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DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Washington, DC 20004-2901

August 11, 2022

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

Dear Secretary Granholm:

The Defense Nuclear Facilities Safety Board (Board) has recently completed a review of the safety basis that supports the planned receipt and repackaging of large amounts of heat source plutonium at the Los Alamos National Laboratory (LANL) Plutonium Facility (PF-4).

Mitigated offsite consequences of a potential seismic event during these operations exceed the Evaluation Guideline of 25 rem total effective dose (TED) that is defined in Department of Energy (DOE) Standard 3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*. Depending on the assumptions used, the calculated mitigated offsite dose consequences range from 490–3175 rem TED. The National Nuclear Security Administration (NNSA) has accepted these elevated consequences via the DOE Standard 3009-2014 provision commonly referred to as the exigent circumstances process. Through this process, a contractor discusses the safety risks of the mission, why safety class controls could not be implemented to reduce the calculated dose consequences below the Evaluation Guideline, and any safety improvements that could be made to the facility or safety controls in the future. This discussion informs DOE's or NNSA's decision on whether to accept the safety risks and proceed with the mission as specified in the safety basis.

DOE should take all feasible actions to avoid the need to apply the exigent circumstances process in existing facilities; new or expanded missions should normally provide the opportunity to plan safety improvements to avoid exigent circumstances. While it would have been difficult for DOE to completely avoid using the exigent circumstances process for this mission, DOE could have reduced safety risks if it had coordinated the mission better between the heat source plutonium shipping site (Idaho National Laboratory) and receiving site (LANL).

NNSA needed to accept elevated safety risk in this situation because, as indicated in the Board's letter dated November 15, 2019, its efforts to improve the safety controls at PF-4 have been significantly delayed. PF-4's current safety control strategy is not commensurate with the safety risks of its expanding mission (e.g., pit production, increased plutonium oxide production, HS-Pu operations). Further, as stated in its March 15, 2022, letter, NNSA has recently changed its strategy to upgrade the active confinement ventilation system to achieve a "robust" system rather than a safety class, seismically qualified system, contrary to the Board's advice. Given this change in strategy, upgrades to other safety systems (e.g., addressing seismic vulnerabilities in the fire suppression system and gloveboxes) have become more important for supporting future mission activities. PF-4 safety control improvements would allow NNSA to better accommodate hazardous missions without having to accept excess safety risk via the exigent circumstances process.

Given the potential for high mitigated offsite dose consequences, the Board advises DOE to implement additional safety controls and operational restrictions, as detailed in the enclosed staff report, to reduce the safety risk of this heat source plutonium mission to the extent practicable.

Sincerely,

Joyce L. Connery
Chair

Enclosure

c: Mr. Ted Wyka
Mr. Joe Olencz

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Report

May 27, 2022

Receipt and Repackaging of Large Amounts of Heat Source Plutonium at the Los Alamos National Laboratory Plutonium Facility

Summary. The National Nuclear Security Administration (NNSA) is planning a mission that involves receiving and repackaging large amounts of heat source plutonium (HS-Pu) at the Plutonium Facility (PF-4) at Los Alamos National Laboratory (LANL). NNSA recently approved an addendum to PF-4's documented safety analysis (DSA) to support this mission.

In the addendum, NNSA's contractor, Triad National Security, LLC (Triad), calculated the potential safety consequences of accidents related to this mission. The mitigated offsite dose consequences of a seismic accident exceed the Evaluation Guideline of 25 rem total effective dose (TED) that is defined in Department of Energy (DOE) Standard 3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis* [1]. Depending on the assumptions used, the calculated mitigated offsite dose consequences range from 490–3175 rem TED. DOE expects its contractors to implement safety class controls to reduce dose consequences below the Evaluation Guideline, but Triad determined it was not feasible to comply in this case.

Because of the high mitigated offsite dose consequences, the DSA addendum uses a provision in DOE Standard 3009-2014 commonly referred to as the exigent circumstances process. Through this process, a contractor discusses the safety risks involved, why safety class controls could not be implemented to reduce the calculated dose consequences below the Evaluation Guideline, and any safety improvements that could be made to the facility or safety controls in the future. This discussion informs DOE's or NNSA's decision on whether to accept the safety risks and proceed with the mission as specified in the DSA.

The exigent circumstances provision should only be applied in exceptional cases (e.g., to address emergent safety issues) and should not be routinely used for new or expanded missions. While it may have been difficult for DOE to avoid having mitigated dose consequences for seismic accidents exceeding the Evaluation Guideline from this mission, better planning and improved safety controls would have resulted in reduced safety risk.

Even without this HS-Pu repackaging mission, the mitigated offsite dose consequences at PF-4 for a seismic event, including post-seismic fire, are relatively high and closely approach the Evaluation Guideline for the current PF-4 mission set. PF-4's safety control strategy is not commensurate with the safety hazards of the expanding mission (e.g., pit production, increased plutonium oxide production, and HS-Pu operations). Further, NNSA has recently changed its strategy to upgrade the active confinement ventilation system to achieve a "robust" system rather than a safety class, seismically qualified system, contrary to the Board's advice. Given this change in strategy, upgrades to other safety systems (e.g., the fire suppression system and

glovebox stands) become more important for supporting future mission activities. Milestones for these safety upgrades should be aligned with the evolving PF-4 mission.

Additional safety controls and restrictions would improve the safety of this mission. For example, LANL could upgrade glovebox stands used for these operations, improve the rigor of controls on combustible materials, and limit operation of heat producing equipment concurrent with HS-Pu repackaging.

Background. In November 2021, Triad submitted a DSA addendum [2] to support the receipt and repackaging of large amounts of HS-Pu at PF-4. The HS-Pu is currently stored at Idaho National Laboratory (INL) in nested configurations of containers within Type B packages (i.e., the 9516 package). NNSA plans to ship the material from INL to PF-4, repackage it into robust containers, and use it for an upcoming National Aeronautics and Space Administration (NASA) mission. Figure 1 shows a schematic of the 9516 Type B package.

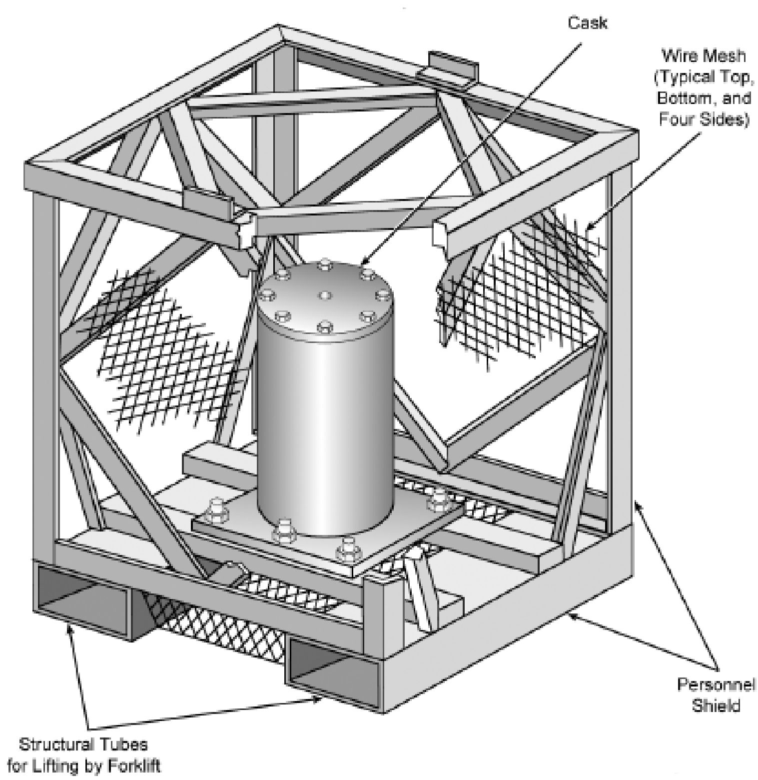

Figure 1: *Schematic of the 9516 Type B package [3]*

To process the material, operators will open the lid of the personnel shield, unbolt and remove the lid from the cask, and remove the containment vessel from the cask. The containment vessel is a stainless steel can "designed to remain leaktight" during hypothetical over-the-road transportation accidents involving the 9516 package [3]. The operators will cut open the containment vessel inside a fume hood and then transfer the product containers nested within to a glovebox. Operators will then perform a series of repackaging steps within various gloveboxes, culminating with packaging the HS-Pu in robust welded containers. These robust containers are credited in the PF-4 safety basis with providing a damage ratio of zero (i.e., no credible accident will result in release of the HS-Pu).

During times when the HS-Pu is within the uncredited product containers but not overpacked in containers that are credited with a damage ratio of zero (e.g., the containment vessel), seismic events involving a fire could result in mitigated offsite dose consequences that exceed the Evaluation Guideline of 25 rem TED defined in DOE Standard 3009-2014. Depending on the assumptions used, the calculated mitigated offsite dose consequences range from 490–3175 rem TED.

The main reason for the high dose consequences is the possibility of a pressurized release from the uncredited product containers in a fire. The wide range of the calculated dose consequences is driven by uncertainty in how much airborne material will exit the building. The PF-4 safety control strategy currently relies on the building to passively confine material during an accident. The mitigation provided by the passive confinement system is quantified using a parameter known as leak path factor, which represents the fraction of airborne plutonium that escapes the building to the outside environment. Since Triad has not analyzed the leak path factor for this mission, the DSA addendum lists a range of leak path factors that might be applicable (0.16–1.0). The Board has previously communicated concerns with the existing leak path factor analysis [4, 5].

Safety considerations and mission needs drive the timeline for this mission. As the plutonium undergoes alpha decay, it produces helium, which remains within the sealed containers. If there is sufficient accumulation of helium, the containers could over-pressurize in a fire, leading to a release of plutonium. Type B packages are qualified to survive a fire scenario, but because of helium accumulation, there are time limits on this qualification for the 9516 package. The Type B packages will reach these time limits between October 2023 and May 2024, after which they will not meet safety requirements for shipping. DOE officials have asserted that INL lacks the capability to repackage the containers, and therefore the shipments to LANL must be completed before the time limits elapse. Regarding mission needs, Triad personnel stated that they need to produce heat source components by 2024–2025 to support NASA's timeline.

NNSA conditionally approved Revision 1 of the DSA addendum [6] on March 28, 2022 [7]. Due to the high mitigated offsite dose consequences, the safety basis approval authority was the NNSA Cognizant Secretarial Officer for Safety with concurrence by the NNSA Central Technical Authority, as required by DOE Standard 1104-2016, *Review and Approval of Nuclear Safety Basis and Safety Design Basis Documents* [8]. NNSA's safety evaluation report included one condition of approval (to resolve unaddressed safety basis review team comments) and a directed change to language in a new limiting condition for operation.

Discussion. While it may have been difficult for DOE to avoid having mitigated dose consequences that exceed the Evaluation Guideline, better planning and improved safety controls would have resulted in reduced safety risk from this mission. Further, there are additional non-credited safety controls and restrictions that LANL should apply to improve the safety of these operations.

Use of the Exigent Circumstances Process—Section 3.3.1 of DOE Standard 3009-2014 specifies requirements for those "circumstances where no viable control strategy exists in an existing facility to prevent or mitigate the consequence of one or more of the accident scenarios from exceeding the [Evaluation Guideline]." This section requires the DSA to include additional information, including:

- A discussion on "the available controls that could reduce the likelihood and/or consequences of the associated accidents...and the reasons why they are not selected as credited controls...."

- A discussion on any planned operational or safety improvements (e.g., facility modifications, material-at-risk reductions).

- A comparison of the facility risk to the safety objectives in DOE Policy 420.1, *Department of Energy Nuclear Safety Policy*.

The DSA addendum uses this provision (commonly called "exigent circumstances") from the standard. This provision should only be applied in exceptional cases (e.g., to address emergent safety issues) and should not be routinely used for new or expanded missions. DOE should take all feasible actions to avoid exigent circumstances. With new missions at existing facilities, DOE should plan to avoid creating exigent circumstances. If exigent circumstances are unavoidable, DOE should implement additional safety measures to reduce safety risk to the extent practicable. These safety measures should preferably be credited safety controls, but DOE should consider any safety control that reduces risk, even if it is not credited.

It would have been difficult for DOE to avoid exigent circumstances in this case. Still, DOE could have reduced safety risks had it coordinated the mission better. For example, certain improvements to PF-4's safety systems (e.g., upgrading the gloveboxes to meet seismic requirements) could have been implemented in time to support this mission (discussed further below). Also, the accident consequences at PF-4 could have been reduced if DOE had loaded fewer uncredited product containers into each Type B container (though Triad personnel noted other considerations, such as worker dose during handling, that also influence such decisions). The mitigated dose consequences for seismic accidents would have still been above the Evaluation Guideline, but the safety risks of this mission would have been reduced.

PF-4 Safety System Upgrades—Even without this HS-Pu repackaging mission, the 23 rem TED mitigated offsite dose consequences of a seismic fire event at PF-4 are relatively high and approach the Evaluation Guideline for the current PF-4 mission set. PF-4's safety controls are not commensurate with the safety risks of its expanding mission (e.g., pit production, increased plutonium oxide production, and HS-Pu operations). For many years, NNSA and LANL have planned to upgrade the active confinement ventilation system and fire suppression system to meet safety class and seismic requirements. However, as indicated in the Board's letter dated November 15, 2019, safety upgrades to these systems have been significantly delayed [5] due in part to engineering challenges, funding perturbations, and other emergent issues. Further, as stated in its March 15, 2022, letter [9], NNSA has changed its strategy for upgrading the active confinement ventilation system, contrary to the Board's advice.

NNSA now plans to upgrade the active confinement ventilation system to be "robust," but it will not meet safety class design and quality assurance requirements or requirements for seismic design. Given this change in safety strategy, upgrades to other safety systems (e.g., addressing seismic vulnerabilities in the fire suppression system and gloveboxes) are now more important. NNSA should renew its focus and identify specific end states and milestones for system upgrades that are aligned with the evolving PF-4 mission.

Opportunities for Risk Reduction—Given the significant mitigated offsite dose consequences associated with this mission, Triad should implement additional safety controls and restrictions to reduce safety risk. For this mission, additional safety controls or restrictions could include upgrading glovebox stands, improving the rigor of combustible controls, and limiting operation of heat producing equipment concurrent with HS-Pu repackaging.

Only one of the four gloveboxes that Triad will use for this mission is known to meet performance category (PC)-2 seismic requirements. Triad should upgrade the remaining gloveboxes and adjacent gloveboxes to eliminate the possibility that the gloveboxes could topple in a design basis earthquake. Removing the toppling hazard would reduce the likelihood of spills and remove the possibility that a glovebox could topple onto spilled plutonium. Triad personnel were not opposed to this concept in principle, but they indicated there was insufficient time to implement such safety upgrades before starting this mission. Triad personnel did not present a schedule to demonstrate this lack of time. Better planning and coordination may have allowed sufficient time to perform the safety upgrades. LANL has previously performed seismic upgrades to HS-Pu gloveboxes, but the seismic hazard increased in 2007–2009 and many of the HS-Pu gloveboxes do not meet PC-2 requirements. As part of the implementation plan for Recommendation 2009-2, *Los Alamos National Laboratory Plutonium Facility Seismic Safety*, LANL focused its efforts on upgrading the glovebox stands for gloveboxes that contain molten plutonium operations. All new gloveboxes that LANL is installing for other missions (e.g., under the Los Alamos Plutonium Pit Production Project) will meet PC-2 or higher seismic requirements; however, LANL does not currently plan to upgrade HS-Pu gloveboxes.

Given the high consequences of fire accidents (including post-seismic fires), Triad should improve the rigor of its combustible control program to improve the safety posture of this mission. For example, Triad is piloting a new safety control in a different part of PF-4 to limit combustible loading such that potential glovebox fires would have a heat release rate below 100 kW. Triad could implement the same safety control in the HS-Pu rooms that will be used for processing the INL material. Triad could also implement more frequent walkdowns by fire protection engineers, establish a fire watch during operations, or clear combustibles from adjacent gloveboxes or pass-through boxes.

Triad personnel indicated that PF-4 operators perform daily inspections for combustibles. However, this inspection is largely subjective,[1] and the staff team has found it allows combustibles to accumulate. The inspection could be improved by introducing specific limits on combustibles and more frequent engagement by fire protection engineers. Given the high

[1] The procedure for this walkdown, TA55-AP-0090 [10], includes subjective language such as: "Ensure transient combustibles are stored in reasonable amounts that are expected to be used in current authorized operations," and "There are no unnecessary combustibles stored in the room."

mitigated offsite dose consequences of this operation, Triad should do more to ensure that combustible materials are minimized in the rooms where these operations will be performed. Based on combustible loading in other areas of the facility, the staff team believes that HS-Pu operators could reduce the combustible loading in their rooms and gloveboxes.

Several neighboring glovebox lines contain heat producing equipment. Triad could restrict operations in these gloveboxes while processing the HS-Pu material from INL. This would reduce the likelihood of a fire starting in a nearby glovebox and impacting the HS-Pu. It would also reduce the potential for an earthquake-induced fire since the residual heat in equipment such as furnaces would still pose a fire hazard even after termination of power by the seismic power shutoff system.

Glovebox Fires and Fire Suppression System Effectiveness—For glovebox fires, the DSA addendum states that the safety class fire suppression system will significantly mitigate offsite dose consequences by washing out airborne material-at-risk. The gloveboxes used for this activity do not have internal fire suppression systems; thus, Triad is relying on the facility fire suppression system to mitigate glovebox fire accidents.

Calculations referenced by the DSA (LA-UR-99-2667, *Mechanistic Analysis of Glovebox Fire Propagation* [11]) show that a glovebox fire would cause only a minimal increase to the room temperature. Consequently, a glovebox fire may not actuate the overhead sprinklers in the laboratory room. Moreover, Triad has not quantified how much mitigation the fire suppression system would provide. In discussions with the staff team, Triad personnel indicated that glovebox fires are typically small and would not result in large leak path factors, and that airborne radioactive material would likely be filtered through the safety class passive confinement system. Triad should refine its safety analysis to better demonstrate the efficacy of its safety control strategy for glovebox fires and to better support its position that the mitigated offsite dose consequences of non-seismic fires do not exceed the Evaluation Guideline.

Containment Vessel Performance—The DSA addendum assumes that the containment vessel can withstand a fire but does not support this assumption with a rigorous evaluation. The addendum focuses on glovebox fires on the grounds that a glovebox fire would expose the containment vessel to higher air temperatures than other fire scenarios. The addendum concludes that the containment vessel would withstand exposure to those air temperatures.

However, there are other potential mechanisms for heat transfer to the confinement vessel, such as radiative heat flux from the fire and flame impingement. The DSA states that it does not consider the impact of flame impingement in a glovebox fire due to the expected transient nature of the fire. However, there are no safety controls for protecting such assumptions. Further, radiative heating and flame impingement could be more important in a room fire (i.e., outside the glovebox), which would not be as oxygen-limited as glovebox fires. Thus, the evaluation would be more persuasive if it considered radiative heating and flame impingement.

The addendum also acknowledges that the containment vessel would not withstand impact from certain equipment that could fall on it but does not identify meaningful safety controls for protecting facility workers from this hazard.

Limiting Operational Upsets—As part of the exigent circumstances process, the DSA addendum asserts that the safety risk of this HS-Pu mission is limited by the short time that HS-Pu will be outside credited containers. Unplanned equipment outages and other unforeseen upsets could prolong the time that HS-Pu is outside credited containers. HS-Pu operations personnel indicated that they reviewed the relevant procedures for needed equipment and found that the only equipment without a backup is the cutting lathe needed to open the containment vessel. They have spare parts for the lathe and are working on procuring a second lathe. LANL would benefit from documenting a formal contingency analysis to ensure it has sufficient spare equipment and procedural avenues to accommodate operational upsets.

Maintaining the Safety Class Pedigree of the Seismic Power Shutoff System—NNSA's review of the addendum led to improvements in safety. For example, based on NNSA's comments on the draft safety basis addendum, Triad revised the addendum to identify the seismic power shutoff system as safety class in the half of the first floor that includes HS-Pu operations.

Additional Staff Team Observations—Appendix A to this report documents the staff team's observations regarding three areas in the PF-4 DSA [12] that appear to be inconsistent with DOE Standard 3009-2014 and warrant consideration during Triad's ongoing development of a DOE Standard 3009-2014-compliant DSA for PF-4 [13].

Conclusion. NNSA recently approved a DSA addendum to support shipment of large amounts of HS-Pu from INL to LANL's PF-4 for repackaging. This mission results in mitigated offsite dose consequences due to a post-seismic fire that greatly exceed the Evaluation Guideline. While it may have been difficult for DOE to avoid these exigent circumstances, better planning would have resulted in reduced safety risk from this mission. Additional safety controls and restrictions would improve the safety risk of these operations (e.g., glovebox stand upgrades, more rigorous combustible controls, and limiting operation of heat producing equipment concurrent with HS-Pu repackaging).

Appendix A—Additional Observations Related to the Plutonium Facility Documented Safety Analysis

The Defense Nuclear Facilities Safety Board's (Board) staff found three areas in the Plutonium Facility (PF-4) documented safety analysis (DSA) [12] that appear to be inconsistent with Department of Energy (DOE) Standard 3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis* [1], and should be considered in the new DSA development [13]:

- In the unmitigated analysis, the DSA assumes that fires do not propagate beyond two glovebox lines (operational fire) or the room (seismic fire). However, PF-4 has the potential for the accumulation of combustibles that could lead to fire propagation. The safety basis does not identify any fire barriers as safety design features to prevent the further spread of fire. Thus, the staff team finds that the unmitigated analysis should consider the further propagation of a fire. DOE Standard 3009-2014 does not allow DSAs to apply the effects of administrative controls such as combustible controls in the unmitigated analysis.

- The DSA analyzes multiple accident scenarios at individual locations (e.g., the first floor, basement, outdoor waste pads) but does not consider a single accident involving all these locations caused by a common initiator (e.g., seismic event).

- For operational fires, the DSA applies a combined airborne release faction and respirable fraction (ARF*RF) value of 2E-3 for HS-Pu solutions. For the post-seismic fire, the DSA applies an ARF*RF value of 3E-5 for the same solutions. Per DOE Handbook 3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities* [14], the 2E-3 value corresponds to boiling of solutions, while the 3E-5 value corresponds to heating of solutions without boiling. The DSA (page 3-318) explains that for the seismic event, the solutions are assumed to spill first and then are exposed to elevated temperatures. The DSA should analyze the bounding accident progression, which in this case is to assume the solutions do not spill and are heated to boiling in the same way as the operational fire accident scenario.

References

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

[2] Los Alamos National Laboratory, *Higher MAR Limits for Receipts of Large HS-Pu Shipments*, TA55-DSA-2020-R1 Addendum 1-R0, November 24, 2022.

[3] Pacific Northwest National Laboratory, *Safety Analysis Report for Packaging (SARP) for the 9516 Package*, R1033-0062-ES, Rev. 4, May 2021.

[4] Defense Nuclear Facilities Safety Board, *Los Alamos National Laboratory Plutonium Facility Leak Path Factor Methodology*, DNFSB/TECH-44, November 2019.

[5] Defense Nuclear Facilities Safety Board, *Safety Basis for the Plutonium Facility at Los Alamos National Laboratory*, November 15, 2019.

[6] Los Alamos National Laboratory, *Higher MAR Limits for Receipts of Large HS-Pu Shipments*, TA55-DSA-2020-R1 Addendum 1-R1, March 3, 2022.

[7] National Nuclear Security Administration, *Safety Evaluation Report*, *Higher MAR Limits for Receipt of Large HS-Pu Shipments,* SET-TA55-DSA-2020-R1 Addendum 1-R1, March 2022.

[8] Department of Energy, *Review and Approval of Nuclear Safety Basis and Safety Design Basis Documents*, DOE-STD-1104-2016, December 2016.

[9] National Nuclear Security Administration, *Los Alamos National Laboratory Technical Area 55 Plutonium Facility 4 Ventilation System Report to the Defense Nuclear Facilities Safety Board*, March 15, 2022.

[10] Los Alamos National Laboratory, *TA-55 Transient Combustible Program*, TA55-AP-090, R22-IPC1, March 8, 2022.

[11] Leonard. M. and McClure, P., *Mechanistic Analysis of Glovebox Fire Propagation*, LA-UR-99-2677, May 25, 1999.

[12] Los Alamos National Laboratory, *TA-55 Documented Safety Analysis*, TA55-DSA-2020-R0.1, June 30, 2020.

[13] Los Alamos National Laboratory, *Project Execution Plan, Update of Accident Analysis Calculations and the TA-55 DSA and TSR to Meet DOE-STD-3009-2014*, PLAN-TA55-525-R4, July 14, 2020.

[14] Department of Energy, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, DOE-HDBK-3010-94, December 1994.