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DEFENSE NUCLEAR FACILITIES SAFETY BOARD

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October 10, 2003

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

Dear Dr. Beckner:

The staff of the Defense Nuclear Facilities Safety Board (Board) has been following the Department of Energy's (DOE) efforts to upgrade Building 12-64 at the Pantex Plant. Upgrades to Building 12-64 have been proposed to increase capacity in support of DOE's Stockpile Stewardship and Management Program and activities under the Stockpile Life Extension Program.

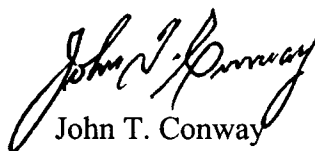
In a letter, dated June 25, 1998, the Board stated that, although margin exists for static loads, "dynamic structural performance under extreme accident conditions is still questionable." DOE, in turn, terminated nuclear explosive operations in Building 12-64 at the conclusion of the W-69 campaign until such time as adequate structural integrity could be demonstrated. Now, in an effort to utilize the facility once again for nuclear explosive operations, DOE has initiated the Building 12-64 Production Bays Upgrade Project.

The Board's staff reviewed Revision 2 of the Conceptual Design Report for the upgrade project that was issued in August 2003. The Board notes that DOE is attempting to address the structural inadequacies with the Building 12-64 bay roofs; however, it is not clear the proposed changes will fully address the structural weaknesses that are identified by the Board's staff in the enclosed report.

Therefore, the Board requests that you examine the issues in the report and provide a briefing to the Board prior to Critical Decision 2 approval on the approach to address the identified structural design deficiencies. Once more detailed design proposals are available, the Board will also evaluate the additional system upgrades and modifications necessary to allow the

resumption of nuclear explosive operations in Building 12-64. Based on this evaluation, the Board may request that your briefing on the 12-64 structural design deficiencies address other aspects of the Building 12-64 Production Bays Upgrade Project as well.

Sincerely,

A handwritten signature in black ink, appearing to read "John T. Conway". The signature is written in a cursive style with a large, sweeping initial "J".

John T. Conway
Chairman

c: Mr. Daniel E. Glenn
Mr. Mark B. Whitaker, Jr.

Enclosure

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

September 17, 2003

MEMORANDUM FOR: J. K. Fortenberry, Technical Director
COPIES: Board Members
FROM: B. Jones and A. Hadjian
SUBJECT: Building 12-64 Structural Upgrade

Members of the staff of the Defense Nuclear Facilities Safety Board (Board) reviewed the Conceptual Design Report for the Building 12-64 Production Bays Upgrade Project, dated August 2003. This document was examined as part of the staff's ongoing review of the adequacy of the Building 12-64 bays to house nuclear explosive operations. The Board's staff identified issues related to the structural integrity of the roof slabs of the Building 12-64 bays. This report documents these issues.

Background. Building 12-64 is a bermed structure, with each bay having a minimum of 2 feet of soil cover over the roof. The bay structures were designed to release the pressure caused by an explosion from within the bay. To this end, each roof consists of two halves separated by a midspan shear key. Although each half of the roof is supported by walls on three sides, only the end wall is connected to the roof slab. These design features support the performance objective that the roof-to-wall joint hinge, allow the roof to rotate open and vent the internal pressure due to an internal explosion. Bay 10 has smaller dimensions than those of the other 16 bays and has a minimum of 4 feet of soil cover.

A letter from the Board to the Department of Energy (DOE) dated June 25, 1998, stated that, although margin exists for static loads in Building 12-64, "dynamic structural performance under extreme accident conditions is still questionable." DOE terminated nuclear explosive operations in Building 12-64 at the conclusion of the W-69 campaign until such time as adequate structural integrity could be demonstrated.

In an effort to utilize the facility once again for nuclear explosive operations, DOE initiated the Building 12-64 Production Bays Upgrade Project. The project issued Revision 2 of the Conceptual Design Report in August 2003.

Design Deficiencies. Two significant deficiencies related to the structural integrity of the roof slabs of the bays have been identified by the Board's staff.

Seismic Loading Effects—ABS Consulting Engineers has analyzed the roof as a simple cantilever and determined that the roof is acceptable. However, when the roof is modeled with as-built boundary conditions, it does not meet the evaluation criteria contained in DOE-STD-

1020, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*. The design of a slab with dimensions similar to the existing bays, supported on three sides and free on the fourth side, requires bottom reinforcing bars throughout the slab in both directions. The Building 12-64 roof slabs do not have bottom reinforcing bars in either direction at the most likely failure zones and are therefore inadequate to support the design basis loads. A “redesign” of the roof slabs to current codes and standards would require a significant amount of reinforcement in areas that currently have no reinforcement. Large cracks have already developed in the roof slabs as a result of this design deficiency. The existing crack patterns are similar in all bays.

Internal Explosion Loading Effects—The existing reinforcement layout does not force yielding at the preferred roof-to-wall joint if subjected to an internal explosion large enough to cause yielding within the roof. Staff calculations have shown that the as-built reinforcement layout would result in a hinge formation away from the roof-to-end wall joint, thus leaving the roof-to-end wall joint intact. Further, because of the lack of bottom reinforcement, a ductile hinge formation cannot be expected. As a result, portions of the roof could become missile hazards if subjected to a large enough internal explosion.

The staff reviewed Technical Report SL-83-6, *An Evaluation of the Separated Bay Concept for a Munition Assembly Complex: An Experimental Investigation of the Department of Energy Building 12-64 Complex*, in which the results of an internal explosion test using an equivalent 300-pound high explosive charge are reported. Results from both a full-scale and half-scale test specimen revealed that this brittle failure mode resulted in a 9-foot by 31-foot piece of concrete flying 100 feet through the air. This behavior did not fulfill the performance objective of the original design of a predictable uncovering of the bay to safeguard other portions of the facility. The report on this experiment states that the roof design must be revised, and in subsequent bay designs this design deficiency was corrected. However, it was not corrected for Building 12-64, and the deficient design is recognized in RPT-SEI-404571, *Seismic Evaluation of Building 12-64 at the Pantex Plant*, dated September 2002. Although this report claims explosive limits have been established to eliminate the missile threat, the staff has not seen an analysis that supports the limit established in the Conceptual Design Report.

Proposed Upgrade. The Conceptual Design Report characterizes the above seismic loading concern as a concrete delamination problem, and proposes to “install shield on interior bay ceilings to catch concrete fragments dislodged during a seismic event.” Additionally, the report proposes to “remove two feet of earth cover over Bay 10 to reduce the facility loading during a seismic event.” While these proposed solutions might mitigate the effects of the problem, they would not correct the design deficiency. Considering that the proposed upgrade of Building 12-64 is a major construction modification project, a permanent solution regarding the structural integrity of the roof slabs should be considered for the long-term use of the facility.

In its current condition, each roof slab is vulnerable to a major structural failure if subjected to either a design basis earthquake or an internal explosion. The roof slabs are not adequate to resist these design basis loads. The proposed shield might not attenuate the effects of such a failure. Catching pieces of falling concrete would not improve the response of the roof

slabs, and this approach assumes relatively small pieces of concrete would break free. Whether a concrete member would fail “safely” by crumbling or fail catastrophically cannot be predicted accurately given the uncertainty of the material properties and the complex loads from blasts and earthquakes.

Proposing to reduce the soil cover over Bay 10 to 2 feet implies that a typical roof is properly designed to carry the soil loads. However, although Bay 10 has twice the soil cover of the typical bays, the stresses due to dead load are only about 15 percent larger because the roof is approximately 20 percent smaller than the typical bays. Furthermore, the calculated deflections of Bay 10, with twice the overburden of the other bays, are slightly less than those of the other bays because deflections are proportional to the fourth power of member dimensions. The logic behind reducing the soil cover of Bay 10 only is based on the unjustified assumption that each roof behaves as a simple cantilever. However, the bays are all similarly overstressed when the as-built boundary conditions are considered. The crack pattern in Bay 10 is similar to the other bays.

The Conceptual Design Report states that nuclear explosive operations in Building 12-64 will be limited to those with explosive limits of a maximum of 230 pounds of high explosives. The report does not provide the basis for this limit to preclude the roof detaching. A charge of 300 pounds resulted in a 46,000-pound roof fragment flying 100 feet during the test. It is not clear that the 230-pound explosive limit would eliminate this missile threat.

The Conceptual Design Report notes an alternative strengthening scheme is being considered that would include a fully supported interior structure to support the weight of the existing roof in a design basis earthquake. This could resolve only the issue related to seismic loading. The use of fiber reinforced polymers to address both seismic and internal explosions deficiencies in a cost-effective manner should also be explored.