DEFENSE NUCLEAR FACILITIES SAFETY BOARD
Washington, DC 20004-2901

September 21, 2015

The Honorable Frank G. Klotz
Administrator
National Nuclear Security Administration
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0701

Dear Administrator Klotz:

The enclosed Defense Nuclear Facilities Safety Board (Board) Technical Report discusses potential actions that would reduce hazards at the Plutonium Facility (PF-4) at the Los Alamos National Laboratory (LANL). Our staff recently completed an effort to identify opportunities to minimize the nuclear material-at-risk in PF-4 and increase the use of robust, certified containers. The Department of Energy's (DOE) directives system clearly articulates the position that "minimization of hazardous materials is the first priority," and we share this philosophy. Accordingly, we provide the enclosed Technical Report for your consideration. The report provides a number of actions that we believe you should consider in order to further reduce the risk associated with PF-4, including:

1. Strengthening efforts related to lifecycle planning and management of nuclear materials, particularly at the activity level. Success requires attention to minimizing material-at-risk, effectively using, tracking, and managing robust, certified containers, and disposing of resulting residues as an integral part of program execution. We note that many of these concepts are already required by DOE Order 410.2, *Management of Nuclear Materials*.

2. Providing priority support for the execution of the Material Recycle and Recovery program, particularly the Accelerated Vault Work-off project. This important risk reduction effort enables routine use of robust, certified containers, disposition of "No Defined Use" materials, and effective use of the PF-4 vault and other hardened storage locations. Success for this risk reduction effort requires continuing management attention, given the PF-4 restart activities and the ongoing challenges with the transuranic waste management system.

Sincerely,

Joyce L. Connery
Chairman

Enclosure

c: Ms. Kim Davis Lebak
Mr. Matthew B. Moury
Mr. Joe Olencz

DNFSB/TECH-39

OPPORTUNITIES FOR RISK REDUCTION AT THE LOS ALAMOS NATIONAL LABORATORY PLUTONIUM FACILITY THROUGH THE MINIMIZATION OF MATERIAL-AT-RISK

Defense Nuclear Facilities Safety Board

Technical Report

September 2015

OPPORTUNITIES FOR RISK REDUCTION AT THE LOS ALAMOS NATIONAL LABORATORY PLUTONIUM FACILITY THROUGH THE MINIMIZATION OF MATERIAL-AT-RISK

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EXECUTIVE SUMMARY

This report identifies opportunities to reduce the radiological risk presented by the Plutonium Facility (PF-4) at Los Alamos National Laboratory (LANL) through actions associated with minimizing or otherwise protecting material-at-risk (MAR). The Defense Nuclear Facilities Safety Board's (Board) LANL Site Representatives, J. Plaue and R. Verhaagen, performed the bulk of this study, which consisted of analysis of the nuclear materials management database, facility walk-downs, and discussions with key federal and contractor personnel. The Board's staff identified the following opportunities that have the potential to reduce risk associated with PF-4 for site personnel to explore further:

- A significant quantity of MAR located on the first floor of PF-4 has not been used recently for programmatic activities, as evidenced by prolonged residence times. Alternative storage locations have sufficient capacity to offer an improved safety posture for protection from potential seismic and fire insults.

- Accelerated execution of the Material Recycle and Recovery program will free up considerable space in the facility vault, which provides better protection for MAR. Additionally, this program supports elimination of large quantities of MAR from the facility and the implementation of robust, certified containers.

- Numerous opportunities exist to strengthen the use, tracking, and management of robust, certified containers that the safety basis credits to survive certain postulated accidents. Effective implementation of these containers could support reducing the MAR limit established in the safety basis.

- Nuclear material lifecycle planning and execution could be strengthened to minimize MAR introduced at the onset of work and to ensure that residue materials are dispositioned properly as part of work completion.

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1. BACKGROUND

Since 2009, the Board emphasized concerns with the risk present at PF-4 from a postulated seismic event with a subsequent fire. The National Nuclear Security Administration's (NNSA) 2014 safety basis characterizes the risk from a postulated seismic event and subsequent fire, without collapse of the facility, as resulting in a mitigated consequence to the public of 24.23 rem committed effective dose [1]. The control set largely relies on the control of various forms of MAR and a passive confinement approach that is modeled to have a leak-path factor of about 13 percent. Consequences will scale linearly with any error in the leakage model (e.g., the model includes an embedded assumption that doors opened during personnel evacuation are all closed within 5 minutes), which is partly why Department of Energy (DOE) directives indicate an active confinement ventilation system is preferred over a passive confinement strategy. DOE's long-term solution to achieve the goal of reducing the mitigated public consequences to a small fraction of the evaluation guideline is to complete upgrades that will seismically qualify and upgrade to safety class the fire suppression system, its supporting firewater supply loop, and the active confinement ventilation system. Efforts are underway to implement these solutions; however, funding uncertainties exist and completion is optimistically 5–10 years away.

It is important to note that the previously discussed accident scenario assumes that the PF-4 structure will not collapse due to a design basis earthquake. However, the Board does not agree with the methodology DOE used to support this conclusion and sent a letter to the Secretary of Energy stating this dated July 17, 2013. DOE is currently pursuing an alternate analysis of the facility's seismic performance to resolve this technical dispute; however, the schedule to complete this effort and make any indicated physical upgrades is indeterminate.

In the interim, while DOE achieves these long-term solutions, one viable method of reducing the risk involves minimizing and protecting the MAR. DOE promulgated this fundamental tenet of nuclear safety in a number of directives, including the hierarchy of controls established in DOE Standard 1189-2008, *Integration of Safety in the Design Process*. This hierarchy explicitly states, "Minimization of hazardous materials is the first priority." Additionally, DOE Order 410.2, *Management of Nuclear Materials*, includes provisions to ensure that nuclear material inventories are "justified, optimized, and available to meet programmatic needs," and for inventory management programs to "provide for safe and secure packaging, storage, stabilization, and consolidation or disposition…."

To a certain extent, LANL management has embraced these concepts and accomplished a significant reduction in MAR in the last decade, while making improvements in nuclear material packaging. For example, safety basis limits for MAR on the first floor of PF-4 were reduced from 5 MT of plutonium (Pu)-239 equivalent in 2008 to 1.8 MT in 2012 in concert with implementing the safety basis addendum for the seismic collapse scenario. LANL has also been at the forefront of the complex-wide effort to develop and implement robust, certified containers for nuclear material storage. Notwithstanding this progress, the Congressional Research Service noted in a May 2015 report [2] that LANL has not rigorously determined the minimum amount of MAR required to support its pit manufacturing mission.

2. MATERIAL-AT-RISK USAGE AND CONTAINERIZATION ON THE FIRST FLOOR OF PF-4

Because LANL has not rigorously analyzed its MAR needs in PF-4, the Board's Site Representatives approached this study by categorizing actual MAR usage. The Site Representatives worked with LANL nuclear materials managers to obtain current inventory information for the first floor laboratory rooms. This information included the duration individual containers of nuclear material were resident within a given room. The Site Representatives used this residence time data as a proxy to help determine whether a container was in a state of active use or storage. The full approach is documented in a formal engineering calculation [3]. The results are based on data taken on March 31, 2015, and employ MAR values in Pu-239 equivalent assuming an S-type (i.e., slow absorption) lung clearance for inhalation dose consequences. Key findings from this study include the following.

2.1 On the First Floor of PF-4, 21 Percent of the MAR and 43 Percent of the Containers Have Been in Their Current Location for Greater Than 3 Years

The Site Representatives selected 3 years as a useful delineation point because it extends the time interval beyond the past 2 years (during which many facility operations have been paused due to nuclear criticality safety and conduct of operations issues) and includes a year of normal operations. The picture of MAR usage can be further refined by excluding Pu-238 operations from the analysis due to their high MAR value when converted to Pu-239 equivalency, which can mask results for other categories of MAR. The results of this study indicate that 37 percent of non-Pu-238 MAR has been idle for at least 3 years, including 20 percent that has been idle greater than 5 years. The full distribution of residence times for MAR and containers is provided in Figure 1. Residence time data beyond 5 years was not readily retrievable, though the Site Representatives identified several items with residence times in excess of a decade. For example, operations personnel are working on disposition plans for various Pu-238 materials associated with the production of power sources for the Cassini space mission in the 1990s.

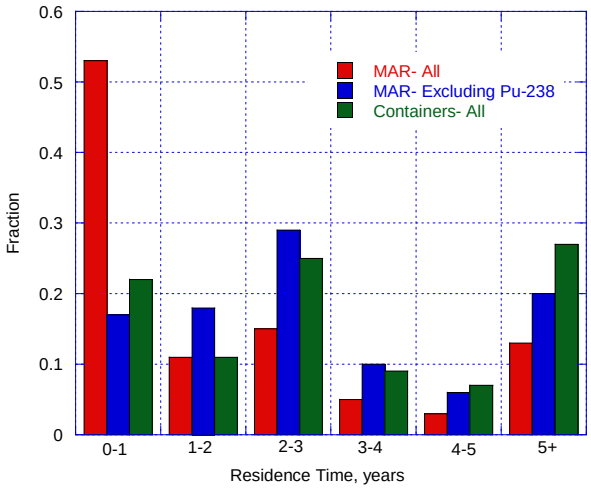

Figure 1: Distribution of residence times within a room for MAR and containers of nuclear material in PF-4

Some MAR is associated with long-term programmatic activities that require continuing residence on the first floor. However, based on discussions with the line managers responsible for operations, the Site Representatives determined that only about 10 kg of Pu-239 equivalent MAR is associated with this type of work in the form of measurement standards and materials supporting the long-term surveillance of containers under DOE Standard 3013-2012, *Stabilization, Packaging, and Storage of Plutonium-Bearing Materials*. This quantity represents less than one percent of the current MAR limit for the first floor. Overall, if one assumes the facility is operating near the allowable limit established in the approved safety basis, this finding indicates that more than 300 kg of Pu-239 equivalent could be moved off the first floor to more robust storage locations.

2.2 The Database Does Not Specify the Container Type for Sixty-Five Percent of the Containers

The safety basis credits certain certified containers as capable of protecting MAR from fire and drop insults. PF-4 personnel calculate their MAR inventory using data drawn from the Local Area Nuclear Material Accounting System (LANMAS). When performing a MAR calculation, PF-4 personnel are able to make reductions in the cumulative MAR inventory if workers specify in the database that the MAR is in certified containers. However, current procedures do not require the material handlers to enter the container type into the database. The database indicates that 12 percent of the containers are of a certified type (Figure 2), but walk-downs of the first floor by the Site Representatives suggest that the actual proportion of certified containers may be significantly higher. The database indicates that 23 percent of the containers are non-certified (e.g., generic "cans" or drums). Additional reductions in the existing MAR inventory (and possibly even credited MAR limits) may be possible by updating and maintaining an accurate database and transitioning away from the use of non-certified containers. One good practice observed by the Site Representatives is that the procedure for the vault requires workers to specify the container type in LANMAS prior to delivery to the vault. Extending this practice to all MAR movements could prove beneficial.

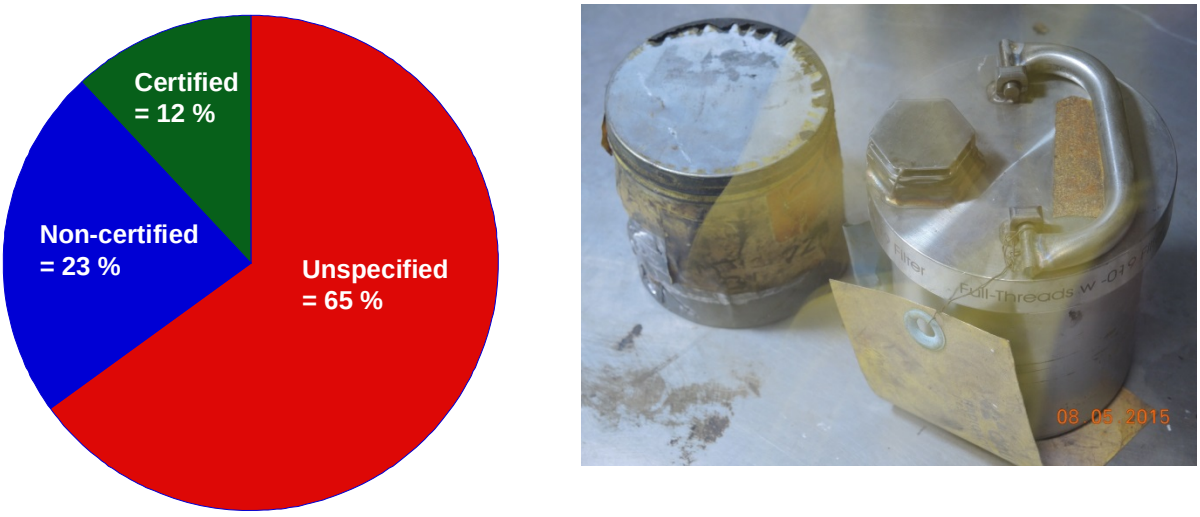

Figure 2: Profile of container types used for MAR storage on the first floor of PF-4 (left) and examples of a certified and non-certified container in a glovebox (right).

2.3 MAR is Distributed as 49 Percent in Gloveboxes, 30 Percent on the Floor, and 13 Percent in Safes

Gloveboxes and floor locations are the most vulnerable to impacts from seismic events and fires, yet these locations hold nearly 80 percent of the MAR (Figure 3). For example, floor locations are simply containers placed on areas demarcated on the floor (Figure 4). The first floor contains numerous safes that offer additional protection; however, while these locations contain about 58 percent by mass of the nuclear material, the Site Representative review revealed that this translates into only 13 percent of the MAR because a high fraction of the MAR in the safes is uranium isotope mixtures, which pose a significantly lower hazard than plutonium. This finding suggests that the MAR in more vulnerable locations could be better protected (in safes) if uranium isotope mixtures were stored elsewhere and then available safe storage were used preferentially instead of glovebox or floor locations.

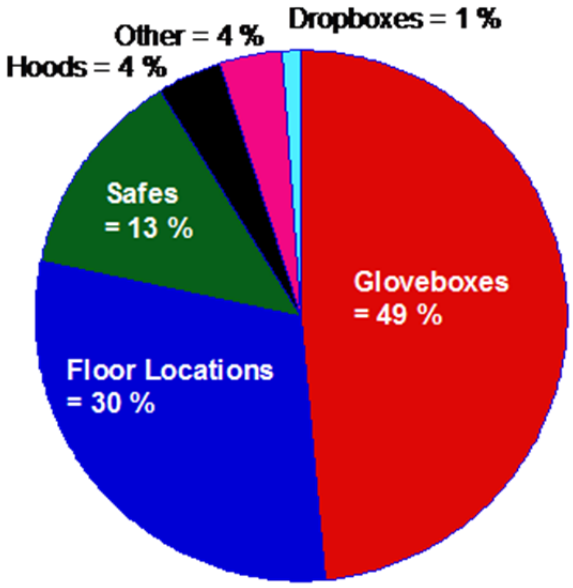

Figure 3: Distribution of MAR by location type on the first floor of PF-4.

Figure 4: Common MAR storage locations on the first floor of PF-4: a glovebox location holding a legacy "popcorn tin" containing plutonium (left) and one example of a floor storage location (right).

3. ALTERNATIVE LOCATIONS FOR MATERIAL-AT-RISK THAT OFFER RISK REDUCTION

The safety basis identifies a number of locations that protect MAR from fire and seismic insults. While the safety basis does not credit these locations to survive a seismically-induced structural collapse, the Site Representatives' engineering judgment suggests that these locations are robust and will provide the best protection available in the facility. The Board previously urged the Secretary of Energy to accelerate disposition of plutonium already designated as waste or surplus material and to implement robust containerization for dispersible forms of plutonium in a letter dated January 3, 2013. This section summarizes these locations and illuminates their capacity to accommodate much of the MAR that has accumulated on the first floor. LANL's nuclear material managers are working on taking advantage of these storage locations but have not made much progress because of the high priority placed on the PF-4 restart effort.

3.1 The Vault Offers Optimum Storage and has Available Capacity

By design, the ideal location in PF-4 for the storage of MAR is the vault. The safety basis credits the main vault and an associated storage array known as the Kardex units to withstand a design basis earthquake. Additionally, these locations have credited fire suppression systems and strict limits on transient combustibles. Determining vault space availability is a complex problem governed by a number of factors, including nuclear criticality safety limits, container geometry, and radiation levels. LANL data [4] indicate that several hundred storage locations of various types are currently available in the vault.

3.2 Safes Could also be Utilized for Protected Storage

PF-4 contains about 50 safes of various sizes and designs that offer improved protection for MAR, including many that the approved safety basis identifies as eligible to use reduced damage ratios in accident consequence calculations. Unfortunately, in most cases the use of safes is impeded by incomplete nuclear criticality safety evaluations, and incomplete seismic anchoring and supporting engineering documentation for the safes. Only limited resources are available to perform these tasks, and making safes available for storage has not been a priority. The Site Representatives' review of inventory information indicates there is ample available capacity. For example, six large, robust safes that were acquired in the past few years could potentially accommodate more than 200 kg of material, but are presently empty (Figure 5).

Figure 5: This safe offering improved protection for MAR is unused.

3.3 MAR Disposal as Transuranic Waste

The Accelerated Vault Work-off project under the Material Recycle and Recovery program aims to recycle, recover, repackage, or dispose of 2.5 MT of nuclear materials from the facility, including about 700 kg destined to leave PF-4, most as transuranic waste [5]. More broadly, this effort addresses much of the materials present that are categorized as No Defined Use[1], which total roughly 40 percent by mass of the plutonium inventory (excluding Pu-238) at PF-4 [6]. This important initiative will free up storage space and greatly improve safety and efficiency for vault users. Unfortunately, this initiative's progress has been hindered by resource conflicts associated with the ongoing PF-4 restart effort and issues at the various LANL facilities that manage transuranic waste. For example, PF-4 operations are nearing the point of curtailing waste generating activities because local waste staging areas are approaching their capacity and Area G remains unable to receive newly-generated waste due to a number of significant safety basis issues (Figure 6).

Figure 6: MAR contained in transuranic waste drums and staged in an operating laboratory.

[1] DOE Order 410.2, *Management of Nuclear Materials*, defines these as "nuclear materials that are not actively being used by any program and not being held for future programmatic use. No Defined Use may include materials that are being stabilized for discard, materials that may require processing, or materials suitable for storage pending future disposition."

4. FACTORS CONTRIBUTING TO ACCUMULATION OF MATERIAL-AT-RISK ON THE FIRST FLOOR

This review identified several common themes that the Site Representatives believe contributed to the quantity of idle MAR on the first floor of PF-4.

4.1 Nuclear Material Lifecycle Planning and Execution Need Strengthening

Discussions with the LANL program groups revealed a lack of lifecycle planning, which is required under DOE Order 410.2, to be the single largest contributor to accumulation of MAR. While some groups are making efforts to improve aspects of the situation, the following problems were apparent:

- LANL management has not implemented a process to ensure efficient MAR usage, likely because of the generous margin authorized in past safety bases. Further, as previously stated, the actual MAR needed to meet production requirements has not been rigorously determined or otherwise optimized.

- Some NNSA programs have not always provided funding for the complete disposition of residual materials and wastes generated as part of their mission. For example, the 2015 mid-year review documents for the Material Recycle and Recovery Program indicate that the disposition of residues by the Pit Surveillance Program has not previously been funded. This resulted in inactive MAR, disposition of which eventually became an unfunded burden to other programs.

- On occasion, operations groups commenced production activities with the knowledge that downstream residue processing was inoperable or did not exist. For example, a program activity generated materials in a glovebox that cannot leave that glovebox because approved material accountability measurements do not exist.

- Disposition of residues was not inherently considered part of completing the production process, or priorities shifted without considering disposition of the material in process. As a positive example, one group now includes disposition of materials as part of the formal traveler process used to guide workflow and accountability.

4.2 Workers Need Simplified Processes for Vault Use and Containerization

Workers indicated that the processes to place items in the vault or retrieve items from it are cumbersome, time consuming, and poorly documented. These difficulties, compounded by concerns over radiation exposure and the need to wear respiratory protection, make use of vault storage an option that is at best unappealing for the workforce. Likewise, workers face similar hindrances when selecting the container for particular MAR and logging the choice of containers into the nuclear material control database. Drivers for container selection stem from diverse and unconnected programs, such as nuclear criticality safety, safety basis controls for the protection of the public, worker protection, and programmatic quality. This results in a situation that is poorly integrated and difficult for a worker to navigate. To their credit, LANL management has recognized this situation as untenable and chartered a process improvement initiative.

5. CONCLUSION

The Site Representatives identified the following opportunities that have the potential to reduce risk in PF-4 for site personnel to explore further:

- A significant quantity of MAR located on the first floor of PF-4 has not been used recently for programmatic activities, as evidenced by prolonged residence times. Alternative storage locations have sufficient capacity to offer an improved safety posture for protection from potential seismic and fire insults.

- Accelerated execution of the Material Recycle and Recovery program will free up considerable space in the facility vault, which provides better protection for MAR. Additionally, this program supports elimination of large quantities of MAR from the facility and the implementation of robust, certified containers.

- Numerous opportunities exist to strengthen the use, tracking, and management of robust, certified containers that the safety basis credits to survive certain postulated accidents. Effective implementation of these containers could support reducing the MAR limit established in the safety basis.

- Nuclear material lifecycle planning and execution could be strengthened to minimize MAR introduced at the onset of work and to ensure that residue materials are dispositioned properly as part of work completion.

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