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DEFENSE NUCLEAR FACILITIES SAFETY BOARD

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March 7, 2002

The Honorable Everet H. Beckner
Deputy Administrator for Defense Programs
Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0104

Dear Dr. Beckner:

Sandia National Laboratories (SNL) has a construction project under way to build an underground facility for its pulse reactors. This facility, the Sandia Underground Reactor Facility (SURF), is to be the home for all activities currently being conducted at SNL's pulse reactors for the next several decades. The Preliminary Design Document and the Preliminary Safety Analysis Report (PSAR) for this facility have been submitted to the Department of Energy's Kirtland Area Office (DOE-KAO) for review and approval.

The Defense Nuclear Facilities Safety Board (Board) has been reviewing the safety-related aspects of the preliminary design of this project. Enclosed are observations made by the Board's staff, which were based on discussions with representatives of SNL and DOE-KAO and the review of associated documents. Of particular concern to the Board is the minimal confinement capability in the proposed design for SURF.

DOE Order 420.1, *Facility Safety*, requires that the design of new Hazard Category 2 and 3 nuclear facilities be based on confining the hazardous materials during normal operation and potential accidents. The Board suggests that the confinement systems should be classified according to the facility's level of hazard, as safety-class or safety-significant. Safety features are then designed to meet the functional safety and operational requirements determined in the PSAR. Appropriate quality assurance requirements for design and procurement activities can then be developed up front to assure overall reliability of such systems necessary to provide adequate safety. A confinement boundary is not defined in the PSAR for SURF because of its low site-boundary dose estimates. However, the PSAR does not address hazards to on-site workers who may be in the buildings adjacent to SURF. This consideration may lead to the need to protect these individuals and an appropriately defined and classified confinement boundary.

Therefore, the Board requests that you examine the issues outlined in the enclosed report and, pursuant to 42 U.S.C. § 2286b(d), provide a report within 60 days of receipt of this letter that (1) defines the confinement system and its boundaries for this new facility, (2) classifies the confinement system based on its potential hazards to the public and workers, and (3) identifies the design and procurement requirements for the confinement system consistent with the level of hazard. In addition, the report should address the safety and design issues identified in the enclosed report and the path to their disposition by the project.

Sincerely,

John T. Conway
Chairman

c: Mr. William John Arthur, III
Mr. Mark B. Whitaker, Jr.

Enclosure

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

January 8, 2002

MEMORANDUM FOR: J. K. Fortenberry, Technical Director

COPIES: Board Members

FROM: A. Matteucci

SUBJECT: Review of Preliminary Design of Sandia Underground Reactor Facility

This report documents a review of the preliminary design for the Department of Energy (DOE) Sandia Underground Reactor Facility (SURF) which includes the Preliminary Safety Analysis Report (PSAR) and associated SURF Title I documentation. This review was conducted by members of the staff of the Defense Nuclear Facilities Safety Board (Board) J. Blackman, F. Bamdad, and A. Matteucci.

Sandia National Laboratories officially submitted the PSAR for SURF to the Kirtland Area Office (KAO) of the National Nuclear Security Administration (NNSA) on November 17, 2001. NNSA's approval of the PSAR is scheduled for March 2002. The SURF Preliminary Design (Title I) Documentation package has also been submitted to NNSA and approval of the performance baseline (Critical Decision 2) is anticipated shortly. Detailed design (Title II) will begin once NNSA has approved the performance baseline.

Background. SURF is being developed to provide a safe work environment for activities involving Category I/II special nuclear material. The security operating cost associated with protecting these materials underground are substantially lower than that required to provide the same protection for the current Sandia Pulse Reactor facilities. The PSAR, a part of the SURF Preliminary Design Documentation Package, was written to comply with 10 Code of Federal Regulations (CFR) 830 Subpart B and relies heavily on experience and documentation from Sandia Pulse Reactors II and III. In particular, source documentation for the SURF PSAR included the Safety Analysis Report (SAR) from Sandia Pulse Reactor II, approved in 1981; the SAR for the Sandia Pulse Reactor facilities (using information for Sandia Pulse Reactor III), approved in 1995; and the SAR for the Annular Core Research Reactor, approved in 1999. This review by the Board's staff focused on assessing the preliminary design, hazard analysis, and identified controls currently available for SURF.

SURF consists of an above-ground Upper Transfer Facility (UTF) and a below-ground Lower Transfer Facility (LTF). The UTF contains in a single one-story steel-framed structure, an entry control facility; an instrument room; and rooms containing mechanical, electrical, and elevator equipment. The LTF contains a reactor room, staging area, storage vaults, personnel and freight access corridors, an emergency refuge area, close-in data acquisition room, and mechanical/electrical room that are contained in a reinforced concrete structure.

SURF Preliminary Design. Preliminary design concepts for SURF considered hazards regarding exposure of workers and the public to radiological and industrial hazards. The primary hazards considered in the preliminary design are the exposure of workers to direct ionizing radiation from the reactor and exposure to hazardous materials associated with the facility and experiments conducted therein. Other hazards considered in the SURF preliminary design concepts are asphyxiation of workers due to the use of nitrogen gas in the below-ground-level reactor room, the impact of using a water fire suppression system in the reactor room on the reactivity of the reactor, and the egress of workers through the single-point access to the lower transfer level during emergency conditions.

Fire Protection—The preliminary design for SURF indicates that a limited-volume reaction sprinkler system will be provided in all areas of the underground facility except the reactor room. All areas will be provided with fire detection. Sprinklers are required throughout the facility by National Fire Protection Association (NFPA) 101, *Life Safety Code*. An exemption has been prepared to document this deviation from NFPA requirements. Because of difficulty in exiting this secure facility, an "area of refuge" has been provided to shelter personnel from fire effects in accordance with NFPA 101. An area of refuge has specific requirements in NFPA 101 for ventilation systems, communications, and egress paths that are met by the preliminary facility design.

The facility is expected to handle small quantities of high explosives in the test program. Explosive detonation is an analyzed accident. However, the facility design does not include consideration of the DOE M440.1-1, *DOE Explosives Safety Manual* . The presence of explosives could result in a high-hazard occupancy designation under NFPA 101, which could lead to changes in exit requirements for life safety.

Safety Basis—The PSAR for SURF was prepared using primarily information available from the existing SAR for the Sandia Pulse Reactor facilities that was submitted to and approved by DOE in 1995. The PSAR was recently sent to DOE for review and approval, and was the basis for the staff's discussions with SURF project personnel. The information provided in the PSAR does not appear to be complete or fully consistent with the project design documents. For example, the PSAR states that a stack monitoring capability will be provided for monitoring of routine and accidental releases; however, the project design does not include such monitoring capability. Additionally, the PSAR does not thoroughly discuss the consequences of potential accidents for collocated workers to support the identification of safety controls. Although the PSAR had not been reviewed by DOE at the time of the staff's visit, it is expected that the contents of the safety basis documents will more accurately represent the actual design of the facility when it is submitted to DOE. Such inconsistencies, if not corrected, could cause deficiencies in the safety basis and potentially affect safe operation of the facility.

- The PSAR estimates the unmitigated consequences of the worst operational events to be about 6 rem total effective dose equivalent to the maximally exposed individual at the site boundary, approximately 3000 meters from the facility. Based on this estimate, no safety-class structures, systems, and components (SSCs) have been identified for this facility. The event is a reactivity increase due to unexpected

movement of the experimental set up. Such movement while the reactor is at power could result in an excessive fission rate, thus destroying the core. The consequences of such an event for collocated workers is not estimated in the PSAR, but could be significant because of the proximity of the engineering support building to the facility and other adjacent buildings. This issue needs to be addressed to ensure that safety-significant preventive and/or mitigative systems will be in place to properly protect workers.

- The SURF ventilation system is designed to provide ventilation of occupied spaces through a cascading differential pressure gradient from the environment to the reactor room (with the reactor room being negative with respect to the environment). The ventilation flow rate is intended to dilute and remove reactor-cooling nitrogen gas, as well as to remove any radioactive gas and airborne contaminants from the reactor room within a reasonable time to allow normal operation and habitability. Nitrogen gas, if released accidently, could cause asphyxiation of workers. This asphyxiation hazard is described in the PSAR as a "not normal industrial" hazard. Although the ventilation system includes two stages of high-efficiency particulate air (HEPA) filters, it is not designed as a safety system because of the relatively low off-site consequences. The Board's staff believes workers may be at risk from hazardous gas and airborne contaminants from the reactor room during accident conditions, and that this risk may warrant consideration of upgrading portions of the ventilation system to provide safety-significant confinement.

- DOE Order 420.1, *Facility Safety*, requires all new Hazard Category 2 and 3 nuclear facilities to provide confinement systems. The purpose of the confinement is to minimize the release and spread of radioactive materials in the facility during normal operations and potential accidents. In a letter to DOE dated July 8, 1999, the Board supported the need for confinement systems and stated that such systems should be classified as safety-class or safety-significant SSCs, if appropriate, commensurate with the hazards mitigated. The Board's staff believes that this requirement should be addressed in the design of the new facility.

Structural Considerations—The Conceptual Design Report (CDR) outlines basic structural design considerations for the facility. SURF is currently classified as a Performance Category 2 (PC-2) structure based on the requirements of DOE-STD-1021-93, *Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components*. Unless otherwise directed by Sandia National Laboratories, the CDR commits the project to meeting the most stringent requirements of DOE Order 420.1, DOE-STD-1020-94, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*; International Building Code (IBC) 2000; American Society of Civil Engineers (ASCE) Standard 7, *Minimum Design Loads for Buildings and other Structures, ASCE*; American Concrete Institute Building Code 318-99, *Building Code Requirements for Structural Concrete & Commentary*; and the American Institute of Steel Construction Design Manual, *Allowable Stress Design Manual of Steel Construction, 9th Edition*. Detailed implementing provisions have not yet been prepared. The CDR also states that seismic design requirements

will be based on IBC 2000 and further specifies related parameters to be used in the seismic design for the facility. The staff has the following observations on structural consideration for SURF:

- Structural design acceptance criteria for reinforced concrete structures designated as PC-2 facilities do not contain provisions for confining hazardous materials. Limited cracking of the structure is permitted. PC-3 acceptance requirements for reinforced concrete structures satisfy the confinement requirements of DOE Order 420.1. Since the structural robustness of portions of this facility (e.g., reactor room) is dictated by the radiological shielding requirements, these areas of the facility may meet PC-3 acceptance requirements. These selected areas of the facility, therefore, may be capable of confining the hazardous materials released during an event, provided that their associated ventilation system and HEPA filters are qualified to a similar set of criteria. The Board's staff discussed this issue with project personnel and proposed further study aimed at identifying a confinement system that will meet DOE's requirements and the Board's expectations.

- The Board's staff believes the seismic design of the LTF cannot be completed by directly following the seismic design provisions of IBC 2000 as outlined in the CDR. The provisions of IBC 2000 treat the structure as a propped cantilever and calculate the equivalent lateral load based on the mechanics of such a system. Since the LTF is below ground, it would not respond as a propped cantilever. As the wave motion of an earthquake moved through the site and impacted the facility, it would induce vertical motion in the building and subject it to alternating vertical elongation and compression motions. This phenomenon, known as a wave passage problem, must be uniquely analyzed. The Board's staff believes this issue needs to be addressed to ensure adequate evaluation of underground structures when subjected to seismic loadings.

While the guidance associated with DOE Order 420.1 is not mandatory, DOE Standard 1020 is referenced as a suggested approach for designing SSCs. DOE Order 420.1 does permit the use of alternative methods that satisfy its requirements as long as they are justified to ensure that an adequate level of safety commensurate with the identified hazards is achieved. DOE Standard 1020 also references several of the above-mentioned standards and codes. The Board's staff believes it is appropriate to use DOE Standard 1020 as the basis for designing the facility structures, supplemented by additional provisions as required.

SURF Design Process. The SURF project is following the provisions of DOE Order 413.3, *Program and Project Management for the Acquisition of Capital Assets*, and has a Federal Project Manager (FPM) and a Contractor Project Manager (CPM). The FPM is in turn supported by a Federal Integrated Project Team, while the CPM is supported by a Contractor Project Team. Holmes & Narver (H&N) is providing architect/engineering services to the project. The preliminary design of SURF (Title I) has been completed. Pending approval by DOE, the project anticipates initiating final design (Title II) in the near future. During

Title II, all of the detailed design, functional and operational project requirements, and Technical Safety Requirements and associated implementing details will have to be incorporated into the design deliverables prepared by H&N.

The processes and procedures for formalizing and transmitting this information to H&N were discussed during the staff visit. Project personnel indicated that three mechanisms are being used for this purpose. The first consists of formal project documents, such as the program design criteria document and the PSAR which contain varying levels of design information. The second is an issue tracking system and weekly project meetings where design details are discussed, and items requiring clarification are identified. The third is a project requirements review to be conducted by H&N. When the design is complete, H&N is required to trace how all design requirements, on a system-by-system basis, were incorporated into the facility design. While these mechanisms may ultimately be adequate to document all design details, the Board's staff believes a more systematic approach is required, using system and facility design descriptions to document project requirements based on the guidance contained in DOE-STD-3024-98, *Content of System Design Descriptions*. Use of such an approach would provide a more thorough means of assembling all required design information relative to the approach now in use. Furthermore, required system information would be readily available to the system engineer during facility design and construction.