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DEFENSE NUCLEAR FACILITIES SAFETY BOARD

August 17, 1994

MEMORANDUM FOR: G. W. Cunningham, Technical Director

FROM: Richard E. Tontodonato, Technical Staff

SUBJECT: Trip Report on DNFSB Staff Review of Methods for Emplacing Nuclear Devices for Underground Testing

1. **Purpose:** This report documents a DNFSB Staff review of methods for emplacing nuclear devices for underground testing at the Nevada Test Site (NTS). The first portion of this review was a May 2-5, 1994, trip by C. Martin, J. Preston, D. Winters, R. Zavadoski, and R. Tontodonato to the Lawrence Livermore National Laboratory (LLNL) and Los Alamos National Laboratory (LANL) to review methods for emplacing nuclear devices for underground testing at NTS. The second portion of this review was a June 15-16, 1994, trip by R. Tontodonato, C. Martin, and H. Massie to NTS to observe Exercise SHORTCAKE, which included emplacement of a simulated nuclear device in a vertical test shaft.

2. **Summary:** Based on this initial review, the emplacement methods, design criteria, and quality assurance provisions used by LLNL and LANL appear to provide adequate assurance that nuclear devices can be safely emplaced in deep vertical shafts for underground testing. Observation of Exercise SHORTCAKE confirmed that the laboratories' designs were adequately translated into action at NTS. However, there was no evidence that procedures were used during some portions of the exercise, and housekeeping was poor in the device installation tower and near the test shaft.

3. **Background:** Since nuclear testing was resumed in 1961, after a three year moratorium, almost all testing at NTS has been done underground. Lowering the test device and associated instrumentation down a shaft for underground testing is called "emplacement." Integrity of the structures used in emplacement is vital, since recovering a nuclear test device inadvertently dropped down a shaft that is potentially thousands of feet deep would be a difficult task. When such an accident occurred in October 1975, the Department of Energy (DOE) chose to destroy the dropped weapon by conducting an adjacent nuclear test, rather than attempting to recover it.

4. **Discussion:**

   a. Emplacement methods: The emplacement process takes two to three weeks depending on the depth of the hole, which is selected to accommodate the projected device yield.

1. LLNL and LANL both use NTS cranes for lifting and lowering test devices, but use different approaches to suspending the device from the lifting fixtures. LLNL uses a single string of heavy pipe sections threaded together to suspend test devices. LANL uses either two or four harnesses made of wire rope to suspend test devices.

2. Both LLNL and LANL lower the device in steps, adding a length of pipe or wire rope harness at each step. The pipe or wire rope must support the weight of the test device and its instrumentation, as well as the loading caused by the addition of the stemming materials (added to the hole to contain the hot radioactive gases created by the test). The high confidence the labs place in this process is based on a mature design methodology, quality assurance, and training and qualification of personnel.

3. It is not obvious that either emplacement method is inherently superior. The difference in approach is related to the generally heavier experimental apparatus used by LLNL. The pipes used by LLNL are made of fracture-resistant steel and are easily inspected, but there is no redundant load path should the emplacement pipe fail. LANL uses two or four load-bearing harnesses, but the wire ropes are difficult to inspect and are not made from fracture-resistant materials. Past incidents during emplacement operations were caused by problems with cranes and other ancillary hardware and did not reveal fundamental flaws with either laboratory's approach to emplacement.

b. Design criteria:

1. LLNL and LANL use conservative design criteria for load-bearing equipment and hardware used in emplacement, including NTS cranes, and pull test all load-bearing items before each emplacement. LLNL designs all components to carry at least two times the emplaced load, and at least 1.5 times the load resulting after the stemming materials are poured onto the emplaced device. LANL designs all components to carry at least two times the emplaced load, and limits the emplaced load on wire rope harnesses to no more than 25% of their breaking strength.

2. LANL pull tests all load-bearing items to two times the actual emplaced load, whereas LLNL pull tests at 1.13 to 1.5 times the emplaced load, or the stemmed load, whichever is larger. LANL personnel consider that the factors of safety (applied to the unstemmed, emplaced load) they use in design and pull testing are large enough that the actual stemmed load will be accommodated. LANL believes that the adequacy of this approach has been proven by their long history of successful emplacements.

3. Seismic loadings have not been explicitly addressed. Both laboratories assume that the probability of a seismic event occurring during emplacement or between emplacement and detonation is negligible. This assumption may be appropriate for a notional test

schedule of two to five tests per year (as allowed by the Hatfield amendment). However, the validity of this assumption during past, aggressive test schedules of more than 20 tests per year might be questioned. It appears that a documented analysis of the likelihood of a seismic event initiating a significant failure during emplacement would be valuable.

c. Quality assurance: The LANL and LLNL quality assurance programs include inspection, testing, and certification of procured materials and hardware, pull testing of each load-bearing item before each use, traceability and control of items used in emplacement, and annual recertification (through pull tests and inspections) of reusable equipment such as cranes, platforms, and lifting gear. Items which are difficult to inspect thoroughly, such as wire rope and threaded fasteners, are subject to larger factors of safety than items which can be adequately inspected.

d. Exercise SHORTCAKE:

1. Background: During the current nuclear testing moratorium, NTS is attempting to maintain nuclear testing proficiency by conducting exercises. Exercise SHORTCAKE featured the delivery of a simulated device to the device installation tower, installation of the device in the test canister, auxiliary system testing, and emplacement of the canister and instrumentation about 500 feet deep in a test shaft. Neither pre-stemming of the canister nor stemming of the hole were included in the exercise. The DNFSB Staff observed activities from the beginning of the exercise through initial insertion of the device canister in the hole, including activities in the LLNL CP-9 control room.

2. Although the arming and firing portions of the exercise were controlled by detailed checklists, other activities did not appear to be adequately controlled:

   (a) The process of moving the device canister from the tower into the hole was controlled by verbal instructions from a foreman, who used no procedures or checklist. The Staff review team had been briefed that the crane operator would raise the canister slightly before lowering it each time the canister was allowed to move down-hole. The reason the canister is normally raised before lowering is to assure the operator that there is enough torque in the motor to control the down-hole motion during descent. This is an administrative procedure that was adopted after a test device was almost dropped during a prior emplacement. This practice was not observed by the review team to be implemented during SHORTCAKE. The only time the canister was raised was when it was initially brought out of the event site tower.

(b) Workers installing the side panels on the canister used power tools which sheared the heads off several bolts (which they did not replace). In addition, the workers neglected to install several other bolts.

3. Housekeeping practices were poor, in violation of 29 CFR 1926.25 as invoked by DOE Orders 5480.4 and 5483.1A. The device installation tower appeared to be unnecessarily crowded due to extraneous tools, equipment and garbage, which should have been removed according to the event mechanical engineer's checklist. Numerous items were observed to be dropped into the hole during the exercise, including bolts, bolt heads inadvertently sheared off by power tools, and bolt ends trimmed off using hand tools.

4. Construction and anchoring of the tower did not appear adequate to withstand earthquake shock or other severe natural phenomena. This is consistent with the statements by LANL and LLNL engineers that seismic events were not considered in the design of the emplacement process.

5. The laboratory nuclear testing organizations were clearly using this exercise as a training opportunity. Several key positions were staffed by two people, to maximize the training benefit. However, SHORTCAKE was not a high fidelity, integrated exercise. The Staff understands that DOE has developed plans for two integrated exercises in early 1995.

5. Future Staff Actions:

a. Conduct a detailed technical review of the standards and specifications governing design, inspection, testing, and certification for LLNL and LANL emplacements.

b. Further examine the laboratories' rationale for neglecting seismic effects and LANL's basis for not explicitly accounting for loads caused by the addition of stemming materials.