material accumulation.

In each of these instances, site-specific corrective actions were taken based on the specific problem encountered. Lessons learned from these events do not appear to have been shared within the DOE complex. Complex-wide corrective actions have not been identified to minimize the occurrence of similar events at other sites. The Board is concerned that undiscovered problems currently exist at other facilities within the DOE complex. It is incumbent upon DOE and its contractors to review current *in situ* NDA measurements to determine whether the assumptions used to derive results are sufficiently conservative to ensure compliance with nuclear safety limits.

## Issues

Three main issues dominate the current technical and regulatory landscape regarding *in situ* NDA measurements: (1) lack of standardized requirements for performing measurements, (2) lack of design requirements for new facilities that would facilitate accurate holdup measurement, and (3) lack of research and development activities for new instrumentation and/or measurement techniques. Each of these issues is discussed below.

*Lack of Standardization*—DOE has not established requirements or guidance for performing *in situ* measurements in its Directives system. While the Board recognizes that measurement techniques can be highly location specific, a requirement to follow methods outlined in national consensus standards when performing *in situ* NDA measurements would

reduce the errors and uncertainty of results. Commercial guidance for NDA is available in a series of standards published by the American Society for Testing and Materials (ASTM). This series addresses good practices for performing NDA measurements, methods for performing specific types of NDA measurements (for example, ASTM C-1133-03, *NDA of Low-Density Scrap and Waste by Segmented Passive Gamma Ray Scanning*), and training and qualification of NDA personnel. While this guidance has been used informally at some sites, DOE has not required its use for NDA measurements.

*Lack of Design Requirements for New Facilities*—Many of the problems that require *in situ* NDA to determine radioactive material holdup arose because facilities were designed and built before the need for NDA technology was evident. As a result, no consistent attempt was made to design facility systems to minimize holdup or facilitate its measurement. This historical trend should not be repeated in new facilities. The necessity of monitoring radioactive material holdup must be considered in the design of new facilities. For example, locations for monitoring can be selected during the design phase on the basis of the most likely locations for holdup to occur. Calibrations can then be performed at these locations *before* the facility begins operations to provide a baseline for future NDA measurements. Facilities can also be designed to minimize holdup in areas where it may be of concern.


*Lack of Research and Development Activities*—Los Alamos National Laboratory (LANL) conducted NDA research for more than 20 years. LANL developed most of the NDA techniques in current use, and conducts associated training programs. However, it is not clear that any significant research and development for *in situ* NDA measurements is currently being conducted within DOE to address serious concerns with material holdup. Research and development activities are focused in other areas, such as nuclear material safeguards and homeland security, but these efforts have different objectives and may not yield results that are beneficial for measurements using *in situ* NDA.

## Recommendation

The Board, therefore, recommends that DOE:

1. Evaluate the extent of condition regarding inaccurate *in situ* NDA programs within DOE. This effort should involve at least two actions:
  - A. Identifying all cases within the defense nuclear complex in which *in situ* NDA results are used to ensure compliance with nuclear safety limits.
  - B. Reviewing the cases identified in step 1.A to validate that the protocols, methodologies, calculations, and assumptions used to obtain NDA results are sufficiently conservative. This review should take into consideration lessons learned from recent events.
2. Establish requirements and guidance in a DOE directive or directives. The requirements and guidance should focus on *in situ* NDA programs that are used to demonstrate compliance with nuclear safety limits. Particular issues to be addressed should include:
  - A. Training and qualification standards for personnel involved in performing NDA measurements, interpreting and reviewing results, and managing site programs.
  - B. Application of standard protocols and methodologies, such as those given in the national consensus series issued by ASTM, for performing NDA measurements.
  - C. Standardization of correction factors for common situations (geometry and self-attenuation factors) and consistent application of uncertainty values.
  - D. Reinforcement of the use of formal lessons-learned mechanisms in the application of NDA programs so that information can be shared easily among affected DOE sites.
  - E. Incorporation of features in the design of new facilities to minimize radioactive material holdup and facilitate accurate NDA holdup measurements.
  - F. Periodic assessments of the need for new NDA technology and the status of ongoing NDA-related research and development programs.
  - G. Periodic assessments to ensure that NDA programs are using the best available technology.

- H. Incorporation of appropriate quality assurance elements into *in situ* NDA measurements when used for *compliance* with nuclear safety limits as required by 10 Code of Federal Regulations Part 830.



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A. J. Eggenberger, Chairman