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 closely followed Los Alamos National Laboratory's (LANL) efforts to update the leak path factor analysis for the Plutonium Facility (PF-4). The leak path factor is an important input to the PF-4 safety basis as it quantifies the amount of radioactive material that might escape from the passive confinement structure during an accident.

For almost two decades, the Department of Energy (DOE) has planned to upgrade the active confinement ventilation system at PF-4 to meet safety class requirements, which would reduce the release of radioactive material during accident scenarios to a small fraction of the evaluation guideline established in DOE Standard 3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*. However, in a March 15, 2022, letter to the Board, the National Nuclear Security Administration (NNSA) stated that it would no longer pursue a safety class active confinement ventilation system at PF-4. Accordingly, its safety control strategy will continue to rely on passive confinement and thus the leak path factor analysis. Because the leak path factor analysis is critical for validating the performance of the passive confinement system, to be in compliance with applicable standards (such as DOE Standard 3009-2014), NNSA and Los Alamos must ensure the updated analysis is conservative and that key inputs and assumptions are protected commensurate with their importance. Given the importance of the leak path factor analysis in ensuring that the passive confinement system can adequately mitigate accident consequences, the Board advises NNSA to address the concerns in the enclosed staff report.

The Board has previously communicated concerns with the leak path factor analysis in a November 15, 2019, letter and Technical Report 44, *Los Alamos National Laboratory Plutonium Facility Leak Path Factor Methodology*. In February 2020, the NNSA Los Alamos Field Office directed the LANL contractor to consider the information provided by the Board in these two letters and document which portions of the input were or were not used and the associated rationale.

Pursuant to 42 United States Code § 2286b(d), the Board requests that DOE provide any analysis LANL has done in accordance with that direction within 30 days of receipt of this letter.

Sincerely,

Joyce L. Connery
Chair

Enclosure

c: Mr. Ted Wyka
Mr. Joe Olencz

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Report

May 25, 2022

Los Alamos National Laboratory Plutonium Facility Updated Leak Path Factor Analysis

Summary. The primary engineered safety control for the Los Alamos National Laboratory (LANL) Plutonium Facility (PF-4) to mitigate radioactive material release during an accident is the passive confinement system. The mitigated analysis section of the facility safety basis quantifies the performance of this control using a numerical coefficient called the leak path factor (LPF).

For almost two decades, the Department of Energy (DOE) has planned to upgrade the active confinement ventilation system at PF-4 to meet safety class requirements, which would reduce the release of radioactivity during accident scenarios to a small fraction of the evaluation guideline established in DOE Standard 3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis* [1]. However, in a recent letter to the Defense Nuclear Facilities Safety Board (Board) [2], the National Nuclear Security Administration (NNSA) stated that it would no longer pursue a safety class active confinement ventilation system.

The Board has previously communicated concerns with the LPF analysis [3, 4], and LANL is in the process of updating it to support a new PF-4 safety basis. Because the LPF analysis is critical for validating the performance of the passive confinement system, to be in compliance with applicable standards (such as DOE Standard 3009-2014), NNSA and LANL must ensure the updated analysis is conservative and that key inputs and assumptions are protected commensurate with their importance.

Background. PF-4 is a hazard category 2 defense nuclear facility at LANL used for plutonium pit and radioisotope power source manufacturing, stockpile assessments, plutonium pit dismantlement and oxide production, and actinide research and development. PF-4 is currently undergoing a major modification to increase its capacity for pit production under the Los Alamos Plutonium Pit Production Project (LAP4).

The PF-4 safety basis [5, 6] and LAP4 safety design strategy [7] rely on the safety class passive confinement system as the primary engineered safety control to mitigate offsite dose consequences. DOE Order 420.1C Chg 3, *Facility Safety* [8], notes that DOE's preferred design approach for providing confinement is an active confinement ventilation system. The order allows alternate confinement approaches if a "technical evaluation demonstrates either that the alternate confinement approach results in very high assurance of the confinement of radioactive materials or that an active confinement system provides no benefits."

In the PF-4 safety basis, the LPF represents the fraction of radioactive material that escapes the facility's passive confinement during an accident. It is a function of the specific accident conditions (e.g., spills, explosions, fires, material location in the building) and the meteorological conditions near the building. For example, for the seismic event with post-seismic fire, crediting the LPF mitigates the calculated offsite dose consequences from 218.6 rem total effective dose to 24.2 rem total effective dose.

From 2017 to 2019, the Board's staff performed a review of the PF-4 safety basis, including the supporting LPF calculations. In November 2019, the Board issued Technical Report 44, *Los Alamos National Laboratory Plutonium Facility Leak Path Factor Methodology* [3], and a Board letter and staff report on the PF-4 safety basis [4]. These reports detailed concerns with the existing PF-4 LPF analysis, namely:

- The LPF analysis assumed that the exterior confinement doors are only open for five minutes following an earthquake**,** which could lead to significantly underestimating the radiological material released during the accident if the doors are open longer;

- The statistical methodology used to derive LPF values resulted in non-conservative values for some accident scenarios;

- Discrepancies in averaged weather data and non-physical trends in LPF values could invalidate the assumed conservatism in the methodology; and

- Software quality assurance issues and inadequate records challenged the integrity of the analyses.

These findings challenge the efficacy of the primary control that is credited to protect the public from the consequences of a seismic event (i.e., passive confinement by the building structure). For example, in an earlier analysis of room fires, when the confinement doors were assumed to be open for 10 minutes, the LPF was about a factor of two higher than if the doors were assumed to be open for 5 minutes [9]. The LPF calculations do not provide very high assurance of the confinement of radioactive materials, as required by DOE directives.

Since 2017, the LANL contractor has been working to develop a new LPF analysis for PF-4 [10]. In April 2020, the current LANL contractor, Triad National Security, LLC, (Triad) submitted working documents [11, 12] to the NNSA Los Alamos Field Office (NA-LA) that describe the revised methodology for calculating LPF values to be used in a new PF-4 safety basis that will comply with DOE Standard 3009-2014. Triad is continuing to refine these working documents and associated computer models ahead of the new safety basis submittal, which is expected in January 2023 [13].

Based on the working papers and on discussions with Triad, the Board's staff found that the updated LPF methodology will have similar issues to the existing LPF methodology but will use different or updated software packages. The LPF methodology and software packages are described in Figure 1. Triad plans to use MELCOR version 2.2, which is newer than the version listed in the DOE Safety Software Central Registry[1] (version 1.8.5); Ansys Fluent release 19.0 (a

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[1] The DOE Safety Software Central Registry is a list of codes with versions that DOE has evaluated against the safety software quality assurance requirements in DOE directives and recommends for safety analysis. Codes listed in the registry are referred to as "toolbox" codes.

non- “toolbox” code); and CFAST version 7.1.1 (a “toolbox” code). For all safety software used, including software listed in the central registry, Triad personnel must ensure that the versions used meet software quality assurance requirements. The staff understands that Triad plans to provide supporting software quality assurance documentation for the code versions used in the final calculations.

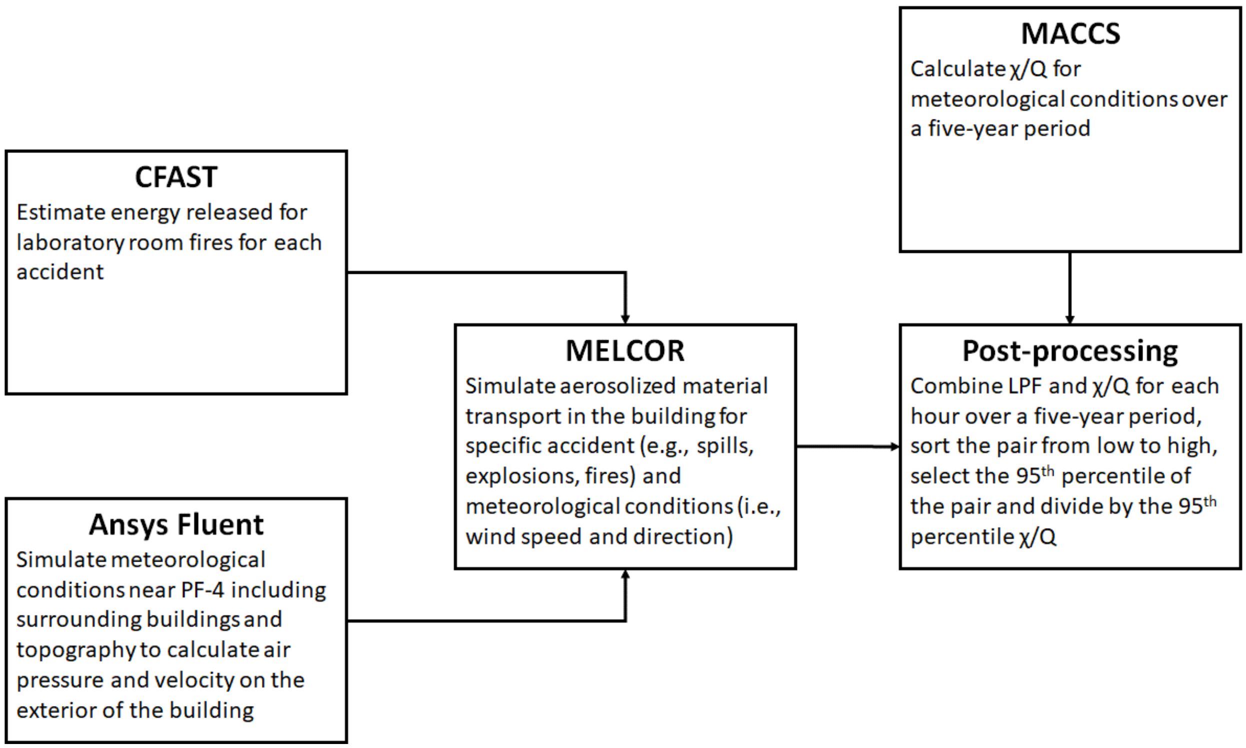

Figure 1. *Leak path factor methodology and software packages*

On August 24, 2020, the staff held a scoping teleconference to understand Triad’s plan for updating the LPF analysis and NNSA’s approach for reviewing and approving the updated analysis. On February 24, 2021, the staff held another teleconference to discuss key inputs to the updated fire model that supports the PF-4 LPF analysis and NA-LA’s efforts to develop a review plan for the LPF analysis and associated calculations. The staff concluded its review with a final teleconference on September 29, 2021, focused on working versions of the PF-4 computational fluid dynamics methodology calculation (i.e., Ansys Fluent) and the MELCOR methodology report.

Discussion. Overall, challenges remain to completing a conservative and technically defensible LPF analysis. In her March 15, 2022, response to the Board’s letter of November 24, 2021 [14], the NNSA Administrator stated that NNSA will no longer pursue a safety class active confinement system at PF-4 [2]. This change in strategy means that LANL will continue to rely on passive confinement as a credited safety control, and thus will need to rely on the LPF analysis. Triad and NNSA must ensure that the LPF analysis, which validates the performance of the passive confinement system, is conservative. In addition, upon implementing the revised safety basis that relies on the update LPF analysis, Triad and NNSA will need to ensure that key inputs and assumptions are protected at a level commensurate with their importance.

Issues Described in DNFSB Technical Report 44 Are Still Applicable—On February 3, 2020, NA-LA directed Triad to consider the information in DNFSB Technical Report 44 and the November 15, 2019, Board letter while it updated the PF-4 LPF analysis [15]. NA-LA also directed Triad to, by December 11, 2020, document which portions of the technical report and the letter would or would not be used for the LPF update and why. Triad has not completed this evaluation, and NA-LA has no plans to require Triad to complete it. Based on discussions with Triad and NA-LA, the Board's staff concludes that several issues outlined in DNFSB Technical Report 44 and the November 15, 2019, Board letter will likely not be resolved in the updated LPF analysis. For example, Triad plans to continue assuming the exterior confinement doors close shortly after the accident begins and remain closed for the duration of the accident.

The LPF analysis relies heavily on how long the confinement doors are assumed to be open during an evacuation. Previously, in the MELCOR model, LANL assumed that the PF-4 confinement doors would only be open for five minutes. For the updated LPF analysis, Triad personnel plan to use the software package *PathFinder* to develop an evacuation model of PF-4. This model will estimate the time required for personnel to evacuate the facility such that the confinement doors can close. DOE Standard 3009-2014 requires that assumptions made when defining a meaningful accident scenario be protected at a level commensurate with their importance. In this case, the staff finds that there are no viable controls to ensure the confinement doors will be closed shortly after the accident initiates or that the confinement doors will remain closed, given that emergency responders will need to enter the facility to engage in firefighting or rescue operations.

Further, Triad plans to continue to use a statistical methodology that couples χ/Q (the atmospheric dispersion factor) with LPF. In the previous analysis, LANL calculated LPF values corresponding to six wind speeds and eight wind directions to form an array of 48 LPF values for each accident scenario in the safety basis. Next, LANL used hourly wind speed and direction data to interpolate within the computed LPF array. This allowed LANL to generate a distribution of LPF values for each hour based on a five-year period of meteorological data for each accident scenario. Then, LANL multiplied the hourly LPF values by the hourly χ/Q values to obtain a distribution of the product of LPF and χ/Q. LANL ordered these paired parameters from low to high values and determined the 95^{th} percentile of the product of χ/Q and LPF. Finally, LANL divided the 95^{th} percentile of the product of χ/Q and LPF by the 95^{th} percentile of χ/Q to obtain the LPF value for each accident scenario. This approach will result in less conservative dose consequence estimates than if each parameter were derived independently and may be inappropriate for calculating co-located worker dose consequences.

Quality of the Analyses Needs Improvement—DOE has established expectations for the justification, documentation, and traceability of safety basis information. DOE Standard 3009-2014 states that "Calculations shall be made based on technically-justified input parameters and underlying assumptions such that the overall consequence calculation is conservative." Some input parameters and assumptions may be based on the existing facility design. These design inputs must be controlled by a formal configuration control process consistent with LANL's approved quality assurance program [16] as required by Title 10 Code of Federal Regulations (CFR) 830, Subpart A, *Quality Assurance Requirements* [17].

Additionally, consistent with DOE guidance, certain inputs and assumptions may need to be protected by safety controls. The final LPF analysis must clearly justify and document all relevant inputs and assumptions and provide a list of approved design documents associated with these inputs. Failure to provide justification for the technical validity of inputs and assumptions would prevent an appropriate independent verification from being performed as required by Title 10 CFR 830, Subpart A.

The staff identified concerns with the quality of the analyses in the working documents (see Appendix A). These issues would challenge LANL's ability to appropriately follow DOE requirements and ensure the validity and protection of the results of the safety basis analysis if not addressed in the final calculation.

Conclusion. The staff reviewed working documents for the updated PF-4 LPF analysis and found that challenges remain to completing a conservative and technically defensible analysis. Since NNSA is no longer pursuing a safety class active confinement ventilation system, the PF-4 safety control strategy will continue to rely on the LPF analysis. Given that this confinement strategy is contrary to the preferred design approach established in DOE Order 420.1C, the LPF analysis is required to demonstrate that the strategy "results in a very high assurance of the confinement of radioactive materials" during accidents. To meet requirements in DOE Standard 3009-2014, DOE Order 420.1C, and 10 CFR 830, Subpart A, Triad and NNSA must ensure that the LPF analysis is conservative, and that key inputs and assumptions are protected at a level commensurate with their importance.

Appendix A—Staff Concerns with the Leak Path Factor Analysis

Modeling Simplifications. The Defense Nuclear Facilities Safety Board's (Board) staff is concerned with some simplifications in the current working versions of the computational fluid dynamics (CFD) and MELCOR models [11, 12], and the validation of the CFD model. While modeling simplifications are often appropriate, some might lead to non-conservative results.

- The current working versions of the CFD and MELCOR models contain simplifications that may strongly influence the results. They should be evaluated for conservatism and model sensitivity (e.g., non-seismically qualified building collapse height and topography, number of room stratifications). Triad National Security, LLC (Triad) personnel noted that the model simplifications followed commonly used approaches in the field and were needed to reduce the computational demands of the model.

- The current working version of the CFD model validation approach seems to validate the software (i.e., Ansys Fluent), rather than the model of PF-4. Triad personnel noted that their validation approach was driven by a lack of available data needed for a direct comparison and that it was similar to the approach used for the original LPF analysis.

- For the MELCOR model, Triad personnel noted that additional time is needed to develop, evaluate, and document assumptions and limitations.

Fire Modeling Assumptions and Combustible Controls. The updated fire methodology uses the Consolidated Fire and Smoke Transport (CFAST) modeling software and inputs based on initial PF-4 room walkdowns to adjust heat release rates (HRR). These HRRs are key inputs for the LPF calculation. For each evaluated room, a Microsoft Excel® spreadsheet (i.e., "HRR calculator") documents the number and type of combustibles found during the walkdown and determines the location where contiguous combustibles result in the maximum HRR for the room. However, the combustible loading assumed in the LPF fire methodology is based on a snapshot in time and may not bound all conditions. Because the assumed combustible loading is not protected in the current combustible control program, operators may introduce combustibles that exceed the amounts assumed in the LPF analysis and invalidate the results.

The Board's staff noted challenges to protecting combustible loading inputs under current operating practices.

- The assumptions and inputs for the CFAST calculation are not associated with the combustible loading program at PF-4. As a result, changes can be made to items in the room, consistent with TA55-AP-090, *TA-55 Transient Combustible Program* [18], leading to combustibles with heat loading greater than what is considered in the updated LPF fire methodology and with different separation criteria (required to ensure that flashover does not occur resulting in a larger fire). TA55-AP-090 provides instructions for personnel on the control of transient combustible materials and "verifies area conditions against the current Base Line Fixed Combustible Loading Surveys." As part of the implementation of this program, combustible loading permits are assigned for every room in the facility. The combustible loading permits for the subject rooms currently allow different items to be placed into the rooms and at greater quantities than what is considered in the updated LPF fire methodology.

- The staff found that operators may change the combustible loading in a room without a review by a person knowledgeable about the CFAST inputs (i.e., a fire protection engineer or safety basis analyst), as long as the change is within room permit limits.

Given the sensitivity of the LPF results to fire intensity, combustible loading inputs should be considered initial conditions in the documented safety analysis that may need to be protected by a specific administrative control consistent with the guidelines established in DOE Standard 3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis* [1]. The Board's staff concludes that these input parameters and the spreadsheet should be maintained through a formal configuration control process consistent with LANL's approved quality assurance program [16] as required by Title 10 Code of Federal Regulations 830, Subpart A, *Quality Assurance Requirements* [17].

Complex Application of Boundary Conditions. The results from the CFD model will be used as boundary conditions in MELCOR. Triad personnel indicated that they would apply different configurations of boundary conditions in MELCOR depending on the wind direction. This approach introduces additional complexity and will require careful application.

References

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

[2] 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.

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

[4] Defense Nuclear Facilities Safety Board, *Safety Basis for the Plutonium Facility at Los Alamos National Laboratory*, August 16, 2019.

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

[6] Los Alamos National Laboratory, *TA-55 Technical Safety Requirements*, TA55-TSR-2020-R0.5, March 10, 2021.

[7] Los Alamos National Laboratory, *Safety Design Strategy for Los Alamos Plutonium Pit Production Project (LAP4)*, SDS-103998-LAP4-00001-R3.1, May 4, 2022.

[8] Department of Energy, *Facility Safety*, DOE Order 420.1C Chg 3, November 14, 2019.

[9] Los Alamos National Laboratory, *Transmittal of TA-55 Leak Path Factor Analysis*, NMT-14: 04-138, December 17, 2004.

[10] 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.

[11] Los Alamos National Laboratory, *PF-4 CFD Methodology*, CALC-CFD-SB-DRAFT, April 2020 draft.

[12] Los Alamos National Laboratory, *Proposed LPR MELCOR Methodology*, RPT-SBD-xxx-R0, April 2020 draft.

[13] Los Alamos National Laboratory, *Contract No. 89233218CNA000001, Impact Assessment of the TA-55, PF-4 Safety Basis for DOE-STD-5506-2021, Preparation of Safety Basis Documents for Transuranic Waste Facilities*, PCM-21-T189, December 7, 2021.

[14] Defense Nuclear Facilities Safety Board, *Conceptual Design of the Los Alamos Plutonium Pit Production Project*, November 24, 2021.

[15] National Nuclear Security Administration Los Alamos Field Office, *Transmittal of Defense Nuclear Facilities Safety Board Chairman letters to the Secretary of Energy regarding the Plutonium Facility*, February 2020.

[16] Los Alamos National Laboratory, *Los Alamos National Laboratory Quality Assurance Program*, SD330, Revision 12, June 22, 2021.

[17] Department of Energy, *Nuclear Safety Management, Quality Assurance Requirements*, 10 CFR 830, Subpart A, October 19, 2020.

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