DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Washington, DC 20004-2901

November 23, 2015

Dr. Monica Regalbuto
Assistant Secretary for
Environmental Management
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-1000

Dear Dr. Regalbuto:

Members of the Defense Nuclear Facilities Safety Board's (Board) staff identified significant issues during a review of the safety basis for the Advanced Mixed Waste Treatment Project (AMWTP) at the Department of Energy's (DOE) Idaho National Laboratory (INL). These issues led to underestimating the likelihood and consequences of some accident scenarios, and may have resulted in inadequacies in the selection and classification of safety controls to protect workers and the public. The enclosed report provides additional details for your information and use.

We understand that the DOE Idaho Operations Office is undertaking actions to resolve our concerns. The Board's staff will continue to monitor these efforts to improve the safety basis development, approval, and implementation processes at AMWTP and other defense nuclear facilities at INL.

Sincerely,

Joyce L. Connery

Joyce L. Connery
Chairman

Enclosure

c: Mr. Richard B. Provencher
Mr. Joe Olencz

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

August 4, 2015

MEMORANDUM FOR: S. A. Stokes, Technical Director

COPIES: Board Members

FROM: R. Quirk

SUBJECT: Advanced Mixed Waste Treatment Project Safety Basis

Members of the Defense Nuclear Facilities Safety Board's (Board) staff reviewed the safety basis for the Idaho National Laboratory's (INL) Advanced Mixed Waste Treatment Project (AMWTP). The review found that the safety analysis does not conform to Department of Energy (DOE) technical standards.

Background. AMWTP is located at the Radioactive Waste Management Complex (RWMC) near INL's southern boundary. The primary purpose of AMWTP is to retrieve waste containers and then characterize, treat, and package the waste for safe transport to the Waste Isolation Pilot Plant in the case of transuranic (TRU) waste or other locations for non-TRU waste. The waste at AMWTP came from various locations across the DOE nuclear weapons complex, such as the Rocky Flats Plant. Prior to 1970, the waste was buried in trenches at the RWMC. Starting in 1970, approximately 100,000 boxes and drums of TRU waste were stored on asphalt pads in the Transuranic Storage Area (TSA). Most of the waste was covered with wood, polyvinyl sheeting, and a few feet of soil. A large steel building, known as the TSA Retrieval Enclosure (TSA-RE) was built over the soil-covered waste containers in 1996.

Project contractors retrieved approximately 90 percent of the waste containers from the TSA-RE and either treated, repackaged, and stored the waste in new storage buildings, or relocated it for final disposal. The structural integrity of many of the waste containers that remain in the TSA-RE is poor. During the past few years, the DOE Idaho Operations Office (DOE-ID) and its contractors implemented engineered controls to limit the spread of radioactive contamination and other hazardous material while handling these degraded containers.

Fossil Fuel Fire. AMWTP's safety analysis improperly evaluates the consequences of a fire in the TRU storage facilities when the fire involves significant quantities of fossil fuel. The Technical Safety Requirements (TSR) [1] include a Specific Administrative Control (SAC) that limits the amount of fossil fuel to 200 gallons in the TSA-RE and the other TRU storage buildings. The Documented Safety Analysis (DSA) [2] notes that the purpose of this control is to limit the consequences of a fire in these facilities. However, the accident analysis in the DSA assumes 40 gallons of fossil fuel, instead of the allowed 200 gallons, which reduces the number of waste containers involved and results in lower offsite and worker dose consequences.

The DSA references a study of fire tests that were performed to quantify the fire hazards of the waste stored in the RWMC. This document, *Fire Test of DOT 7A Boxes* [3], notes that a pool fire with approximately 164 gallons of fossil fuel will breach waste boxes and engulf the entire storage array. The DSA does not include this scenario, where the entire array is burned, in the design basis accident analysis of a fire in the TSA-RE, even though 164 gallons of fossil fuel is less than the amount allowed by the SAC. Instead, the DSA identifies a fire that involves an entire storage array as a beyond design basis fire.

The offsite consequence for the beyond design basis fire event is 2.3 rem Total Effective Dose (TED), as compared to the 1.6 rem TED for the design basis fire. However, other DSA issues discussed below may increase the consequences for these scenarios and drive consideration of safety-class controls. The contractor concluded that this issue was a Potential Inadequacy in the Safety Analysis (PISA) and an Unreviewed Safety Question (USQ). The contractor implemented appropriate compensatory measures such as limiting the number of diesel-fueled vehicles in the TSA-RE as well as the amount of fuel in each vehicle.

Fires and Explosions of Large Propane Tanks. The controls for propane in large tanks at AMWTP are inconsistent with DOE Standard (STD) 3009-94 Change Notice 3, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses* [4]. Several AMWTP facilities use propane from these large tanks for facility heating, hot water, and steam boilers. A 45,000-gallon storage tank is located in the south side of the AMWTP complex, and a 30,000-gallon tank is located near the north side of the complex. There are no credited safety structures, systems, and components (SSCs) or SACs for accidents involving either of these storage tanks. The same is true for the 12,000-gallon propane delivery (refueling) truck. The DSA identifies several safety management programs as Defense-in-Depth for accidents involving the large propane tanks and the delivery truck.

The hazards analysis table in the DSA lists a number of propane-fueled fires and explosions that could result in the release of radioactive material. The table notes three of these accidents would have high impacts on the public. One is a boiling liquid-expanding vapor explosion (BLEVE) for one of the storage tanks, with a frequency of beyond extremely unlikely. The other two, designated extremely unlikely, include a fire at a storage tank and the propane delivery truck. The Board's staff review team noted two distinct issues related to the propane accidents. The first is for a BLEVE, and the second is for a vapor cloud explosion.

BLEVE—The DSA does not evaluate the consequences of a BLEVE for the large propane tank because the scenario is considered incredible based on a calculation for the 30,000-gallon storage tank, *Estimate of BLEVE Frequency at the RWMC* [5]. This calculation, completed in 1993, concluded the frequency of a BLEVE is 7.6×10^{-7} per year, and therefore it is an incredible event. The frequency calculation is based on *An Initial Prediction of the BLEVE Frequency of a 100 Te Butane Storage Vessel* [6], which assumes various actions and components reduce the frequency of the BLEVE. The calculation assumes no more than one relief valve fails to open, auto-isolation valves close when required, and fire response personnel will prevent the BLEVE if they have 30 minutes to respond. Based on these assumptions, the Board's staff team considers this frequency calculation to be a realistically calculated analysis, not a conservative one. DOE-STD-3009-94 indicates that man-made external events should be included as design basis events if the frequency is greater than 1×10^{-6} when conservatively calculated or greater than 1×10^{-7} per year when realistically calculated. With a frequency of 7.6×10^{-7} per year, a BLEVE of the large propane tanks needs to be evaluated as a design basis accident.

The DSA notes that a BLEVE of a propane delivery tank during refueling of the tanks is classified as a beyond design basis accident with an estimated dose to the public of 4 rem TED. A BLEVE of the significantly larger storage tanks will result in dose consequences that would require consideration of safety-class controls.

Vapor Cloud Explosions—The second major issue for these propane tanks is the potential for vapor cloud explosions. The DSA describes a design basis accident for a fire involving the propane delivery truck. This accident is a leak of propane that collects until it is ignited by an unknown source and explodes, and the resulting overpressure damages a corner of the Characterization Facility. The DSA calculates the consequences to the collocated worker and maximally-exposed offsite individual to be 22 and 0.357 rem TED, respectively. Both of these are below the level that would require an evaluation for safety controls, and no safety SSCs or TSR controls are specified. The supporting analysis by the AMWTP contractor [7] assumes the explosion is at the refueling station for the 45,000-gallon tank, which is approximately 100 feet from a corner of the Characterization Facility. The analysis assumes that only a portion of waste in this facility is impacted. However, there is another analysis by Hughes Associates [8] for a vapor cloud from a liquid propane leak that drifts to the Type II Storage Modules before exploding. These storage modules contain more material-at-risk (MAR) than the Characterization Facility. The DSA incorrectly states that a fuel-air explosion is not possible in these facilities because they do not have external propane tanks. An explosion near the Type II storage modules would likely release more radioactive material than the current design basis event, which impacts waste in only one corner of the Characterization Facility. As such, safety controls may be warranted.

While evaluating the issues noted by the Board's staff, the contractor implemented appropriate precautionary measures to reduce the risk of a major leak from the propane tanks. These include frequent inspections for tank leaks as well as keeping the large rollup doors on the Type II Storage Modules closed except when the buildings are occupied. The contractor also determined that this issue was a PISA and is completing an analysis to determine if it is a USQ.

Conformance with DOE-STD-5506-2007. The safety analysis does not conform to some of the required methods and assumptions in the DOE-STD-5506-2007, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities* [9]. In accordance with a May 2007 memorandum from the Chief Operating Officer for the DOE Office of Environmental Management (EM) [10], a prior AMWTP contractor developed a gap analysis between the newly issued DOE-STD-5506-2007 and the DSA. The gaps were to be addressed during the next annual update of the DSA, revision 5, in November 2008 [11]. The associated Safety Evaluation Report (SER) from DOE-ID notes that the requirements of the standard were implemented.

DOE-STD-5506-2007 is not required by the current contract, but both the 2008 and current DSA revisions note they were prepared using the requirements of this standard. However, the Board's staff review team noted discrepancies between the requirements in DOE-STD-5506-2007 and the analysis that supports the safety basis, which will make the safety basis non-conservative.

Quantity of Respirable Material Released—One of the most significant discrepancies is the fraction of radioactive material released to the atmosphere and considered respirable during a fire. The safety basis notes that this quantity, calculated as the airborne release fraction times the respirable fraction (ARF×RF), has a value of 5×10^{-4}. However, DOE-STD-5506-2007 notes that some of the MAR will be ejected from the top row of drums involved in a pool fire. Figure 4.4.3-1 of the standard, reproduced as Attachment 1 to this report, provides direction on how to calculate the source term for drums involved in the fire, but this information was not used in the accident analysis. As noted in Attachment 1, the ARF×RF could be as high as 1×10^{-2} when the material is burned in an unconfined manner after being ejected. The dose consequence to the worker and public from this portion of the burning material is 20 times higher than is currently used in the accident analysis. When combined with the non-conservative quantities of fossil fuel allowed in the TSA-RE, using the DOE-specified values of ARF×RF will significantly increase the calculated doses to workers and the public and result in the need to evaluate additional controls.

The material in the degraded waste boxes in the TSA-RE pool fire is also modeled in a non-conservative manner. As the stacks of boxes burn, some material would likely be ejected and burned in an unconfined manner. Additionally, the stacks may collapse and release additional material to burn in an unconfined manner. The DSA asserts that the ejected material would be "packaged" in plastic and therefore can still be considered confined burning. However, the plastic bags would burn when exposed to a large fire, such as in a pool of burning diesel fuel and wood boxes, and then the waste would no longer be confined. The review team concluded that burning waste that was in plastic bags in robustly burning and collapsing stacks of wood boxes should be treated as unconfined burning. The team concluded the larger values for ARF×RF specified in DOE-STD-5506-2007 should be used for this waste.

Risk Binning of Accidents—Another non-conservative aspect of the DSA is the initial risk binning of accidents, which is not consistent with DOE-STD-5506-2007. For example, many of the design basis events are described as anticipated or unlikely when the average MAR is used. But the DSA reduces the frequency by orders of magnitude when the worst-case MAR is used. This impacts several design basis accident analyses, including the TSA-RE fire discussed above. This approach is inconsistent with and non-conservative compared to the methods used in DOE-STD-5506-2007 section 6.2, *Risk Ranking and Control Selection*. Reducing the frequency of these design basis accidents can lead to downgrading the selected controls, such as from safety SSCs to safety management programs.

Deposition Velocity. The dose consequences presented in the DSA are calculated using plume models with values for deposition velocity that are not reasonably conservative. In 2011, the DOE Chief of Nuclear Safety issued a Safety Bulletin [12], which identified that the default values for deposition velocity in the MACCS2 Computer Code Application Guidance for Documented Safety Analysis [13] may not lead to reasonably conservative results. The bulletin offered a few options. The option selected by DOE-ID was to have its contractors review their safety analyses and determine if they were still reasonably conservative. DOE-ID committed to document its technical justification for not using the conservative value of deposition velocity in their next annual update to the safety basis. However, the contractor failed to do this. DOE-ID subsequently sent letters to its contractors directing them to provide the technical justification for not updating the analyses with a more conservative deposition velocity [14].

The Board's staff review team believes that the impact of using an incorrect value for the deposition velocity needs to be considered together with the other non-conservative items noted above to determine whether the DSA is based on reasonably conservative accident analyses.

Other Corrections. In discussions with the Board's staff review team, the AMWTP contractor stated that it would correct numerous minor problems in the DSA in the next annual update. These issues include references to out-of-date and superseded documents, as well as inconsistencies between the tables describing the risk binning process and the actual process used.

Conclusions. The staff team concluded that the AMWTP safety basis is non-conservative with respect to the amount of fossil fuel that is allowed in facilities that store TRU waste, does not properly address the hazards associated with large tanks of propane, fails to incorporate some of the methods and assumptions in DOE-STD-5506-2007, and includes accident analyses that use a non-conservative value for deposition velocity in dose consequence calculations.

Cited References

[1] Idaho Treatment Group, *Advanced Mixed Waste Treatment Project Technical Safety Requirements*, RPT-TSR-03, Rev 13, November 2013.

[2] Idaho Treatment Group, *Advanced Mixed Waste Treatment Project Documented Safety Analysis*, RPT-DSA-02, Rev 11, October 2014.

[3] J. D. Jensen, *Fire Test of DOT7A Boxes*, TREE-11356, May 1979.

[4] Department of Energy, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, DOE-STD-3009-94, Change Notice 3, March 2006.

[5] J. P. Poloski, *Estimate of BLEVE Frequency at the RWMC*, RWMC-583, January 1993.

[6] K. W. Blything and A. B. Reeves, *An Initial Prediction of the BLEVE Frequency of a 100 Te Butane Storage Vessel*, SRD-R488, 1988.

[7] M. Main, *BLEVE Event Involving Propane Delivery Vehicle*, EDF-0154, Rev. 0, March 2007.

[8] Hughes Associates, *Unconfined Vapor Cloud Explosion Analysis for Accidental Releases from 45000-gal LP-Gas Storage Tank*, October 2007.

[9] Department of Energy, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities*, DOE-STD-5506-2007, April 2007.

[10] I. R. Triay, Memorandum, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities*, May 2007.

[11] M. C. Brown, Memorandum to M. B. Moury, *DOE-Idaho Response to Safety Bulletin No. 2011-02, Accident Analysis Parameter Update, Regarding Environmental Management Nuclear Facilities (EM-NSPD-11-081)*, October 2011.

[12] G. S. Podonsky, *Accident Analysis Parameter Update*, Safety Bulletin 2011-02, May 2011.

[13] Department of Energy, *MACCS2 Computer Code Application Guidance for Documented Safety Analysis*, DOE-EH-4.2.1.4-MACCS2-Code Guidance, June 2004.

[14] J. P. Zimmerman, Letter to D. J. Richardson, *Safety Bulletin No. 2011-02, Accident Analysis Parameter Update (EM-NSP-15-022)*, May 2015.

Attachment 1: Damage Ratio, Airborne Release Fraction, and Respirable Faction for TRU Waste Drums in a Pool Fire
(From DOE STD-5506-2007 Figure 4.4.3-1)