[DNFSB LETTERHEAD]

September 4, 1996

The Honorable Victor H. Reis
Assistant Secretary for Defense Programs
Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0104

Dear Dr. Reis:

The Defense Nuclear Facilities Safety Board (Board) is interested in the safe, long-term storage capability for plutonium within the Department of Energy's nuclear weapons complex, particularly the next generation of plutonium storage vaults. These include the vaults proposed for the Los Alamos National Laboratory (LANL), the Rocky Flats Environmental Technology Site, and the Savannah River Site.

Members of the Board staff recently reviewed the conceptual design for the upgrade of the Nuclear Materials Storage Facility (NMSF) at LANL. Their concerns and observations are reflected in the enclosed trip report. The Board understands that the facility, as currently constructed, is not acceptable for handling and storing plutonium and, as a result, is undergoing extensive renovation to support mission needs for LANL. The Board also understands that LANL is dedicating substantial and effective internal resources to support this design upgrade.

Most significantly, the Board notes several issues with the portions of the structure to be preserved from the original construction; these issues include potentially out-of-specification reinforcing steel placement in the concrete walls. Cognizant personnel at LANL are actively pursuing these issues and are developing a plan to resolve them. The Board suggests that in the interest of maintaining safety under passive cooling, as is now contemplated, it would be prudent to review current decisions limiting the need for and extent of real-time monitoring of critical plant parameters.

The Board staff will continue to closely follow the renovation of the NMSF.

Sincerely,

John T. Conway
Chairman

c:
Mr. Mark B. Whitaker, Jr.
Mr. Bruce G. Twining

Enclosure

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

August 13, 1996

MEMORANDUM FOR:	G. W. Cunningham, Technical Director
COPIES:	Board Members
FROM:	J. Sanders
SUBJECT:	Review of the Renovations for the Nuclear Materials Storage Facility (NMSF), Los Alamos National Laboratory (LANL)

1. **Purpose:** This report documents the Defense Nuclear Facilities Safety Board (Board) staff review of the renovations for the Nuclear Materials Storage Facility (NMSF) at Los Alamos National Laboratory (LANL) conducted on July 30 - August 1, 1996, by Joseph Sanders, Joel Blackman, Albert G. Jordan, and Lani Miyoshi.

2. **Summary:** The NMSF, as it is currently constructed, is not acceptable for handling and storing special nuclear material (SNM) for reasons recognized by LANL and detailed in Appendix A. As a result, NMSF is undergoing a substantial upgrade that will involve almost entire reconstruction. LANL is dedicating substantial and effective internal resources to support this design upgrade. In addition, LANL has developed a Preliminary Hazards Assessment (PHA) to identify and eliminate or mitigate hazards as early as possible in the design.

   LANL had the concrete strength and reinforcing steel placement surveyed to verify the construction quality of the original facility without complete construction records. Results indicate that the concrete strength meets construction specifications in the areas surveyed. However, the thickness of concrete cover above the reinforcing steel was found to exceed code requirements in several locations, resulting in a possible reduction in the moment resisting capacity (out-of-plane resistance) of the concrete section. LANL representatives are aware of these issues and are developing a plan for resolution.

   Thermal analyses for the proposed vault passive cooling system indicate that the design margin in meeting temperature limits is not large. As a result, the final design of the holding fixture for the SNM container will need to be sufficiently robust to satisfy maximum SNM temperature limits. Relatedly, consideration should be given to monitoring air and drywell temperatures and vault air effluents.

3. **Background:** The preliminary design of the existing NMSF commenced in 1984, and construction was completed in 1987 under supervision of the U.S. Army Corps of Engineers. However, NMSF has never operated as a nuclear facility because of major design and construction deficiencies detailed in Appendix A.

   Based on current projections, existing storage space for SNM (primarily plutonium) at LANL will be loaded to capacity in 2002, which could adversely impact LANL's ability to meet its mission requirements. As a result, the decision was made to renovate the NMSF. The conceptual design for the upgrade was completed in late 1995 by ICF Kaiser Engineers, Inc. (Kaiser), and a draft version of the Functional and Operational Requirements was completed in early 1996. Representatives of LANL intend to select an architect/engineer by September 30, 1996, as a subcontractor to perform activities including the Title 1 (Preliminary) and Title 2 (Final) Design, and LANL has requested funding for FY97 to complete Preliminary Design. Facility readiness for operations is scheduled for late 2002.

This facility will be designed to store up to 6,600 kg of plutonium metal or oxide, or provide for the dissipation of 20 kilowatts from heat generation (whichever is more limiting). It will likely be classified as a Hazard Category 2 facility consistent with the applicable Department of Energy (DOE) Standard. The total cost of the upgrade project is estimated to be $56.6 Million. A more detailed description of the proposed renovation is provided in Appendix B.

4. **Discussion:**

   a. ***Hazards Identification and Risk Reduction***: NMSF's primary hazards stem from handling and storing SNM, particularly plutonium. In conjunction with the preparation of the Conceptual Design Report for NMSF, LANL prepared a draft PHA. The risks to the public, the workers, and the environment were addressed in a manner appropriate to the current stage in design.

      1. ***Criticality***: A criticality event would present a serious hazard to the facility worker. Conservative analyses indicate that a criticality could occur if five canisters are placed in an optimal configuration. Therefore, extra precautions will need to be taken during canister handling, placement in the basket assembly, and insertion into the storage drywells. The baskets holding the canisters in the drywells and the drywells themselves will need to resist the Design Basis Earthquake (DBE) in order to prevent critical configurations from developing.

      2. ***Plutonium Release and Dispersal***: Stabilized plutonium metal and oxide (packaged in accordance with the current DOE Standard) and pits (packaged in AT400A containers) will be accepted for storage in the vault. This packaging will provide primary and secondary confinement barriers. The drywell walls will provide the tertiary confinement barrier for release to the cooling air, while the structure and HEPA filtration system provide tertiary confinement during handling activities. The vault structure, storage drywells, and canister holding fixtures will be designed to sustain a DBE. Furthermore, the thermal design of the vault system should prevent the a-phase plutonium metal from heating to the a-d phase transition temperature of 225·F, causing expansion and possibly resulting in failure of the inner canister or pit cladding.

      3. ***Routine Radiation Hazards***: Radiation exposure hazards from material stored in the vault will also be limited by design. A thick, concrete charge deck with shield plugs capping the storage drywells and borated concrete-

thickened vault sidewalls will ensure annual worker doses do not exceed 500 mrem. Extensive shielding analyses have been performed to support the conceptual design, and the conservative results indicate that the radiation dose to a person over the charge deck with a shield plug removed will be less than 0.25 mrem/hr if standing at least 1.5 meters away from the hole.

b. ***Facility Structural Adequacy***: A review of the construction records for the NMSF by LANL personnel revealed that quality control documents for concrete strength and reinforcing steel placement could not be located. Since the structure will perform a safety class function, a condition survey was undertaken to establish in situ concrete strength and confirm that the reinforcing steel was properly installed. The survey of the building was conducted by Concrete Technology Laboratories (CTL) and the results assessed by ICF Kaiser. Based on testing of concrete cores, it was determined that the in situ concrete strength exceeds required design strength (average concrete strength is 7662 psi versus required design strength of 4000 psi). Therefore, the concrete strength appears to be adequate.

   The placement of reinforcing steel was measured by magnetic sensing and impulse radar testing which revealed that the center-to-center spacing of the reinforcing steel generally conformed to the design drawings. While not specifically stated in the report, the Board staff understands that the cross-sectional dimensions were determined to be within design tolerances. However, the depth of concrete cover above the reinforcing steel significantly exceeded specified allowable tolerances. The effect of the increased cover is to reduce the moment resisting capacity of the concrete section. In-plane shear capacity is not affected by this problem. ICF Kaiser used an average value of 2.6 inches versus 0.75 inches required cover to assess the significance of the deficiency in the exterior walls and concluded that the deficiency was not detrimental to the overall integrity of the structure. However, a review of the test report by the Board staff revealed that the variation of cover ranged from 0.5 to 5 inches, and that an average cover significantly exceeding 2.6 inches extended over entire wall panels. The Board staff believes that the use of an overall building average to evaluate concrete section capacity reduction is not appropriate for a safety class structure and that reductions in capacity should be based on actual panel reductions.

   In addition, the actual cover of the reinforcement closest to the exterior surface of the wall was not measured in the original CTL study. Due to moment reversal during a seismic event as well as changes in curvature, the Board staff believes that the location and amount of cover for the exterior reinforcement should also be determined by field measurement.

   Due to the potential significance of the problems discussed above, the DNFSB staff believes that a very thorough condition survey and structural adequacy assessment of the structure should be performed to validate its adequacy as a safety class structure.

During a tour of the NMSF, the Board staff was shown a tunnel that is intended to facilitate transfer of SNM between PF-4 and NMSF. This tunnel, which is a safety class structure, had not been examined as part of CTL's testing program. The concrete in an approximately 30-foot section of the tunnel appeared to be degraded. Numerous hairline cracks in this section, discoloration of the concrete finish, and efflorescence (indicative of water seepage through the concrete) were present and are indications of poor concrete quality. Based on this observation as well as the reinforcing steel placement issue previously discussed, the DNFSB staff believes that a thorough assessment of the structural integrity of the tunnel is warranted.

c. ***Effluent Monitoring***: DOE Order 6430.1A, *General Design Criteria*, specifies that "all exhaust outlets that may contain plutonium contaminants shall be provided with two monitoring systems. These monitoring systems shall [ensure that] all exhaust ducts or stacks that may contain radioactive airborne effluents shall be provided with effluent monitoring systems." However, monitoring of the air stream exiting the vault to the environment is not currently planned because it would be expensive to maintain and releases are not expected during the facility operating lifetime. If this monitoring is ultimately determined to be unnecessary, alternative means for rapidly identifying any releases of plutonium to the cooling air should be identified, or persuasive reasoning for why it is unnecessary would appear prudent. Furthermore, the staff believes it would also be prudent to evaluate the need for and practicality of monitoring for plutonium within individual drywells to prevent a worker exposure event during removal of a shield plug.

d. ***Thermal Design and Monitoring***: The thermal limits used in the conceptual design are 176·F and 149·F, respectively, for plutonium metal and pits under normal conditions, and 212·F under loss-of-cooling conditions. Thermal analyses have been performed to support the conceptual design of the drywell and holding fixture for the individual containers within the drywell, termed "baskets." The analyses are decoupled into two calculations. The first calculates the maximum temperature of the air cooling the external drywell surface. This is derived from the ambient air temperature and the overall heat output in the vault. From this maximum air temperature, the second calculation evaluates the maximum temperature of the material. The results of these evaluations indicate that thermal limits can be satisfied under normal and accident conditions. However, the degree of margin available is significantly less than the Fort St. Vrain Facility, a model for the NMSF design. Furthermore, the final design of the baskets will need to be robust from a thermal perspective. Given the limited margin available and uncertainties associated with passive cooling systems, it may be valuable to consider monitoring for the outlet air and drywell temperatures to ensure system thermal performance is adequate.

The DOE Standard for plutonium storage permits a maximum thermal output of 30 watts per container. However, the current vault design allows a maximum thermal output of only 15 watts per container, creating an inconsistency. The lower limit for the vault should not impact containers storing weapons-grade plutonium with relatively modest heat generation of approximately 2.2 watts per kilogram, but it may preclude storage of higher burnup plutonium from other sources.

5. **Future Staff Actions:** The Board staff plan to continue reviewing the renovation of the NMSF throughout its design and construction. The staff intends to follow up on those issues identified in the report and perform the next review following completion of the Preliminary Design.

Appendix A

Major Design and Construction Deficiencies in the Existing Nuclear Materials Storage Facility

- **Radiological control boundaries:** potentially contaminated air plenums in uncontrolled areas; radiation workers would have to traverse uncontrolled areas en route to the change rooms; the elevator to be used to transport special nuclear material (SNM) from the receipt area to the vault area crosses uncontrolled areas.
- **Operational security boundaries:** the garage, designed to accommodate two safe secure trailers (SST), is too narrow and would not allow the doors of the SSTs to be opened and secured; the secure elevator crosses administrative areas.
- **Cooling of the storage vault:** the vault design would not ensure adequate cooling of the SNM.
- **Fire/explosion hazards:** two natural gas boilers are currently located in the Nuclear Materials Storage Facility. This is prohibited by DOE Order 6430.1A, *General Design Criteria*, because it creates an internal explosion hazard.
- **Faulty decontamination design:** the "Placite" coating applied to the concrete walls for ease of decontamination, is peeling extensively.
- **Vault storage cabinets and retrieval system:** vault cabinets were not properly sized to house packages containing SNM. The retrieval system would not preclude significant radiation exposure, and is therefore inconsistent with the ALARA principle.

Appendix B

Proposed Renovation to the Nuclear Materials Storage Facility

The renovation to the Nuclear Materials Storage Facility (NMSF) will essentially remove and replace all building systems, components, and structures. The outer structural walls and certain internal structural walls will be saved. The project will include construction of a passive, air-cooled storage vault for special nuclear material (SNM), somewhat similar in design to the passively cooled spent fuel storage vault at the Fort St. Vrain Facility in Platteville, Colorado. This system will be designed to provide adequate cooling for the high density array of vertical drywells to meet material thermal limits with an overall material heat output of 20 kilowatts. The vault is expected to be approximately 35 feet high, 30 feet wide, and 130 feet long and comprised of three subsections, each capable of holding approximately 170 material drywells. The drywells will be suspended from the horizontal charge deck separating the passive cooling area from the material loading area. Each drywell is currently designed to hold 14 SNM containers.

Like Fort St. Vrain, the cooling system is a passive, self-regulating, natural convection cooling system. Ambient air enters the vault and is convectively heated as it flows past the surface of the storage drywells. Decay heat is transferred from the various SNM isotopes through the storage canisters and drywells to the air in the vault and buoyancy-driven flow is induced. The heated air rises up the vertical outlet duct because of its lower density relative to ambient air. This provides the buoyancy head to sustain continuous air flow over the drywell surfaces.

All material to be stored, other than pits, will be stabilized as metal or oxide before placement into the vault. Metal and oxide will be sealed in metal containers consistent with DOE Standard 3013-94 (or later revisions), *Criteria for Long-Term Storage of Plutonium Metal and Oxides*, and pits will be stored in AT400A containers. Three barriers will exist to prevent the release of plutonium from the system; two qualified containers will serve as the primary and secondary containment for repackaged metals and oxides. In the case of pits, the cladding, having been leak-tested prior to insertion in the AT400A, will provide the primary confinement, while the AT400A containment vessel will provide secondary confinement. The storage drywell will provide the tertiary barrier.

NMSF upgrades will also incorporate a secure, temporary SNM staging area, SNM unpacking area, nondestructive assay laboratory, and an intermediate storage area. NMSF will maintain a tunnel connection with PF-4; this will serve as a secure transport medium between the facilities. As a result, the Materials Access Area will be continuous through PF-4 and NMSF (PF-41).