DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Washington, DC 20004-2901

July 15, 2013

The Honorable Ernest J. Moniz
Secretary of Energy
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-1000

Dear Secretary Moniz:

The staff of the Defense Nuclear Facilities Safety Board (Board) performed a review of the Criticality Safety Program at Los Alamos National Laboratory in May 2013. This review identified significant non-compliances with applicable Department of Energy requirements and industry standards in the implementation of the Criticality Safety Program. In addition, this review identified criticality safety concerns stemming from weaknesses in conduct of operations at the Plutonium Facility. The Board notes that some of these deficiencies are long standing and indicate flaws in the federal oversight and contractor assurance systems.

The Board is aware that the Laboratory Director paused programmatic activities in the Plutonium Facility on June 27, 2013. The Board provides the attached report to aid in the ongoing assessment and development of corrective actions. Pursuant to 42 U.S.C. § 2286b(d), the Board requests a report and briefing by the National Nuclear Security Administration (NNSA) within 30 days of receipt of this letter that details (a) any corrective actions NNSA is taking to incorporate criticality safety controls into procedures, and to improve procedures, procedure use, criticality safety postings, and criticality safety support of operations, (b) any root causes NNSA has identified for recent criticality safety infractions, and (c) any improvements NNSA has determined are needed to the federal oversight and contractor assurance systems relative to criticality safety, conduct of operations, and effectiveness of corrective actions.

Sincerely,

Peter S. Winokur, Ph.D.
Chairman

Enclosure

c: Mr. Bruce Held
Mr. Geoffrey L. Beausoleil
Mrs. Mari-Jo Campagnone

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

July 2, 2013

MEMORANDUM FOR: S. Stokes, Acting Technical Director

COPIES: Board Members

FROM: D. Kupferer and J. McComb

SUBJECT: Criticality Safety at Los Alamos National Laboratory

This report documents a review performed by the staff of the Defense Nuclear Facilities Safety Board (Board) of the Los Alamos National Laboratory (LANL) Criticality Safety Program (CSP) during May 21–23, 2013. The staff's review included discussions with personnel representing the Los Alamos Field Office (LAFO) and the contractor, Los Alamos National Security, LLC (LANS), as well as walk-downs of various fissile material workstations and operations in the Plutonium Facility (PF-4). The staff conducted a follow-up teleconference with LAFO and LANS personnel on June 19, 2013, to obtain additional information.

Summary. National Nuclear Security Administration (NNSA) Headquarters, LAFO, and LANS have acknowledged that the LANL CSP is not compliant[1] with applicable requirements. The significant shortage of LANS criticality safety staff has hindered the ability of LANS to address these deficiencies, and the backlog of unresolved criticality safety issues continues to grow. In addition, the Board's staff identified the following non-compliances during its review:

- Most criticality safety controls are not incorporated into operating procedures.
- Operators typically do not utilize written procedures when performing work.
- Fissile material labels do not list parameters relevant to criticality safety (e.g., mass).
- Some fissile material operations lack Criticality Safety Evaluations (CSEs).
- Some CSEs do not analyze all credible abnormal conditions.

On June 27, 2013, the LANL Laboratory Director paused programmatic activities in PF-4. LANS has committed to develop a comprehensive "get-well" plan to bring the LANL CSP into compliance with applicable requirements. Given the deficiencies associated with criticality safety and conduct of operations, the staff believes the following actions should be considered during resumption of fissile material operations in PF-4:

[1] Throughout this report, the terms compliance and non-compliance refer specifically to alignment of the LANL CSP with Department of Energy directives and the American National Standards Institute (ANSI)/American Nuclear Society (ANS)-8 standards.

(1) incorporate criticality controls and limits into procedures; (2) improve conduct of operations including utilization of procedures; (3) evaluate procedures that contain criticality safety controls for designation as Use Every Time procedures; (4) review and approve criticality safety postings to ensure they are accurate and of high quality; and (5) enhance criticality safety support for ongoing operations.

Background. Prior to 2005, LANL's CSP was expert-based and highly dependent on the knowledge and experience of its criticality safety staff. In 2005, NNSA performed an assessment and determined that LANL's expert-based CSP was not compliant with applicable Department of Energy (DOE) requirements and industry standards [1]. In 2006, in response to NNSA's review, LANS developed a Nuclear Criticality Safety Program Improvement Plan (PIP), which was intended to align LANL's CSP with applicable requirements. The PIP's primary objective was to establish compliant CSEs for all operations [2].

In 2007, in response to concerns raised by the Board's staff, LANS determined that the authorized loading of vault storage rooms in PF-4 could lead to a critical configuration. As a result, LANS performed an Augmented Limit Review of all fissile material operations (FMOs) to confirm the adequacy of existing criticality safety limits. Due to a variety of issues, including staffing shortages, LANS did not complete execution of the PIP and, to date, has not developed updated CSEs for more than 100 FMOs.

In 2011, an event occurred at PF-4 in which fissile material handlers violated procedural requirements and criticality safety controls while moving and photographing eight plutonium rods. These violations included the following: failure to properly plan and obtain authorization for the activity, failure to adhere to posted requirements, and improper response to the infraction [3]. Following this event, LANS executed several corrective actions including improvements to the training, qualification, and certification processes for fissile material handlers.

In 2012, DOE's Criticality Safety Support Group (CSSG) performed a review of the LANL CSP and identified several deficiencies, including the operational impact of the contractor's declining criticality safety staff [4]. In response to the CSSG's review, LANS developed a Corrective Action Plan to improve several aspects of the CSP [5]. Beginning in 2012, LANS experienced an 18-month exodus of criticality safety professionals from its criticality safety group. LANS currently employs 2 full-time and 2 part-time qualified criticality safety analysts, in addition to 3 part-time subcontractors—far fewer than the 17 criticality safety analysts it has determined to be necessary to support operations, meet mission goals, and maintain the CSP.

DOE Requirements and Guidance. Title 10, Code of Federal Regulations, Part 830, *Nuclear Safety Management* (10 CFR Part 830), requires all Documented Safety Analyses (DSAs) to define a CSP that meets applicable nuclear criticality safety standards. In addition, Appendix A to Subpart B of 10 CFR Part 830 states that DOE Order 420.1, *Facility Safety*, provides DOE's expectations with respect to criticality safety. DOE Order 420.1B requires the development of a CSE for each FMO in accordance with DOE Standard 3007, *Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear*

Facilities. Each CSE provides the basis for subcritical operations under all normal and credible abnormal conditions. DOE Order 420.1B states that CSPs must satisfy the requirements of the criticality safety standards of American National Standards Institute (ANSI)/American Nuclear Society (ANS)-8, which include ANSI/ANS-8.1, *Nuclear Criticality Safety in Operations With Fissionable Materials Outside Reactors*, and ANSI/ANS-8.19, *Administrative Practices for Nuclear Criticality Safety*.

Staff Observations. During its review, the staff identified the following non-compliances and weaknesses associated with LANL's CSP and conduct of operations in PF-4. Collectively, the staff's observations call into question whether controls have been properly identified and implemented. Additional areas for improvement are discussed in the Attachment.

Procedures—The staff reviewed operating procedures for more than a dozen PF-4 FMOs during the onsite review. The Board's site representatives subsequently observed LANS evaluations of the workability of procedures in PF-4. The staff identified the following deficiencies regarding content and execution of procedures at PF-4.

- *Incorporation of Criticality Safety Requirements*—Procedures fail to incorporate many of the criticality safety controls and limits relevant to the operations in PF-4. This practice is not compliant with ANSI/ANS-8.1, Section 4.1.3, which states, "[p]rocedures shall specify all parameters that they are intended to control," and ANSI/ANS-8.19, Section 7.2, which states "[p]rocedures shall include those controls and limits significant to the nuclear criticality safety of the operation." Although the reviewed procedures typically cited the applicable Criticality Safety Limit Approval (CSLA)[2], CSLA documents were not readily available at some workstations.

- *Procedure Use*—ANSI/ANS-8.19, Section 1, states, "An effective nuclear criticality safety program … relies upon conformance with operating procedures." During discussions with operators and walk-downs in PF-4, the staff observed that operators rely on postings rather than written procedures when performing work. Criticality safety postings are considered by the ANSI/ANS-8 Standards, the site-wide CSP, and the TA-55 CSP to be only supplements to procedures. During the LANS workability evaluations, the Board's site representatives observed several instances in which either (a) operating procedures could not be executed as written or (b) procedural steps were inconsistent with how operators actually performed work. These observations further indicate that operators typically do not rely on procedures when performing work.

  All operating procedures reviewed by the staff are designated as Reference procedures rather than Use Every Time procedures. LANL's Conduct of Operations Manual states that a Use Every Time procedure must be considered if a procedural error could result in significant consequences [6]. Conversely, the Conduct of Operations Manual states that a Reference procedure describes activities for which

[2] The CSLA is a complete listing of all the criticality safety controls that establish the required safety margin.

training and expertise may be relied upon. The manual also states that Use Every Time procedures are to be present and in use during operations, while Reference procedures are not required to be located at the immediate workstation.

According to LANS, approximately 70% of procedures associated with FMOs in PF-4 are designated as Reference procedures. A June 13, 2013, memorandum from the LANS Associate Director for Plutonium Science and Manufacturing to his workforce notes that, "Two of the most critical elements of safe operations are that written technical procedures define the proper operational parameters and controls and that those procedures are followed as intended" [7]. Given these critical elements and the nature of many PF-4 operations, the staff believes it would be prudent to evaluate designating procedures for appropriate PF-4 operations as Use Every Time, particularly when criticality safety controls are required.

- *Posting Quality*—As discussed above, PF-4 fissile material handlers rely on the content and accuracy of facility postings. ANSI/ANS-8.1, Section 4.1.4 states, "area posting shall be maintained specifying material identification and all limits on parameters subject to procedural control." The staff identified several criticality safety postings that included unclear or inconsistent requirements, and other postings with basic formatting errors. Postings often directly reflect language from their parent CSLAs and CSEs, and the deficiencies typically extend to these documents. Posting quality was also listed as an opportunity for improvement in the 2012 CSSG report [4], yet was not addressed by the Corrective Action Plan developed in response to the CSSG's report.

  LANL criticality safety postings require no formal approval. The lack of a rigorous review and approval process for postings, in addition to the posting deficiencies observed by the staff, underscores the fault of relying on these postings (rather than procedures) to meet criticality limits. The staff believes it would be prudent to consider near-term improvements to postings while procedural upgrades are completed.

Fissile Material Tracking and Labeling—During walk-downs, the staff observed that fissile material handlers rely on an electronic inventory database (LANMAS), rather than material and container labeling, to adhere to applicable criticality safety limits. Typically, container labels included only a material tracking number and the material type. This practice is not compliant with ANSI/ANS-8.19, Section 9.2, which states, "appropriate material labeling … shall be maintained, specifying material identification and all limits on parameters that are subject to procedural nuclear criticality safety control." Additionally, the LANL CSP states, "The ORS [Operations Responsible Supervisor] must require that material/containers be unambiguously labeled with specifications consistent with parameters that are under control (e.g., mass, material type, and volume)" [8]. The staff believes it would be prudent to consider implementing a clear and rigorous method for ensuring compliance with criticality safety limits and ANSI/ANS-8 requirements.

Criticality Safety Evaluation Quality—Starting in 2005, the PIP aimed to develop evaluations for FMOs with missing CSEs and update evaluations for FMOs with deficient CSEs. This effort attempted to bring these operations into compliance with DOE Standard 3007, and LANL Policy 06.06, *Criticality Safety Evaluations*. A number of issues, including limited staff resources, impacted execution of the PIP, and many of the CSEs were never developed. While updating CSEs, operations were subjected to an Augmented Limit Review, which took place in 2007 and 2008. Documentation of this review process is sparse. Currently, 135 of 513 LANL FMOs (110 of 419 PF-4 FMOs) lack CSEs [9].

In preparation for the review, the staff analyzed updated CSEs associated with twelve FMOs in PF-4. Although these updated CSEs were intended to align with DOE and ANSI/ANS requirements, numerous deficiencies remain. The staff identified several (a) upset conditions that are inadequately analyzed or wholly unanalyzed and (b) assumptions that lack documented technical bases. These deficiencies conflict with DOE Standard 3007, which states, "all credible contingencies shall be identified, analyzed, and documented," and "assumptions about the process and scope limitations that impact the CSE should be stated and justified." Examples of unanalyzed upset conditions identified by the Board's staff include:

- Potential upsets associated with fires and earthquake scenarios are not evaluated in the following CSEs: NCS-CSED-12-001, NCS-CSED-09-042, NCS-CSED-07-034, and NCS-CSED-08-074.

- NCS-CSED-12-001 does not evaluate a situation in which a fissile material container could become fully moderated and reflected due to a leak in collocated cooling water system.

The staff believes it would be prudent to analyze these upsets to determine whether additional controls are warranted. Examples of assumptions that lack documented technical bases include:

- In NCS-CSED-07-034, collocation of more than three containers is assumed to be incredible without justification.

- NCS-CSED-09-002 states that, "moderation is explicitly controlled by exclusion of solution/moderated materials." However, no administrative requirements are identified to limit moderating materials. Polyethylene, an effective moderator, is a packaging material commonly used in this storage location.

Similar deficiencies in updated CSEs were noted by a recent extent-of-condition review conducted by LANS. The LANS review found that, "CSEDs have consistently lacked (1) applicable controls, (2) content accuracy, (3) scenario clarity, and/or (4) upset condition completeness" [10]. In addition, LAFO has provided comments to LANS on 150 CSEs that indicate non-compliance with requirements [9]. LANS reported three Potential Inadequacies in the Safety Analysis to NNSA during the past two years as a result of CSE deficiencies [11-13].

Issue Tracking and Compliance with Requirements—NNSA Headquarters, LAFO, and LANS have acknowledged that the LANL CSP is not compliant with DOE Order 420.1B and applicable ANSI/ANS-8 Standards. Furthermore, LANS relies on several disconnected databases and improvement plans to track its corrective actions, including the Corrective Action Plan, the PIP, the Performance Feedback and Improvement Tracking System, and a database of LAFO comments. However, LANS has not comprehensively identified the gaps between its CSP and the applicable requirements, and has no comprehensive, resource-loaded plan to address these gaps. On June 20, subsequent to the staff's review, LANS committed to provide LAFO with a comprehensive "get-well" plan for the CSP by October 1, 2013 [14].

Staffing—Maintaining a qualified criticality safety staff has challenged LANS for the past eight years. The severe staffing shortage in the criticality safety group raises significant questions regarding the ability of LANS to support safe operations. This staffing shortage also inhibits the ability of LANS to resolve the deficiencies identified in its existing plans and databases (e.g., Corrective Action Plan, PIP, Performance Feedback and Improvement Tracking System, and LAFO CSE comments). Currently, LANS employs 2 full-time and 2 part-time qualified criticality safety analysts, in addition to 3 part-time subcontractors fulfilling some analyst roles and responsibilities. A 2013 CSSG review found that LANS will likely require 3 to 5 years to hire, train, and qualify the targeted number of additional criticality safety analysts [15]. This is especially concerning given that the LANS staffing plan does not account for the resources necessary to address existing deficiencies. LANS has recently made progress to address its staffing shortage. However, the staff believes more aggressive actions and additional resources may be necessary to expedite these efforts (e.g., utilizing available DOE and corporate resources).

Fissile Material Handler Training and Certification—The number of infractions identified in the first 6 months of 2013 nearly matches the yearly totals from 2012 and 2011 (15 in the first half of 2013, 15 in all of 2012, and 16 in all of 2011) [16,17]. Of the 15 criticality safety infractions identified in PF-4 this year, 9 were identified by LANS personnel, 5 were identified by LAFO personnel, and one was identified by the Board's staff during its review. The staff is concerned that the significant proportion of infractions identified by oversight personnel may indicate that facility personnel should be more familiar with and sensitive to criticality safety requirements. The overall increase in infractions this year may indicate a half-life of the fissile material handler training and certification effort which took place after the significant criticality infraction in August 2011. The staff believes that it would be prudent to consider criticality safety refresher training for fissile material handlers.

While performing a walk-down of a glovebox in Room 429 of PF-4, the staff identified a container of fissile material in a portion of the glovebox without an assigned mass limit (i.e., the CSLA did not allow fissile material to be stored in this location). LANS personnel took appropriate actions by evacuating the room and notifying criticality safety staff of the potential criticality safety infraction. The following day, LANS conducted a critique to discuss and resolve the potential infraction. At the conclusion of the critique, senior LANS management appropriately determined the configuration resulted in a criticality safety infraction. Based on this infraction and other recent infractions, LANS paused operations in the room until an extent-

of-condition walk-down could be performed. During the critique, several fissile material handlers and production managers argued against categorizing the event as an infraction due to the current configuration of the glovebox. Specifically, the argument was made that certain requirements did not apply at that time because no liquids were present in the glovebox. The staff believes this argument may further indicate that facility personnel should be more sensitive to criticality safety requirements.

Conclusion. The LANL CSP states that written procedures, formality of operations, and criticality safety controls are essential elements to a properly functioning CSP and that, "the only safe course of action, under circumstances in which any one element is inadequate, is not to perform operations until appropriate corrective actions are implemented" [8]. Before PF-4 personnel resume fissile material operations in the Plutonium Facility, the staff believes that it is essential to demonstrate the adequacy of these elements.

The staff believes the following actions should be considered during resumption of fissile material operations in the Plutonium Facility: (1) incorporate criticality controls and limits into procedures; (2) improve conduct of operations including utilization of procedures; (3) evaluate procedures that contain criticality safety controls for designation as Use Every Time; (4) review and approve postings to ensure they are accurate and of high quality; and (5) enhance criticality safety support for ongoing operations.

The staff recognizes that achieving compliance with applicable requirements will involve significant time and resources. LANS has committed to provide LAFO with a comprehensive "get well" plan for criticality safety by October 1, 2013. The staff believes this plan should identify the resources and schedule required to achieve compliance milestones. Additionally, the staff notes that long-standing issues, such as staffing shortages in the LANS criticality safety group and CSE compliance, indicate flaws in the federal oversight and contractor assurance systems.

Attachment – Additional Staff Observations

Upper Subcritical Limit—The staff notes that LANS analysts use a non-conservative upper subcritical limit (USL) when performing evaluations. The USL is a value of k_{eff} against which the results of a model may be compared to determine whether the modeled condition is subcritical.[3] ANSI/ANS-8.24, *Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations*, Section 7.3 states, "An upper subcritical limit shall be established based on the calculational margin and the margin of subcriticality." The calculational margin includes bias, bias uncertainty, and additional uncertainties associated with extrapolation and interpolation. Bias represents the systematic difference between calculated results and experimental data. Bias is often determined by modeling well-documented benchmark experiments and comparing the modeled result to the experimental result. Effectively, the calculational margin represents how accurately (and with what uncertainty) a computer code can reproduce the properties (i.e., k_{eff}) of a well-known physical system.

In addition to this calculational margin, as ANSI/ANS-8.24, Section 6.4, states, "a margin of subcriticality must be applied that is sufficiently large to ensure that the calculated conditions will actually be subcritical. The selection of a margin of subcriticality should take into account the sensitivity of the system or process to variations in fissile form, geometry, or other physical characteristics." ANSI/ANS-8.24 further states in Section 8.1.5, "The margin of subcriticality and its basis shall be documented."

In all 12 of the CSEs reviewed by the staff, LANS compares its modeled k_{eff} values against an upper subcritical limit of 0.98 to determine whether the evaluated process would remain subcritical during all normal and credible abnormal conditions. Effectively, LANS derives its USL of 0.98 by assigning a value of 0.02 to the sum of the calculational margin and margin of subcriticality. LANS's calculational margins range between 0.0099 and 0.0186 for various subsets of benchmark models [18]. In other words, LANS uses a variable margin of subcriticality between 0.0101 and 0.0014. The smallest value is more than an order of magnitude smaller than the margin of subcriticality used at other DOE sites. For example, Lawrence Livermore National Laboratory and the Y-12 National Security Complex both typically use a margin of subcriticality of 0.02 [19, 20].

Of the 12 CSEs reviewed by the staff, 8 describe credible abnormal conditions where the modeled k_{eff} is greater than 0.96. If LANS were to use a margin of subcriticality of 0.02, many of these conditions would exceed the USL. The staff believes it would be prudent to reevaluate this margin of subcriticality and to determine whether additional controls are necessary.

Control Evaluation Linkage Document—DOE does not require the incorporation of all criticality safety controls into the Documented Safety Analysis (DSA) and associated Technical Safety Requirements (TSRs). Rather, DOE Standard 3007 requires all criticality safety controls be *evaluated* for inclusion in the DSA and TSRs. The standard recommends the development of

[3] Theoretically, $k_{eff} = 1$ represents a critical configuration.

a linking document to summarize the results of this evaluation. The staff notes that LANS does not document its control evaluation process.

Annual Walk-down Form—ANSI/ANS-8.19, Section 7.8, states, "operations shall be reviewed frequently (at least annually) to ascertain that procedures are being followed and that process conditions have not been altered so as to affect the nuclear criticality safety evaluation." The staff notes that the Implementation and Annual Process Review Form currently used in PF-4 lacks detail and may not prompt the appropriate level of scrutiny during the performance of annual walk-downs. The staff believes a more detailed form (e.g., a detailed checklist) could improve the rigor of these walk-downs. LANS has created a corrective action in its Performance Feedback and Improvement Tracking System to address this deficiency by August 2013.

References

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[3] OE-3:2012-07, *Importance of Conduct of Operations and Training for Effective Criticality Safety Programs*, Department of Energy, Office of Health, Safety and Security, December 2012.

[4] *CSSG Review of LANL Criticality Safety at PF-4*, Criticality Safety Support Group, April 13, 2012.

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[9] *List of FMOs: CSED Level & Status, CSLA Status, DOE Comment Level and PIP Designation*, Los Alamos National Laboratory, Safety Basis, Criticality Safety, May 17, 2013.

[10] NCS-MEMO-13-008, *Closure and Extent of Condition Review of Completed Nuclear Criticality Safety Actions*, Los Alamos National Laboratory, Safety Basis, Criticality Safety, April 24, 2013.

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[15] *CSSG Assessment of Scope of Operations and Criticality Safety Staff Capacity and Review of Los Alamos National Laboratory CAP and Metrics for the Nuclear Criticality Safety Program*, Criticality Safety Support Group, May 2013.
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