DEFENSE NUCLEAR FACILITIES SAFETY BOARD
Washington, DC 20004-2901

July 26, 2021

The Honorable Jennifer M. Granholm
Secretary of Energy
US Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-1000

Dear Secretary Granholm:

The Department of Energy (DOE) is preparing a revision of DOE Standard 5506, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities*. This standard, originally issued in 2007, specifies how DOE sites should analyze and control the hazards involved with DOE's transuranic waste.

DOE will significantly improve the safety of its transuranic waste operations by completing the revision and implementing it in the field. Careful implementation of the revised standard should help prevent radiological release events like those that occurred in February 2014 at the Waste Isolation Pilot Plant and in April 2018 at the Idaho National Laboratory. Rigorous implementation of the revised standard could address many of the Board's concerns on safety bases for facilities at Los Alamos National Laboratory outlined in Technical Report 46, *Potential Energetic Chemical Reaction Events Involving Transuranic Waste at Los Alamos National Laboratory*.

Over the last several months, the Defense Nuclear Facilities Safety Board's (Board) technical staff has engaged with DOE on the standard. The Board appreciates DOE's transparency and resolution of most of the Board's comments. However, the Board identified concerns that remain unresolved, which are provided in the enclosure. The Board also recognizes that DOE will not achieve needed safety improvements until the revised standard is implemented by incorporation into facility management contracts or by other means.

Pursuant to 42 United States Code § 2286b(d), the Board requests a briefing within 60 days of receipt of this letter, which will describe DOE's approach for the following concerns:

- Underestimation of release fractions for container deflagrations,

- Non-conservative amount of liquid fuel assumed in fuel pool fires, and
- Implementation of the revised standard.

Sincerely,

Joyce L. Connery

Joyce Connery
Chair

Enclosure

c: Mr. Matthew Moury
Mr. Joe Olencz

Staff Review of DOE Standard 5506

Over the last several months, the Defense Nuclear Facilities Safety Board's (Board) technical staff has engaged with Department of Energy (DOE) staff working on the revision to DOE Standard 5506, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities*. The DOE team communicated effectively with the Board's staff and was receptive to feedback on the draft standard.

Positive Impacts to Nuclear Safety. The draft of DOE Standard 5506 contains several additions that, when implemented, will result in positive impacts to nuclear safety. The following are just a few examples of constructive updates:

- *Chemical Compatibility Evaluations*—The 2007 version of DOE Standard 5506 did not require a chemical compatibility evaluation to identify potential undesired chemical reactions. The proposed draft requires that a facility's hazard analysis include "an evaluation of the chemicals potentially in the waste to consider whether adverse chemical reactions could occur." This new language will help ensure that DOE contractors meet the requirement in Title 10, Code of Federal Regulations, Part 830, *Nuclear Safety Management*, for providing "a systematic identification of both natural and man-made hazards associated with the facility."

- *Release Fraction for Energetic Chemical Reactions*—In DOE's investigation of the 2014 radiological release event at the Waste Isolation Pilot Plant (WIPP), DOE found that the release "was much larger than what would be modeled in accordance with the methodology described in" DOE Standard 5506-2007 and other DOE documents [1]. The draft incorporates information from the 2014 WIPP event by adding a composite release fraction[1] of 0.2 that must be used "for combustible waste when waste constituents have the potential for heat generation and rapid pressure buildup of combustible gases." Importantly, the draft also notes that the higher release fraction (0.2) should be applied if waste characterization information does not exist to sufficiently rule out a similar energetic chemical reaction. Lastly, the draft incorporates information from the 2018 event at Idaho National Laboratory (INL) by adding a release fraction of 0.05 for use with some chemical reaction events involving powders.

- *Administrative Controls for Material-at-Risk (MAR)*—For the purposes of safety analysis, DOE Standard 5506-2007 provides a methodology for determining how much MAR may be present in the location where a postulated accident occurs. In Technical Report 43 [2], *Deficiencies in DOE Standard 5506-2007*, the Board's staff evaluated this methodology, and found that the actual MAR in the facility might sometimes exceed the MAR that is assumed in the safety analysis. The draft standard states that administrative controls "should be used to protect assumptions and

[1] The composite release fraction is the fraction of radiological material in a container that becomes airborne in a respirable form as a result of the accident (i.e., the product of the damage ratio, airborne release fraction, and respirable fraction).

conclusions of the hazard/accident analysis." This guidance will help ensure that the safety analysis remains conservative with respect to MAR.

Unresolved Concerns. The proposed draft of DOE Standard 5506 contains a few areas of concern that the Board's staff considers unresolved.

Underestimation of Release Fractions for Container Deflagrations—An important step in safety analysis is the estimation of the potential consequences of postulated events. To guide this consequence analysis, DOE Standard 5506 specifies release fractions for various waste types involved in different postulated accidents, including container deflagration events. Container deflagrations involve the rapid combustion of a flammable gas or vapor, such as hydrogen, that has accumulated in a waste container. A deflagration would cause the pressure in the container to increase, potentially leading to failure of the container and the release of some waste. For deflagration events involving powder-like waste, the standard provides a correlation between the airborne release fraction and pressure, making it important to obtain conservative estimates of the pressures that can be reached.

Regarding deflagration pressures, Section 4.4.1 of the draft standard states "a deflagration above powder is expected to be bounded by a low pressure (< 25 [pounds per square inch gauge, psig]) release, however, for added conservatism, the recent slow pressure testing of drums as discussed in Section B.2.6 … shows that the worst failure was around 50 psig."

In contrast, the appendices to the standard show that deflagrations can result in pressures higher than 50 psig, based on both experimental measurements and thermodynamic calculations. For example, Section B.2.2 shows pressures exceeding 50 psig for a broad range of initial hydrogen concentrations. The highest measured pressure in a drum deflagration test was 320 psig.

The 50 psig value cited by the DOE team in Section 4.4.1 is not relevant to deflagrations because it was not measured in a deflagration test. Rather, that value was obtained in pneumatic testing where containers were filled with compressed gas until they failed. As stated in Appendix B, the "low failure pressures [in pneumatic testing] are not indicative of the pressures achieved during an H_2 deflagration." The DOE team also cited a series of drum deflagration tests performed by the Southwest Research Institute [3]. In these tests, the peak pressures measured in the drum ranged from 16 to 27 psig. While these are hydrogen deflagration tests, the staff team finds that they do not represent bounding conditions. The hydrogen-air mixture did not fill the headspace of the drum; rather, it was confined to a smaller test chamber within the drum. The hydrogen concentrations were also lower than the bounding conditions. The staff team thus concludes that 50 psig does not represent an upper bound to deflagration pressures.

The choice of deflagration pressure has a significant impact on the release fraction used in the consequence analysis. Using the maximum deflagration pressure suggested by DOE ("around 50 psig") results in a release fraction of 0.014. The higher deflagration pressures documented in the appendices to the standard would result in higher release fractions, using the correlation proposed by DOE. For example, using 320 psig and the respirable fraction specified by DOE results in a release fraction of 0.051. The staff team finds that DOE should provide recommendations on deflagration pressures that are consistent with the applicable data cited in

the appendices, to ensure that conservative release fractions are used for deflagration events involving powders.

Non-conservative Amount of Liquid Fuel Assumed in Fuel Pool Fires—DOE Standard 5506 provides guidance and requirements on how DOE contractors analyze accident scenarios that could potentially affect facilities with TRU waste. One accident scenario involves liquid fuel pool fires, in which a flammable or combustible liquid spills onto the ground, ignites, and results in a burning pool. In the typical scenario, this liquid spills from a tank on a vehicle that is involved in an accident at the facility. The volume of the spilled liquid is a parameter that defines the severity of the accident, since it determines the area of the pool and thus the number of radiological waste containers exposed to lid loss or seal failure conditions.

The revision to the standard allows contractors to assume that the entire capacity of a metal tank would not contribute to the pool. The DOE team's rationale is that it is unlikely the fuel tank would be full at the time of the accident and that it is unlikely all of the liquid would spill from the tank during a hazard insult. The draft standard notes that the tank breach might not occur at the bottom of the tank, and that transfer lines typically connect to the top of the tank, making it less likely for all the fuel to drain out through those lines.

The standard allows the use of a "derating" factor, such that only 75 percent of the tank's liquid capacity is assumed to contribute to the pool area. This derating factor is based on guidance on building fire loads in a National Fire Protection Association (NFPA) Handbook [4]. However, the staff team finds that the derating factor in the NFPA Handbook is not relevant to a liquid fuel pool fire scenario. The derating factor in the NFPA Handbook is related to ordinary combustible materials enclosed in metal, such as books in a metal bookshelf. The derating factor is based on observations that the metal container provides some protection, such that not all the combustible material (e.g., books) would burn.

Thus, the considerations in the NFPA Handbook are physically different from the probability-based factors that the DOE team is considering: whether the liquid tank is full, or whether all of the liquid leaks out of the tank. The DOE team noted that it used the most conservative derating value in the NFPA Handbook, and that a method specifically for liquid fuel was not readily available. It also noted that the standard includes other conservative assumptions for modeling pool fires. The staff team does not find these reasons compelling as the methodology is not relevant to the scenario as noted above. Further, the staff team notes that a breach near or at the bottom of the tank is possible, allowing all the liquid fuel to spill out and contribute to the fuel pool fire.

DOE Standard 5506 is intended to supplement the safe harbor methods in Appendix A to Subpart B of Title 10, Code of Federal Regulations, Part 830, *Nuclear Safety Management*, such as DOE-STD-3009-2014 [5]. DOE Standard 3009-2014 states that calculations regarding the consequences of potential accidents "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 staff team finds that the derating factor proposed

by the DOE team is not technically justified, and its use may lead to the analysis of accident scenarios that are not bounding. In the absence of a more relevant technical basis, the staff team concludes that it would be more appropriate to assume that the entire capacity of the tank contributes to a pool fire to ensure a technically-justified and conservative consequence calculation, as required per DOE Standard 3009-2014.

Concerns to Address in the Future. The following concerns are for DOE's consideration for future revisions of DOE Standard 5506 and as it implements the current revision.

Lack of Applicable Test Data—The appendices of DOE Standard 5506 outline much of the available literature related to the behavior of TRU waste and waste containers during accident scenarios. However, only limited applicable test data exist in several areas, which allows for poorly justified and potentially non-conservative or overly conservative assumptions about accident phenomenology to be present in the standard. Test data are necessary to ensure release fractions and assumptions appropriately predict consequences, resulting in an appropriate control set. The following are examples of areas that would benefit from additional testing campaigns:

- Behavior of contaminated combustible waste and finely divided waste in metal drums during fires and deflagrations.

- Behavior of overpack configurations (e.g., drum-in-drum and drum-in-standard-waste-box) in fires and deflagrations.

- Conditions required for seal failure during fires and deflagrations (e.g., heat flux or internal pressure) and corresponding magnitude of release.

Implementation of the Standard—Given the significant improvements included in the standard and the information gathered from the WIPP and INL events, the Board's staff concludes that an urgent approach to implementation of the updated DOE Standard 5506 is warranted. In addition, it will be important for DOE to oversee how its contractors implement the new requirements and guidance on chemical reaction events. Under the revised standard, contractors will be evaluating whether facilities have the potential for adverse chemical reactions, whether those reactions could cause "rapid pressure buildup" in a container, and what pressure could be reached. The draft standard has relatively little guidance on how to make such evaluations. Calculations of pressure rise will tend to be highly assumption-driven, with uncertainties stemming from incomplete information on the waste composition and configuration. Accordingly, it will be important for DOE to perform oversight to ensure that its contractors appropriately identify and control such hazards.

As DOE finalizes the revision of DOE Standard 5506, the Board's staff plans to evaluate DOE's approach to applying the revision, including ensuring that facilities implement any necessary additional controls in a timely manner. In addition, the Board's staff is evaluating lower priority concerns associated with the standard.

References

[1] Department of Energy, *Accident Investigation Report Phase 2, Radiological Release Event at the Waste Isolation Pilot Plant, February 14, 2014*, Office of Environmental Management, 2015.

[2] Defense Nuclear Facilities Safety Board, *Deficiencies in DOE Standard 5506-2007, Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities,* DNFSB/TECH-43, 2018.

3] Southwest Research Institute, *Deflagration Testing for CH Payload Containers and Filter Vents*, SwRI Project No. 01.20698.01.001, March 2015.

[4] National Fire Protection Association, *Fire Protection Handbook*, 17th edition, 1991.

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