DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

January 16, 2009

MEMORANDUM FOR: T. J. Dwyer, Technical Director

COPIES: Board Members

FROM: E. Elliott

SUBJECT: Review of Nuclear Criticality Safety Evaluations for Highly Enriched Uranium Materials Facility at Y-12 National Security Complex

This report documents the results of a review conducted by the staff of the Defense Nuclear Facilities Safety Board (Board) at the Y-12 National Security Complex (Y-12) during July 29–31, 2008. The review focused on nuclear criticality safety (NCS) evaluations and supporting documents for planned operations in the Highly Enriched Uranium Materials Facility (HEUMF). The Board's staff examined the final report from the National Nuclear Security Administration's (NNSA) NCS review, which was issued in August 2008, as well as initial actions that the Y-12 Site Office (YSO) took in November 2008 to address those noncompliances. The Board's staff also evaluated the revised Implementation Plan for DOE Standard 3007-2007 that was issued by the Y-12 contractor on January 15, 2009.

Introduction. HEUMF will store large quantities of highly enriched uranium metal and oxide. The majority of the building will be devoted to long-term storage of this material in drums or rackable can storage boxes (RCSBs). Repackaging operations will be conducted in two separate areas of the facility; these operations are limited to removing fissionable material containers (cans or polyethylene bottles) from drums or RCSBs and placing them into other approved containers. Material in transport containers will be brought to the facility's loading dock in trucks. Opening of primary containers that would directly expose the material is not permitted in HEUMF.

The planned operations are covered by four NCS evaluations (general container limits, handling of drums and RCSBs, repackaging, and truck parking at the dock) and several supporting documents. The staff reviewed Revision 1 of the NCS evaluations; Babcock & Wilcox Technical Services, LLC (B&W Y-12) initiated another revision of the evaluations just prior to the site visit.

Background. As context for the results of the review, requirements for process analyses (i.e., NCS evaluations) given in American National Standards Institute (ANSI)/American Nuclear Society (ANS) consensus standards and in Department of Energy (DOE) directives (which invoke applicable DOE standards), as well as Y-12's implementation of those requirements, are summarized below:

ANSI/ANS Consensus Standards—ANSI/ANS-8.1-1998, *Nuclear Criticality Safety in Operations with Fissionable Material Outside Reactors*, contains both a requirement and a recommendation for NCS evaluations. Section 4.1.2, "Process Analysis," requires: "Before a new operation with fissionable material is begun or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and credible abnormal conditions." Section 4.2.2, "Double Contingency Principle (DCP)," recommends: "Process designs should incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible." A change in a process condition significantly impacts the reactivity of the fissionable material operation, affecting one of the nine traditional criticality safety parameters (mass, moderation, etc.). Each "unlikely" (see below) change in a process condition (i.e., process parameter) must be shown to be subcritical. Because the DCP cannot be applied to every operation, it is not a separate or equivalent criterion for complying with the requirement to demonstrate subcriticality through the process analysis; it is one means of meeting the requirement. Exclusive reliance upon the DCP can result in failure to adequately address all credible abnormal conditions, as discussed below.

DOE Directives—Beginning with DOE Order 5480.24, *Nuclear Criticality Safety*, and continuing through DOE Order 420.1A, *Nuclear Facility Safety*, DOE chose to augment the ANSI/ANS standards by making compliance with the DCP a requirement, not a recommendation. In these Orders, DOE defined the DCP as either control of two independent process parameters or multiple independent controls (at least two) on one process parameter. The former method, as stated in the DOE Orders, was identified as preferred, and the latter meant to address situations in which only one parameter could realistically be controlled. Implementation of this guidance by DOE contractors resulted in a subtle shift away from the ANSI/ANS-8.1 definition of the DCP: control failures became equivalent to process parameter changes, regardless of whether these failures significantly affected the reactivity of the system. This produced a focus on counting the number of controls rather than analyzing the range of normal and credible abnormal conditions and implementing truly robust controls; this issue was noted previously by a DOE review in 2000 following the Tokai-mura criticality accident. As a result, the credible change in the process parameter may not be evaluated and shown to be subcritical. This approach does not achieve the same safety margin as that attained by appropriately applying the ANSI/ANS standard. DOE Order 420.1B, *Facility Safety*, now requires control of two parameters, unless specifically approved by DOE.

DOE Standards—DOE Order 420.1B requires the use of DOE Standard 3007-2007 (the successor document to DOE Standard 3007-93), *Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear Facilities,* to prepare NCS evaluations unless an alternative methodology is approved by DOE. DOE Standard 3007 defines the term "unlikely" as "the attribute of being improbable on the basis of commonly accepted engineering judgment. An unlikely event is not expected to occur more than once in the lifetime of a facility." This definition did not originate with DOE Standard 3007-2007; it is also in DOE Guide 421.1-1, *Criticality Safety Good Practices Program Guide for DOE Nonreactor Nuclear Facilities*, issued in 1999. This definition of "unlikely" is extremely important when applying the DCP. Incorrectly categorizing a contingency as "unlikely" reduces the safety margin for the operation and can result in the failure to identify and implement appropriate NCS controls.

Y-12's Implementation of Requirements—When DOE Order 420.1B was issued, B&W Y-12 modified its NCS program procedures to capture any new or changed requirements. It also reviewed all active NCS evaluations to determine what gaps, if any, would be encountered in the implementation of DOE Standard 3007-2007. This review specifically examined the impact of the definition of "unlikely" and determined whether any operations relied solely on control of one parameter. The review revealed minimal gaps, and B&W Y-12 believed that DOE Order 420.1B was adequately implemented. However, the results of the staff's review, discussed below, indicate that the full ramifications of the changes to the DOE Order and the invoked standard were not fully addressed by the gap analysis. Site personnel have acknowledged this weakness. This topic was discussed during the August 2008 B&W Y-12 quarterly senior manager's meeting. B&W Y-12 subsequently submitted a revised Implementation Plan to bring the site into compliance with DOE Standard 3007-2007 to YSO on January 15, 2009.

Results of Review. One overarching issue was identified during the staff's review: NCS evaluations failed to comply with all requirements of ANSI/ANS-8.1-1998, DOE Order 420.1B, and Y-12's NCS program procedures. The staff noted two particular areas of noncompliance: (1) all identified credible abnormal events were not analyzed to demonstrate subcriticality, and (2) events deemed unlikely to occur do not meet the definition of "unlikely" provided in the site's NCS program procedures.

Generic Failure to Ensure All Credible Abnormal Conditions are Analyzed—Y-12's NCS program summary (Chapter 6 of Y/FSD-17) states that implementation of the DCP fulfills the process analysis requirement of ANSI/ANS-8.1-1998. This approach does not meet the ANSI/ANS standard and can result in failure to properly analyze some credible abnormal conditions. In particular, when a credible abnormal condition affects more than one parameter, compliance with the DCP may not be sufficient to ensure that an operation will remain subcritical under the abnormal condition. Controls identified and implemented using this approach may therefore be insufficient to establish the requisite safety margin. For example, a fire can result in moderation and reflection from fire or sprinkler water and cause geometry

changes due to container compromise. In those cases, the NCS evaluation must show subcriticality for all changes in process conditions resulting from the single initiating event.

Specific Failure to Analyze Credible Abnormal Condition—For HEUMF, a large fire is identified in the Documented Safety Analysis as extremely unlikely (credible), per the definition used in DOE Standard 3009-94, Change Notice 3, *Preparation Guide for US Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*. One of the NCS evaluations noted that this credible abnormal condition was not analyzed to demonstrate subcriticality. The NCS evaluation stated that the large fire was "beyond double contingency" since two unlikely, independent, concurrent *failures* (initiation of the fire and subsequent failure of the sprinkler) were required before it would occur. This is an incorrect interpretation and misapplication of the DCP and fails to meet the requirement from Section 4.1.2 of ANSI/ANS-8.1. First, the DCP applies to criticality parameters, not individual operational failures. Second, the large fire had already been determined to be credible, so the DCP cannot be applied to preclude it from being analyzed to show subcriticality. Therefore, as required by ANSI/ANS-8.1, the NCS evaluation should have analyzed the effects resulting from a large fire and, if necessary, established additional controls to ensure subcriticality.

Incorrect Use of the Term "Unlikely"—Y-12 procedure Y70-150, *Nuclear Criticality Safety Program*, takes its definition of "unlikely" verbatim from DOE Standard 3007-2007. This definition, given above, is specific to criticality analysis and differs from that in DOE Standard 3009-94, Change Notice 3. Several contingencies classified as "unlikely" in the NCS evaluations for HEUMF are actually anticipated, since they have occurred in similar operations at other Y-12 facilities handling fissionable material. One example is violation of an administrative spacing limit for two containers, which has happened several times at the site. These contingencies should have been analyzed as normal (anticipated) conditions.

Results of the NNSA Review. Issues similar to those discussed above were identified by NNSA during its NCS review of other fissionable material operations, conducted in May 2008 at the request of YSO. The NNSA report was finalized in late August 2008; YSO took action to address some of these noncompliances in late November 2008, and has directed B&W Y-12 to ensure that HEUMF NCS evaluations comply with DOE Standard 3007-2007 prior to the start of the operational readiness reviews for HEUMF. As noted above, B&W Y-12 submitted a revised Implementation Plan for DOE Standard 3007-2007 to YSO on January 15, 2009, which addresses other items from the NNSA review. However, the revised Implementation Plan does not address the issues identified by the Board's staff.

Conclusions. Proper analysis of fissionable material operations (i.e., meeting the requirements of ANSI/ANS-8.1-1998 and DOE Order 420.1B) establishes a safety margin that is considered adequate to protect against a criticality accident. If these requirements are not met or are improperly applied, the safety margin may be unknown, but certainly will be smaller than

would otherwise be the case. Some fissionable material operations at Y-12 may require different or more restrictive control sets if reanalyzed using the correct criteria.

The issues noted above stem from problems with the implementation of, and possible deficiencies within, the site's NCS program; other NCS evaluations reviewed by DOE-Headquarters personnel have revealed some of these same problems. It is not clear how far the misuse of the DCP noted by the Board's staff during this review has propagated through the NCS program, to what extent it is characteristic of current NCS evaluations, and why evaluations that fail to meet Y-12's procedural requirements are being authored and approved. The noncompliances identified by the staff may also indicate that the NCS training and qualification program needs to be strengthened.