DEFENSE NUCLEAR FACILITIES SAFETY BOARD

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March 27, 2006

The Honorable Linton Brooks
Administrator
National Nuclear Security Administration
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0701

Dear Ambassador Brooks:

The staff of the Defense Nuclear Facilities Safety Board (Board) conducted a review of the design of the Criticality Experiments Facility (CEF) project. This facility, previously operated at Technical Area 18 at Los Alamos National Laboratory, is to be relocated to the Device Assembly Facility (DAF) at the Nevada Test Site. The staff's review focused on the adequacy of the authorization basis for CEF facility, the criticality safety program, the fire protection program, the confinement features, and the management and oversight roles of the National Nuclear Security Administration.

As the enclosed reports illustrate, issues were identified in each of the above areas. Major issues include inattention to the interface requirements between the existing DAF facility and proposed CEF operations and continued lack of acceptable resolution of safety issues previously identified by the Board. For example, issues such as the need for fire protection, ventilation, and criticality alarms in the bays and cells have been languishing for more than a year. Other issues, such as potential exposure of nearby workers and water in-leakage into DAF, have been poorly assessed for their potential impact on the project design. These and other issues have been brought to the attention of the design team by the Nevada Site Office's Safety Basis Review Team (SBRT) in its Preliminary Safety Evaluation Report. As of the time of the review by the Board's staff, little real progress had been made toward resolving these issues.

Therefore, pursuant to 42 U.S.C § 2286b(d), the Board requests a report within 60 days of receipt of this letter describing the steps being taken to resolve the issues raised by the SBRT, as well as the deficiencies noted in the enclosed reports.

Sincerely,

A. J. Eggenberger
Chairman

c: Ms. Kathleen A. Carlson
Mr. Mark B. Whitaker, Jr.

Enclosures

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

February 22, 2006

MEMORANDUM FOR: J. K. Fortenberry, Technical Director

COPIES: Board Members

FROM: R. Layton
C. March

SUBJECT: Fire Protection at the Criticality Experiments Facility

This report documents a review of the fire protection program at the Criticality Experiments Facility (CEF), conducted at the Nevada Test Site (NTS) on January 9–13, 2006, by the staff of the Defense Nuclear Facilities Safety Board (Board), V. Anderson, F. Bamdad, J. Deplitch, R. Layton, C. March, R. Raabe, C. Shuffler, and R. Zavadoski. This review encompassed the relocation of CEF to the Device Assembly Facility (DAF) at NTS.

Background. The Board's staff met with representatives of the Nevada Site Office (NSO), Bechtel Nevada, Los Alamos National Laboratory, and Lawrence Livermore National Laboratory to review fire protection and walk down facilities at CEF. The CEF project has just completed Critical Decision-2 (CD-2) and is entering final design. The Board's staff reviewed the facility Fire Hazards Analysis and Documented Safety Analysis (DSA) for two bays, two cells, two storage vaults, the loading area, and control room portions of DAF that together make up CEF.

Discussion. CEF will occupy portions of DAF to house criticality experiments. Remaining issues associated with the facility involve fire modeling, combustible loading limits, removal of fire suppression systems, fire system/ventilation system interfaces, and Department of Energy (DOE) oversight.

Software Quality Assurance—The CEF fire analysis does not meet current software quality assurance (SQA) requirements of Title 10 of the Code Federal Regulations, Part 830, *Nuclear Safety Management*. The fire analysis, developed using the Consolidated Fire and Smoke Transport (CFAST) software to support the safety basis for CEF, was taken from the DAF DSA. The DAF analysis did not reflect current requirements because it was performed before those requirements were published. Subsequently, in July 2004, DOE promulgated DOE-EH-4.2.1.4, *CFAST Computer Code Applications Guidance for Documented Safety Analysis*. No effort was made to satisfy these requirements for CEF. Specifically, the critical phenomenon of the fire calculated with the approved version of the code is whether the room will reach "flashover," defined as a critical level of upper gas layer temperature leading to a

rapid increase in both heat release rate and temperature—usually a minimum of 450 to 600° C. The fire analysis identified a number of rooms for which temperatures higher than 450° C could be assumed, yet the conclusion was no potential for flashover with no further analysis. According to DOE-EH-4.2.1.4, however, any temperature over 450° C requires further analysis. Additionally, the analysis includes no discussion regarding the uncertainties associated with these temperatures.

Fire Suppression Systems—It has been proposed that the fire sprinklers presently located in DAF be removed from the bays and cells in which critical and subcritical experiments will be conducted. DOE Order 420.1A, *Facility Safety*, specifically requires some form of automatic fire suppression system. The contractor provided an evaluation justifying removal of the fire sprinklers, *Technical Basis for Disabling Wet-Pipe Sprinklers in Areas of CEF,* in December 2005. The primary reasons given for not using wet-pipe sprinklers in the area of the experiments are that water from the sprinkler system could act as an uncontrolled reflector, resulting in increased reactivity, and that the water could react detrimentally with experiment materials. The evaluation does not justify removing sprinklers from mechanical heating, ventilation, and air conditioning (HVAC) rooms of the cells, the interlocks, staging areas, and the corridors leading to the cells. In these areas, criticality configurations are not expected. Additionally, this evaluation was not part of the CD-2 package approved by DOE.

The contractor's evaluation lacks sufficient detail to permit the conclusion that a fire in these areas with no suppression system would not result in untenable life safety conditions for workers and firefighters, extensive damage to adjacent criticality experiment equipment and materials, or the release of hazardous materials. The Fire Hazards Analysis describes the criticality experiment equipment and materials as "one-of-a-kind" items that cannot be replaced. The potential for an unsuppressed fire to damage this equipment and result in the release of hazardous materials needs to be addressed. The evaluation also does not address conversion of the wet-pipe sprinklers to a pre-action system (normally dry pipe). This dry pipe could preclude water delivery to the bays or cells during periods when the criticality materials are in a near-critical configuration.

The evaluation concludes that an alternative suppression agent (INERGEN) could be used, but assumes that its installation would be based on a cost-benefit analysis left to the project. Basing this decision on a cost-benefit evaluation is contrary to DOE Order 420.1A. Moreover, no exemption or equivalency has been proposed.

Ventilation Interface—The DAF DSA describes the interface between the fire suppression and ventilation systems. The ventilation exhaust filtration is credited as risk mitigation for exposure to the general public. However, fire dampers installed in the bays and cells could close off the ductwork during a fire, precluding proper operation of the exhaust system. The operation sequence of the fire dampers/suppression system and the HVAC system needs to have clear design criteria, along with system description(s) describing how those criteria have been met. Additionally, further guidance in DOE Technical Standard 1066, *Fire Protection Design Criteria*, regarding fire protection for filtration units has not been addressed.

Fire Analysis—The CEF Preliminary Documented Safety Analysis (PDSA) does not include sufficient detail on the nature of fire in the bays or cells for CEF. Section 3.4.2.4 briefly describes compartment fires, identifying a 130-megawatt fire analyzed in the DAF DSA as the bounding case for CEF. The extent to which this description represents fires in CEF is unclear. For a fire in the bays and cells, for example, it is unclear to what extent the criticality experiment equipment contributes to the fire. The event tree in Figure 3-4 of the DAF DSA, used to calculate outcome probabilities, identifies the use of automatic suppression systems or personnel extinguishing the fire as mitigating events, conditions that would not be present in CEF without sprinklers. If sprinklers were removed, there would be limited detection and alarm capabilities for notifying personnel of a fire because the water flow signal is the primary initiator of a fire alarm. There is also no description of the susceptibility of the criticality experiment equipment to fire damage in the CEF PDSA.

The basis for most of the fire analysis for CEF assumes ventilation-constrained, oxygen-limited fires. The size of the fire is reduced not because of the lack of fuel, but a lack of oxygen in the compartment. It is true that fires in a single tight compartment can be oxygen-limited, but as the fuel is pyrolized, entrained into the fire plume, and raised to its ignition temperature, it lacks only oxygen to burn. Once any amount of this pyrolized fuel reaches oxygen, it will ignite. This could occur when the fire department opens the door (backdraft), or the fuel could leak out of the room and ignite in adjacent fire areas (corridors) or penetrate the high-efficiency particulate air filtration system, which also is unprotected. Using an oxygen-limited fire is an acceptable modeling technique, but the analysis fails to consider or even address the subsequent potential for the spread of fire. The CEF PDSA lacks sufficient detail to enable a full understanding of the various fire scenarios. It is not enough simply to refer to the DAF DSA.

Combustible Loading—Combustible loading assessments performed by the fire protection system engineer indicate the need for a 6-foot standoff of combustibles from the criticality experiment equipment. The contractor could not describe the basis for that distance. No technical basis for the combustible loading limits or standoff distance has been provided.

DOE Oversight—The Board's staff is concerned that numerous technical issues affecting the identification of safety systems and controls remain unresolved. The staff does not understand how DOE could approve CD-2 without addressing the issues associated with removal of the fire suppression systems.

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

February 22, 2006

MEMORANDUM FOR: J. K. Fortenberry, Technical Director

COPIES: Board Members

FROM: V. Anderson
R. Raabe

SUBJECT: Safety Basis for the Criticality Experiments Facility at the Device Assembly Facility on the Nevada Test Site

This report documents a review of the safety basis for the Criticality Experiments Facility (CEF) at the Device Assembly Facility (DAF) on the Nevada Test Site (NTS). This review was conducted by members of the staff of the Defense Nuclear Facilities Safety Board (Board) V. Anderson, F. Bamdad, J. Deplitch, R. Layton, C. March, R. Raabe, C. Shuffler, and R. Zavadoski. A meeting was held at the site on January 10–12, 2006, to discuss the observations summarized in this report.

Background. The Department of Energy (DOE) is in the process of relocating devices and materials associated with the criticality experiments currently located at Technical Area 18 at Los Alamos National Laboratory (LANL) to NTS. A significant portion of DAF will be dedicated to conducting the experiments and storing special nuclear materials (SNM). DAF was originally designed for nuclear explosive operations and as such is capable of limiting the consequences of an accidental high explosive detonation. Two round rooms at DAF will house four criticality experiment machines; two high bays will be used for training, exercises, and general-purpose programmatic criticality research activities. Additionally, two high explosive/SNM staging bunkers will be converted to SNM storage vaults.

A Preliminary Documented Safety Analysis (PDSA) was prepared and submitted to the National Nuclear Security Administration (NNSA) as part of the Critical Decision 2 (CD-2) milestone. This PDSA was prepared by Lawrence Livermore National Laboratory (LLNL), which operates DAF, and by LANL, which will conduct the experiments in CEF. The CD-2 package was approved by NNSA on December 5, 2005. CD-2 approval by NNSA signifies acceptance of the preliminary design for CEF and the adequacy of its safety strategy, and confirms its associated baseline cost. However, NNSA's Nevada Site Office (NSO) reviewed and commented on the PDSA with the expectation that its comments would be resolved prior to the granting of CD-3 approval (start of construction). Several design weaknesses were identified by NSO, but it appears that their resolution was not deemed to impact the cost of the project. The Board's staff reviewed the PDSA and some of the CD-2 package documents, and discussed its findings with NSO and its contractor representatives.

Discussion. CEF is a major design modification project being performed at an existing facility, i.e., DAF. Its safety basis employs the same methodology that was used for DAF instead of the latest DOE requirements. For example, the PDSA was prepared using an outdated revision (Change Notice 1) of DOE Standard 3009-94, *Preparation Guide for U.S. DOE Nonreactor Nuclear Facility Documented Safety Analysis*, that was in effect when the DAF DSA was prepared, instead of the latest revision (Change Notice 2). Although this was deemed by the project to be inconsequential, the design ramifications may be considerable. Change Notice 2 was issued in April 2002 and expanded the considerations for worker safety by including the latent effects of significant radiological exposures to workers as the basis for identification of safety-significant structures, systems, and components (SSCs) in addition to the acute worker fatality and serious injury included in Change Notice 1. Consequently, the adequacy of the set of safety features identified in the PDSA for CEF relevant to protecting workers is questionable.

Furthermore, the Design Criteria document for CEF, submitted to NNSA as part of the CD-2 package, identifies DOE Order 420.1A, *Facility Safety*, as one of the applicable orders and standards for which compliance is required. Several requirements in this order are not captured in the design of CEF and may have a significant impact on the final design of this facility. For example, compliance with the requirements regarding multiple layers of protection and confinement of uncontained radioactive materials is not demonstrated in the design of CEF. The main reason for this lack of compliance is that the activities in CEF are to be performed within an existing facility, and the project has not investigated how a facility designed for nuclear explosive operations could meet the requirements of DOE Order 420.1A related to criticality experiments.

Additionally, the Design Criteria document states that fire protection design shall conform to the requirements of DOE Order 420.1A, including installation of fire sprinkler systems that shall be automatically actuated. The Design Criteria document also states that the existing wet-pipe sprinkler system in the round rooms and the high bays shall be disconnected and decommissioned because of criticality concerns. The document fails, however, to require other alternatives for suppressing a fire in these areas that can be accommodated for compliance with the order—for example, use of pre-action sprinklers or alternative suppression agents. It should be noted that the current DSA for DAF identifies the fire suppression system as safety-class for protection of the public. Although the project appears to have been studying the alternatives (after submitting the CD-2 package and the PDSA), the associated cost and safety impacts (especially on worker safety) of the alternatives are not captured as part of NNSA's approval.

Hazards Analysis—The PDSA and its supporting documents for CEF have not adequately analyzed the hazards associated with the operation of CEF. Instead, the PDSA relies mainly on the hazards analysis for DAF and does not address the impact of those hazards on the criticality experiments. For example, the DAF DSA identifies the facility structure as designed to Performance Category 3 seismic events, which may be adequate for DAF's current operations but not necessarily for the criticality experiments. The PDSA also relies on the seismic design of the facility to protect the CEF operations. This assumption may not be valid, however, given

that the critical experiments are not seismically restrained to the facility and that an earthquake could easily topple some of the machines and cause an unidentified hazard (e.g., criticality).

Similarly, DAF is designed to relieve the consequences of a high explosive detonation in one of the round rooms and protect the rest of the facility from the resulting overpressurization effects. The severe ground acceleration generated by such an explosion, however, would be an external hazard for the CEF operations and could have a significant impact on the safety of those operations. The PDSA does not identify or evaluate such a hazard.

Development and Implementation of Controls—A significant worker safety issue associated with CEF operations is radiation exposure due to inadvertent criticality, yet LANL and LLNL have not resolved their disagreement on what portions of CEF will require a criticality alarm system. LANL has stated that a criticality alarm system may not be appropriate for the round rooms where criticality machines are located. However, it is not clear that the same argument could be made about the rest of the facility, especially the bays. DOE's Criticality Safety Support Group was asked to evaluate the positions of LANL and LLNL on the inclusion of criticality alarm systems in light of relevant standards. The group concluded that some type of criticality alarm system is advisable in the general-purpose bays and assembly bay. Neither the PDSA nor the CD-2 package includes any contingencies for installation of a criticality alarm system.

Another control related to worker safety is the ventilation system that is in place but not appropriately classified. Each building (e.g., round rooms or bays) in DAF has an independent high-efficiency particulate air (HEPA)-filtered ventilation system, with the exception of the storage vaults, which share a common exhaust. The majority of these systems are designated as safety-significant in the DAF DSA to provide confinement of radioactive material in the event of spills, small fires, and seismic events. However, the PDSA for CEF does not identify ventilation as remaining a safety-significant control. Several accident scenarios in the PDSA result in sizable unmitigated doses at the site boundary, which is 6.6 miles from the facility (0.59 rem from fire, 1.6 rem from inadvertent criticality, and 3.2 rem from reactivity insertion). Consistent with the requirements of DOE Standard 3009, it is expected that the dose to collocated workers would be high enough to warrant safety-significant controls, such as the ventilation systems.

In addition to problems associated with controls that could reduce worker exposure in accident situations, controls for the prevention of criticality may be inappropriately credited in some cases. In the PDSA, several potential criticality accidents are reduced in frequency from likely (annual occurrence between 10^{-1} and 10^{-2}) to beyond extremely unlikely (annual occurrence less than 10^{-6}) exclusively through the use of administrative controls. While exclusive use of administrative controls for accident prevention is not preferred practice, the situation for CEF is especially problematic because the controls credited for reducing accident frequency are not sufficiently independent.

Authorization of Operations—As stated earlier, the PDSA is based on the same methodology used to prepare the DAF safety basis, that is, using Change Notice 1 to DOE Standard 3009. The DSA for DAF, however, will incorporate the requirements of Change Notice 2 in its next annual update. On the other hand, the CEF project is planning to incorporate the completed PDSA as an addendum to the DAF safety basis to allow for a single safety basis document governing all operations within DAF. The result will be a significant discrepancy within this single safety basis for the facility unless the PDSA is revised to be consistent with the requirements of Change Notice 2. Currently there appears to be no plan in place to accomplish this integration, even though it may affect the cost and the safety posture of CEF activities as discussed above.

Authorization of operations may also prove difficult with respect to criticality safety requirements, as expectations for criticality safety documentation differ between the procedures used by LANL to conduct the critical experiments and those used by LLNL to govern DAF activities. LLNL's procedures (adopted at DAF) dictate full compliance with the criticality requirements of DOE Order 420.1A, including a documented double contingency analysis, while LANL's procedures do not require such documentation. NNSA has approved LANL's approach by granting an exemption from that portion of the Order 420.1A requirements in the laboratory's most recent contract. On the other hand, LLNL's procedure has been adopted by DAF as necessary for safely conducting activities within the facility. Since the LLNL approach is more conservative, it would be prudent from both safety and interface standpoints for LANL to adopt it for CEF operations.

Nuclear Criticality Safety Program—The Board has expressed concern in the past regarding the potential loss of criticality experiment capability at DOE while these machines are being moved from LANL to DAF. NNSA's Technical Area 18 Closure Plan of October 2004 states that the loss of this capability will be limited and will not exceed 1 year, that is, from the third quarter of fiscal year (FY) 2005 to the third quarter of FY 2006. During the course of this review of CEF activities by the Board's staff, it became apparent that the early start of COMET operations, which is essential to maintaining the Closure Plan schedule, is no longer considered feasible by LANL. In essence, the proposed new schedule would delay COMET operations at CEF until after FY 2009, 3 years later than NNSA's original commitment. NNSA may have other plans for maintaining its critical experiment capability during this period; however, any such plans were not shared with the Board's staff during the meetings held for this review.