

Bruce Hamilton, Chairman
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**DEFENSE NUCLEAR FACILITIES
SAFETY BOARD**

Washington, DC 20004-2901



June 1, 2020

The Honorable Dan Brouillette
Secretary of Energy
US Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-1000

Dear Secretary Brouillette:

The Defense Nuclear Facilities Safety Board completed a review of the safety basis of the Highly Enriched Uranium Materials Facility (HEUMF) at the Y-12 National Security Complex. The review focused on materials discovered in the facility that were not authorized in the safety basis, as well as materials transferred to HEUMF as part of a site-wide material-at-risk reduction strategy.

Although the NNSA Production Office has approved continued storage of the discovered materials, those materials as well as other materials being transferred to HEUMF have been neither fully characterized nor confirmed to be chemically stable. The Board recognizes that HEUMF is a more robust storage facility than alternative facilities at Y-12 due to its structural design and controls such as safety-significant fire suppression and secondary confinement ventilation systems to mitigate hazards, however, until these discovered materials have been appropriately characterized, a determination of acceptable risk from energetic events cannot be made.

Pursuant to 42 USC § 2286b(d), the Board requests a briefing, including analysis or supporting data, to describe NNSA's strategy for safe storage of these materials at HEUMF within 90 days of receipt of this letter. The briefing should address the following:

- Strategies to protect facility workers from energetic events initiated inside storage containers;
- Actions to ensure materials received, or already stored, at HEUMF are suitable for prolonged storage, including identification of criteria for determining the stability of the materials stored at HEUMF, characterization of their potential reactive hazards, and potential stabilization of those materials; and
- Disposition path of materials determined unsuitable for storage at HEUMF.

The enclosed report provides additional details for your information and use.

Yours truly,

A handwritten signature in black ink that reads "Bruce Hamilton". The signature is written in a cursive style with a large, prominent "B" and "H".

Bruce Hamilton
Chairman

Enclosure

c: Mr. Joe Olencz

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Report

April 21, 2020

Reactive Materials Stored at HEUMF

Summary. The Defense Nuclear Facilities Safety Board's (Board) staff completed a review of the safety basis of the Highly Enriched Uranium Materials Facility (HEUMF) at the Y-12 National Security Complex. The review of the safety basis included the documented safety analysis (DSA), potential inadequacies of the safety analysis (PISAs) as a result of unauthorized transfer and storage of enriched uranium materials, justification for continued operations (JCO), and safety evaluation reports. The review also included an evaluation of the Area 5 de-inventory (A5D) campaign to transfer enriched uranium materials stored at existing facilities to HEUMF as part of the site-wide material-at-risk (MAR) reduction strategy. The staff team conducted two on-site interactions: on April 16–17, 2019, with Consolidated Nuclear Security, LLC (CNS) personnel, and on November 6, 2019, with National Nuclear Security Administration (NNSA) Production Office (NPO) personnel.

The staff team concluded that the materials associated with the JCO (JCO materials) and some of the materials associated with the A5D campaign (A5D materials) pose a risk to the facility worker at HEUMF because the materials are not fully characterized to predict their chemical reactive behavior. These materials have not been confirmed to be stable and may pose an internal hazard¹, which could result in an energetic exothermic event (e.g., pyrophoricity, lid ejection), and potentially cause serious injury to the worker. The staff team finds the safety basis does not prevent internal hazards of materials while in storage. Additionally, the staff team concluded that existing safety controls may not be effective at protecting the facility worker from these internal hazards.

Background. CNS declared three PISAs as a result of unauthorized transfer of enriched uranium materials to HEUMF. In February 2018, CNS personnel discovered that 16 containers containing enriched uranium alloys in the form of turnings and flashings were stored on the racks in HEUMF. CNS declared the first PISA because the “‘turnings’ and ‘flashings’ do not meet the material requirements for long term storage in [prolonged low maintenance storage] (dry, stable metals and oxides) per the DSA, because turnings/flashings have the potential to be pyrophoric and/or ignitable” [1]. This is further exemplified in Y-12's site standard Y/ES-015, *Criteria for the Safe Storage of Enriched Uranium at the Y-12 National Security Complex*, which does not allow prolonged low maintenance storage of such materials. The first PISA led to a positive unreviewed safety question determination (USQD) and a subsequent extent of condition review of the HEUMF inventory [2].

During the April 2018 extent of condition review, CNS personnel discovered additional containers with enriched uranium materials that were not authorized for storage in HEUMF.

¹ Throughout this report, the term “internal hazard” refers to a runaway chemical reaction initiated inside a storage container with the potential to release enough energy to breach container integrity and impact the facility worker.

CNS declared a second PISA because the “material in these additional eight drums has the potential to be pyrophoric and contained ‘fines’ which represent a material form that has not been analyzed in the facility DSA. In addition, the accident analysis in the [DSA] specifically states that ‘uranium metal [chips], fines, and turnings are not stored in the facility.’ This material form could result in an accident of a different type that has not been previously evaluated in the facility DSA. As a result, the accident analysis and controls may not be bounding for facility operations as analyzed in the facility DSA” [3]. Shortly after, CNS declared a third PISA because “unanalyzed material in Rackable Can Storage Boxes (RCSBs) has the potential to impact the safety functions of the RCSBs (could expand above BoroBond poison in the RCSB) and represents a material form that has not been analyzed for storage in RCSBs in the facility DSA” [4]. Both the second and third PISAs led to positive USQDs [5] [6].

Following these discoveries, CNS prepared a JCO, imposed two administrative controls to justify safe continued storage of these materials in HEUMF, and re-categorized all materials that were originally considered as ignitable and potentially pyrophoric as not pyrophoric. The compensatory administrative controls consisted of combustible and hot work controls, in addition to clearly marked stickers on the drums that prohibited any further movement or handling activities [7]. NPO approved the JCO and directed the contractor to revise the DSA and incorporate the material types that were the subject of the JCO into the facility safety basis. NPO approved the revised DSA that incorporated these material types, but the compensatory administrative controls listed above were not incorporated into the revised DSA.

The staff team also evaluated the A5D campaign of materials transferred into HEUMF because these materials can have characteristics similar to the JCO materials. Y-12 has been actively transferring materials from existing facilities (e.g., Buildings 9212, 9215, and 9720-5) to HEUMF since 2010. The MAR reduction strategy is a high priority at Y-12; in August 7, 2014, NNSA directed the site to “accelerate the reduction of the Area 5 uranium inventories” and “utilize HEUMF to store the majority of enriched uranium at Y-12 and as appropriate, modify the Safety Basis for the HEUMF to expand the material types and containers allowed in storage” [8]. NNSA stated such activity would reduce the site’s overall facility safety risk by reducing the potential off-site dose and improve safety using HEUMF as a “robust facility” because of its modern design features [9].

Discussion. The staff team identified one safety item related to the transfer of the JCO materials and some of the A5D materials to HEUMF. The safety basis does not address prevention or mitigation of potential internal hazards that could cause an energetic event at HEUMF since the chemically reactive behaviors of those materials are not fully characterized. Therefore, the existing control set may not protect the facility worker adequately.

Characterization and Stability of the Materials—The containers that resulted in the three PISAs/USQDs were categorized in the JCO as the following reactive material types:

- Drums with ignitable materials (turnings and/or flashings),
- Drums with pyrophoric materials (chips, turnings, and/or fines), and
- Drums and RCSBs with expandable materials.

However, Y-12 personnel re-categorized the materials in subsequent revisions of the JCO upon further review of data from the Central Scrap Management Office database, photographs, and material receipt documents. Y-12 personnel modified the previous three categories into two categories, both of which require an ignition source: (i) ignitable and water-reactive or (ii) ignitable and expandable. As part of this re-categorization, materials previously determined to be pyrophoric were designated as either stable and acceptable for continued rack storage, or ignitable with piloted ignition and water-reactive.

DOE Handbook 1081-2014, *Primer on Spontaneous Heating and Pyrophoricity*, states that “uranium in a finely divided form is readily ignitable, and uranium scrap from machining operations is subject to spontaneous ignition.” The handbook defines pyrophoric as “a material that, even in small quantities and without an external ignition source, can ignite at or below 54.4°C (130°F) in contact with air” [10]. Pyrophoric behavior of uranium forms has been observed at Y-12 facilities, such as uranium fines created from machining operations in Building 9215 [11]. Further, spontaneous exothermic events involving uranium briquettes occurred in storage at Building 9212 [12 – 15]. Changes over time in chemical composition and reactive properties for materials in storage may also increase the risk of internal hazards.

CNS determined the JCO materials are safe in storage and revised the DSA to allow for future receipt of these materials at HEUMF; NPO approved the revised DSA. The staff team does not agree with Y-12 personnel’s determination that these materials are not pyrophoric for the reasons listed above. Further, Y-12 personnel made this determination using expert judgment based on visual examination and review of documentation without proper technical justification. Sampling to enable analyses such as ignition tests and chemical characterization may be necessary to accurately define the chemical reactivity and predict chemical stability. Some of the A5D materials may have chemically reactive properties similar to the JCO materials; therefore they may have similar internal hazards.

The HEUMF safety basis does not include credited controls to prevent or mitigate potential internal hazards, such as pyrophoricity, that could cause an energetic event and impact the facility worker (e.g., via a lid ejection). During the on-site interaction, DOE and CNS personnel stated that the safety-significant fire suppression and secondary confinement ventilation systems were robust controls to mitigate reactive hazards associated with materials in storage at HEUMF. The staff team recognizes the robustness of the control set to mitigate the consequences of energetic events to the collocated worker and public. However, these controls do not mitigate or prevent consequences to facility workers from internal hazards that may be present at HEUMF. The DSA identifies that inner containment vessels within containers could reduce the risks from internal hazards for materials in storage, but this is not part of the credited control set. The staff team does not consider the existing credited control set adequate to prevent and mitigate internal hazards for these materials in storage at HEUMF.

Disposition Strategy and Long-term Plans—The Y-12 site-wide standard Y/ES-015, *Criteria for the Safe Storage of Enriched Uranium at the Y-12 National Security Complex*, was created to establish the criteria for material types that are acceptable for short-term staging or long-term storage at Y-12 facilities. This standard assigns storage categories to enriched uranium materials based on the material form, container type, future use, storage time, and other

program needs. The categories include transient storage, interim storage, and prolonged low-maintenance storage. The site-wide standard states “enriched uranium assigned to Prolonged Low-Maintenance Storage shall be a metal or a stable oxide and shall not be classified as ‘in-process’” [16].

The site-wide standard’s criteria for prolonged low-maintenance storage are inconsistent with the revised DSA. CNS personnel stated a campaign exists to disposition some of the materials stored at HEUMF that may be unsuitable for prolonged low maintenance storage; this campaign applies to a subset of such containers. During discussions with the staff team, NPO acknowledged the need for alternative disposition strategies (such as stabilization) for the remainder of the materials stored in HEUMF that do not meet the criteria for prolonged low-maintenance storage.

Conclusion. The staff team concluded that the HEUMF safety basis does not prevent or mitigate potential internal hazards that could cause an energetic event; therefore the existing control set may not protect the facility worker adequately. NPO has authorized storage of uranium material forms (e.g., chips, turnings, flashings) known to exhibit pyrophoric behaviors without adequate characterization of the chemically reactive properties of the materials. Continued storage of these materials could further increase the risk due to chemical aging phenomena. The staff team concluded that a strategy is needed to characterize and mitigate these internal hazards, ensure materials received at HEUMF are suitable for storage, and disposition materials determined to be unsuitable for storage at HEUMF. Such a strategy would help ensure that energetic events, such as those experienced at the Waste Isolation Pilot Plant and Idaho National Laboratory in February 2014 and April 2018, do not occur at Y-12.

References

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- [2] Consolidated Nuclear Security, LLC, *PISA Involving Potentially Ignitable Material as Turnings/Flashings in HEUMF*, USQD-18-9720-82-0002, March 2018.
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- [4] Consolidated Nuclear Security, LLC, *New Information/PISA Entry Disposition*, USQ 21234-KMATTERN-20180411-A, April 2018.
- [5] Consolidated Nuclear Security, LLC, *PISA Unanalyzed Material in HEUMF*, USQD-18-9720-82-0004, April 2018.
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- [10] Department of Energy, *DOE Handbook Primer on Spontaneous Heating and Pyrophoricity*, DOE-HDBK-1081-2014, 2014.
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- [12] Defense Nuclear Facilities Safety Board, *Oak Ridge Activity Report for Week Ending December 16, 2016*, December 2016.
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- [14] Defense Nuclear Facilities Safety Board, *Oak Ridge Activity Report for Week Ending June 30, 2017*, June 2017.
- [15] Defense Nuclear Facilities Safety Board, *Oak Ridge Activity Report for Week Ending August 18, 2017*, August 2017.
- [16] BWXT Y-12 LLC, *Criteria for the Safe Storage of Enriched Uranium at the Y-12 National Security Complex*, Y/ES-015, November 2007.