Bruce Hamilton, Chairman
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DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Washington, DC 20004-2901

October 07, 2019

The Honorable James Richard Perry
Secretary of Energy
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-1000

Dear Secretary Perry:

The Defense Nuclear Facilities Safety Board completed a review of the Oak Ridge National Laboratory's Building 2026 preliminary documented safety analysis for the Initial Processing Campaign. During the course of this review, the Board identified that the accident analysis uses different airborne release fraction (ARF) and respirable fraction (RF) values for the release of pressurized oxides than the DOE recommended bounding values given in DOE Handbook 3010, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*. The lower ARF and RF values used in the accident analysis may not result in a conservative analysis. If not addressed now, this type of error could also be carried forward into the documented safety analyses for future campaigns.

Additional details on this safety item and on opportunities for improvement are provided in the enclosure for your information and use.

Yours truly,

Bruce Hamilton
Chairman

Enclosure

c: Mr. Joe Olencz

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Report

May 31, 2019

Oak Ridge National Laboratory Building 2026 Preliminary Documented Safety Analysis

Summary. Members of the Defense Nuclear Facilities Safety Board's (Board) staff reviewed the preliminary documented safety analysis (PDSA) and other key documents for the Initial Processing Campaign at Building 2026 at the Oak Ridge National Laboratory (ORNL). The staff review team conducted discussions with the Oak Ridge Office of Environmental Management (OREM) and the contractor, Isotek Systems, LLC (Isotek), while on site from December 3–4, 2018. The staff review team and the site held a teleconference to discuss additional lines of inquiry on April 2, 2019. The staff review team identified a safety item regarding whether the airborne release fraction (ARF) and respirable fraction (RF) values used in the accident analysis were bounding.

Background. The Department of Energy's (DOE) Office of Science transferred Building 2026 to the Office of Environmental Management on May 1, 2017. The building is currently a Hazard Category 3 defense nuclear facility in surveillance and maintenance status and ORNL is preparing it for the start of processing activities. The Initial Processing Campaign is the first of several planned campaigns to down-blend uranium-233 from Building 3019 for disposal as low-level waste at the Nevada National Security Site. This campaign will focus on the dissolution, down-blending, and solidification of uranium oxide powders. Future campaigns will address uranium metals, U_3O_8 monoliths, and salts (e.g., UF_6 traps).

DOE determined that the Initial Processing Campaign constitutes a major modification as defined in Title 10, Code of Federal Regulations (10 CFR) Part 830, Subpart B, *Safety Basis Requirements* [1]. ORNL will operate Building 2026 as a Hazard Category 2 facility for the U-233 dissolution and downblending campaign, the first of which is scheduled to start in 2020.

Discussion. The Board's staff review team identified the following safety item during the review.

ARF and RF Values in the Accident Analysis—DOE Standard 3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis* [2], states that, "calculations shall be made based on technically justified input parameters and underlying assumptions such that the overall consequence calculation is conservative. Conservatism is assured by the selection of bounding accident scenarios, the use of a conservative analysis methodology, and the selection of source term and input parameters that are consistent with that methodology." The standard also states that "bounding estimates, and in many cases median estimates, for radionuclide ARFs and RFs for a wide variety of MAR [material at risk] and release phenomena are presented in DOE-HDBK-3010. The bounding estimates shall be used unless a different value is provided in an applicable standard or is otherwise technically justified."

DOE Handbook 3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities* [3], presents an ARF value of 0.1 and an RF value of 0.7 for pressurized releases of powders in the range of 25–500 psig. Facility personnel explained that their canisters are expected to fail before being pressurized above 100 psig and therefore they considered it appropriate to calculate a different ARF and RF. DOE Handbook 3010 does not offer separate ARF and RF values for a release at 100 psig.

For release of oxide powders at a pressure of greater than 25 psig, the accident analysis in the PDSA uses an ARF value of 0.0304 and an RF value of 0.34. For this calculation, Isotek interpolated ARF and RF values from the raw data in Appendix A of DOE Handbook 3010. The staff review team questioned the use of raw data from only the 350 gram (350 g) source of depleted uranium oxide (DUO) powder. Isotek also chose to use raw data from the 350 g DUO powder at 500 psig for the RF value, but there were other sources and other pressures (i.e., closer to 100 psig) that resulted in higher RF values. In addition, there is not much data and the data from the experiments are imprecise in some cases. Therefore, the staff review team considers that using the raw data in this way is not adequately justified and will not result in a conservative analysis.

For the Initial Processing Campaign, the maximum unmitigated dose consequence to the co-located worker is 22 rem total effective dose (TED) from a full facility fire. For purposes of comparison, the same accident scenario using the bounding ARF and RF values from DOE-HDBK-3010 for a pressurized oxide release would result in unmitigated dose consequences of more than 100 rem TED to the co-located worker. For the subsequent campaigns to down-blend uranium-233, the ARF and RF values likely will change since the material form will be different (e.g., metal, monoliths, and salts). If not addressed now, a similar coefficient selection error could also be carried forward into the documented safety analyses for future campaigns.

The staff review team notes that Building 2026 does have a safety significant confinement ventilation system, which likely would help mitigate the dose consequences in several of the accident scenarios. However, the PDSA has not qualified and does not credit the confinement ventilation system to operate during a seismic event.

Additional Observations. The Board's staff review team identified the following observations during its review of the Building 2026 PDSA.

CAAS Evaluation—The PDSA refers to DOE Standard 3007-93 Change Notice 1, *Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear Facilities* [4]. The version of the standard that was current at the time the Code of Record was developed for the Initial Processing Campaign was DOE Standard 3007-2007. In addition, DOE Order 420.1C, *Facility Safety* [5], at the time invoked DOE Standard 3007-2007. The 1993, CN1, version of the standard does not mention CAAS, but the 2007 version references American National Standards Institute (ANSI)/American Nuclear Society (ANS) ANSI/ANS-8.3-1997, *Criticality Accident Alarm System* [6], which requires that the need for a CAAS be evaluated if the inventory of fissionable materials exceeds specified amounts.

ANSI/ANS-8.3-1997 indicates that alarm systems are installed in facilities with a non-trivial risk of criticality. The standard states that, "The need for criticality alarm systems shall be evaluated for all activities in which the inventory of fissionable materials in individual unrelated areas exceeds 700 g of U-235, 500 g of U-233, 450 g of Pu-239, or 450 g of any combination of these three isotopes." Since the facility will be allowed to accept amounts of fissionable material above the thresholds identified in the standard, the staff review team has concluded that Isotek should have performed an evaluation of whether a CAAS is needed to alert workers to promptly evacuate.

Isotek's nuclear criticality safety reports (NCSR) establish limits and controls to ensure subcriticality under normal and credible abnormal conditions. The PDSA states that, "with implementation of the engineered and administrative controls identified in the NCSRs, the NCSRs demonstrate that the risk of a nuclear criticality accident during the Initial Processing Campaign is trivial. Based on this determination and guidance in ANSI/ANS-8.3-1997 R2012 […], a CAAS or CDS [criticality detection system] is not required to support the Initial Processing Campaign." However, the contractor did not meet the intent of the standard and did not adequately demonstrate that criticality for this processing campaign is trivial. ANSI/ANS-8.3-1997 states that, "A criticality alarm system meeting the requirements of this standard shall be installed in areas where personnel would be subject to an excessive radiation dose [equal to or greater than 12 rad in free air]." Isotek did not explicitly demonstrate that, without the suite of controls in place, personnel could not be subject to an excessive radiation dose.

Emergency Lighting—The emergency lights and their supports in Building 2026 are not seismically qualified, and the PDSA did not identify any alternative lighting. In post-seismic events, the emergency lighting may not function to allow facility workers to evacuate. In several of the accidents scenarios (e.g., fire scenarios), workers are assumed to be able to leave the area, resulting in low facility worker consequences.

American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI) 7-16, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* [7], establishes seismic performance expectations for equipment commensurate with its life safety function. DOE Order 151.1D, *Comprehensive Emergency Management System* [8], states that "equipment must be maintained and tested, as applicable, to ensure equipment functions as designed for emergency response and implementation of protective actions based upon the all hazards planning basis." While no operator actions are required to place the facility in a safe condition, personnel in Building 2026 are assumed to be able to evacuate after a seismic event. The expectation, then, is that the facility's emergency lighting should be qualified to function in such an environment, or an alternate means of lighting identified.

Hazard Controls for Normal Operations—The analyses described in the PDSA are focused on identification of safety significant controls and do not clearly describe the protection provided for the facility workers from high radiation levels emitted by uranium compounds during routine operations. For example, Isotek's calculations performed to estimate direct radiation dose rates [10], referenced in the Critical Decision 2/3 package and in the PDSA, compared the normal operational dose exposures to the facility workers with the 100 rem TED criterion for identification of credited controls. The PDSA does not address all the hazards that would result in dose consequences below 100 rem TED to the workers during normal operations and their associated controls. DOE Standard 1189-2008, *Integration of Safety Into the Design Process*, states that the approach for major modifications "ensures formal DOE concurrence in the establishment and implementation of nuclear safety design criteria and selection of hazard controls as early as possible in the modification process." This suggests that the contents of a PDSA should not be limited to descriptions of safety significant and safety class controls. For example, the technicians operating the manipulators are located a few feet from piping that delivers uranium solutions. However, the PDSA does not discuss any controls to protect them from the direct radiation.

Isotek's representatives stated that routine exposure is described in a document that has been prepared (*ALARA Design Review*) to demonstrate compliance with 10 CFR Part 835, *Occupational Radiation Protection* [11], and does not need to be described in the PDSA. The staff review team noted that the *ALARA Design Review* [12] is based on "average" source terms instead of conservative source terms and makes assumptions that are not identified in the PDSA for their protection and implementation. Subpart B to 10 CFR Part 830 requires safety bases (i.e., the PDSA in this case) to demonstrate adequate protection of the public and the workers for "normal, abnormal, and accident conditions." The PDSA focused on identification of safety-significant controls for instances where the dose consequences would exceed 100 rem TED to co-located workers, but it did not explicitly describe the protection provided for the facility workers during routine operations.

Conclusion. The Board's staff review team identified a safety item after reviewing the PDSA and relevant documentation for the Initial Processing Campaign. The accident analysis uses lower ARF and RF values for the release of pressurized oxides than the bounding values given in DOE Handbook 3010. If the bounding values were to be used instead, the unmitigated dose consequences to the co-located worker for certain scenarios may increase to more than 100 rem TED. This would require consideration of additional engineered controls to protect the co-located worker.

References

[1] *Nuclear Safety Management*, 10 CFR Part 830, January 2001.

[2] Department of Energy, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*, DOE-STD-3009-2014, November 2014.

[3] Department of Energy, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, DOE-HDBK-3010-94, (Reaffirmed) December 2013.

[4] Department of Energy, *Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear Facilities*, DOE-STD-3007-93, CN1, September 1998.

[5] Department of Energy, *Facility Safety*, DOE Order 420.1C, Chg. 1, February 2015.

[6] American National Standards Institute/American Nuclear Society, *Criticality Accident Alarm System*, ANSI/ANS-8.3-1997, (Reaffirmed) 2017, May 1997.

[7] American Society of Civil Engineers/Structural Engineering Institute, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, ASCE/SEI 7-16, 2016.

[8] Department of Energy, *Comprehensive Emergency Management System*, DOE Order 151.1D, August 2016.

[9] Department of Energy, *Nuclear Air Cleaning Handbook*, DOE Handbook 1169-2003, November 2003.

[10] Isotek Systems, LLC, *Direct Dose Estimates for Processing Campaigns in Building 2026*, ISO-SAF-CALC-605, Rev. 0, March 2017.

[11] *Occupational Radiation Protection*, 10 CFR 835, January 2011.

[12] Isotek Systems, LLC, *ALARA Design Review: Initial Processing Campaign*, ISO-RAD-ADR-600, Rev. 0, August 2018.