Office of Environment, Health, Safety and Security
Operating Experience Summary

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Uranium Accumulation Discoveries at Y-12

Introduction

This Operating Experience Summary provides information about multiple discoveries of unexpected accumulations of uranium in processing equipment at the Y-12 National Security Complex (Y-12).

Background

During 2017 and 2018, Consolidated Nuclear Security, LLC (CNS) made multiple discoveries of unexpected accumulations of uranium in processing equipment at the Y-12 National Security Complex (Y-12). In all instances, CNS paused operations while executing corrective actions to address identified issues. CNS is aggressively addressing the underlying causes of these accumulations across its facilities and programs. In August, CNS completed the Extent-of-Condition phase of the accumulation response effort and transitioned into a phase of executing long-term improvements, which are being managed via a site-level initiative on Nuclear Material Stewardship.

The Sand Separator Discovery

In June 2017, in preparation to repair a hydraulic leak in a knockout glovebox (see Fig. 1) within the Reduction area[1] of Building 9212, radiological survey measurements were taken for equipment below the glovebox. The results of these surveys indicated that more than 800 grams of enriched uranium had unexpectedly accumulated in the sand separator beneath the glovebox. Given the potential for moderation within this unfavorable-geometry equipment, this situation represented a significant nuclear criticality safety concern.

Figure 1. Knockout Glovebox

Immediate Response

CNS immediately responded by suspending operations in the subject glovebox until the necessary analysis could be performed and additional criticality safety controls could be implemented. Subsequent to taking these immediate actions, CNS performed a root cause analysis and executed a series of Extent-of-Conditions evaluations intended to ensure necessary crosscutting programmatic improvements were identified and implemented.

[1] The purpose of the Reduction process is to produce purified uranium metal via an exothermic chemical reaction involving UF4 and calcium within a reactor vessel. A portion of the overall Reduction Process occurs in a 'knockout' glovebox, where the reaction products are dumped out of the reactor vessel and separated for disposition. Some of the reaction products are swept into a 'sand separator' through a hole in the floor of the glovebox. The purpose of the sand separator is to mechanically separate MgO sand from other reaction products.

Root Cause Analysis Results

Several years ago, the knockout process was modified with regards to how slag produced during the Reduction process was dispositioned. The historical process involved routing the slag through a chute in the floor of the knockout glovebox into a can beneath the glovebox (see Fig. 2). The new process involved putting the slag into a tray, which was then handed-off to an adjacent hood. At the time the process was modified, operators errantly assumed that material was no longer collecting in the can at the end of the chute beneath the glovebox. In reality, a mixture of MgO sand and uranium was slowly (over a period of years) accumulating in the can, accumulating up the chute, and eventually accumulating up the sand separator (see Fig. 3). The root cause analysis team determined that the following three root causes led to the unanalyzed 'process drift' and unexpected accumulation of uranium in the sand separator:

- Processes to formally assess proposed changes to operations (i.e., processes to evaluate the potential for 'process drift') were inadequate
- Criticality Safety Evaluations lacked necessary analysis and controls
- Operating Procedures failed to include key subtasks

Figure 2. Floor of the Knockout Glovebox

In addition, the team identified the following missed opportunities:

- Information about inventory and holdup measurements was not shared between Criticality Safety, Non-Destructive Assay, and Nuclear Material Control & Accountability personnel
- The existing Inadvertent Accumulation Prevention Program (IAPP) had not been rigorously implemented and maintained

Figure 3. Sand Separator and Slag Collection Chute

- Annual Operations Reviews performed by Criticality Safety personnel were not comprehensive in scope

Extent-of-Condition Review Scope and Results

A series of broad and thorough Extent-of-Condition (EOC) reviews were performed following the discovery of unexpected accumulation in the sand separator. These reviews included evaluating the following areas:

- Process documentation, field conditions, and implementation of Criticality Safety Controls
- Previously identified weaknesses within Criticality Safety Evaluations
- The Inadvertent Accumulation Prevention Program
- Annual operational reviews performed by Nuclear Criticality Safety personnel
- Operating procedures and operator training

Numerous actions were taken as a direct result of these reviews. These actions included the following:

- A database consisting of over 1000 backlogged issues in Criticality Safety Evaluations was evaluated to identify any other scenarios where potential material accumulations and associated moderation scenarios may be insufficiently analyzed. These 1000+ items were previously determined to be low significance issues that

were allowed to languish over time due to competing funding priorities. Review of this database led Criticality Safety personnel to identify 23 Potential Nuclear Criticality Safety Issues (the Y-12 Criticality Safety program equivalent to a Potential Inadequacy used in standard Safety Analysis applications).

- A few dozen open recommendations from past IAPP reports were evaluated to determine whether any high-priority process modifications were warranted. These open recommendations were presented to Y-12's Nuclear Criticality Safety Advisory Council for prioritization and disposition.
- IAPP reports were re-evaluated, to include field walk-downs being performed by multi-disciplinary teams representing multiple organizations (e.g., production, engineering, security, etc.). More than 20 outdated IAPP reports were subsequently updated based on new information gathered during these reviews and walk-downs.
- All Criticality Safety Evaluations were reviewed to identify criticality safety controls that are implemented via after-the-fact measurements of process parameters or potential accumulation points. Nineteen controls were identified that fall into this category. In each case, past measurement results were reviewed to ensure these controls were being properly implemented and that criticality safety limits had not been exceeded.

Figure 4. Conveyor within the Casting Line

Casting Accumulation Discoveries

Between November 2017 and March 2018, while executing the Extent-of-Condition reviews described above, CNS identified three additional instances of unexpected accumulations of uranium in casting line of Building 9212. Specifically, the three instances involved (a) non-uniform accumulation of oxide below the casting line (see Fig. 4), (b) a large quantity of legacy oxide and small pieces of metal in a difficult-to-access area of the casting line, and (c) accumulation of oxide in bowls beneath the casting furnaces (see Fig. 5). These accumulations were inconsistent with assumptions (both explicit and implicit) made in applicable criticality safety analyses.

Figure 5. Casting Bowl

Discovery of these additional issues led CNS to suspend and thoroughly evaluate 44 processes throughout Y-12 that were determined to have a higher potential for accumulation-related issues.

Following the casting discoveries, CNS directed that multi-disciplinary teams perform walk-downs of 44 higher-risk operations. The processes were selected primarily due to a combination of the following factors being present in the process: unfavorable geometries, high-equity material, and the potential for oxides or fines with moderating materials.

A thorough root cause analysis was performed of the casting accumulation issues. In general, the causes identified aligned with causes of the sand separator

accumulation issues discussed above, including vague documentation of process assumptions and lack of awareness across organizations of how certain process anomalies impact each program.

Long-term Improvements

Formal corrective actions targeting process-specific issues were identified as a normal part of executing the Y-12 issues management process. However, based on the results of the aforementioned causal analysis and Extent-of-Condition reviews, senior CNS management developed and has committed to executing a site-level initiative for improving stewardship of nuclear material across Y-12. This initiative includes the following long-term improvement actions:

- Improving communication and integration between site-wide organizations
- Reviewing and clarifying the roles, responsibilities, and field-time metrics for both criticality safety engineers and criticality safety officers
- Developing a metric to track the quality of criticality safety evaluations and drive prioritization of updates to evaluations
- Improving processes for maintaining, updating, and controlling IAPP reports
- Reviewing execution and effectiveness of actions taken for similar events
- Improving the scope and execution of the Nuclear Criticality Safety annual operational reviews
- Reviewing administrative after-the-fact, measurement-based criticality safety controls for potential improvements
- Performing an external review of crosscutting causes of accumulation discoveries, to include evaluation by independent criticality safety experts from across the complex
- Improving processes for evaluating changes to enriched uranium processes
- Improving contractor assurance processes used to evaluate the effectiveness of site-wide safety management programs
- Improving operator and supervisor training

Lessons Learned

Senior CNS management directed development of this Operating Experience Summary to ensure lessons learned from this series of discoveries are shared with other organizations through the Department of Energy's nuclear complex. Key Lessons Learned identified during execution of aforementioned evaluations and reviews include the following:

- Evaluating Process Changes—At Y-12, formal and rigorous processes exist for evaluating changes to procedures and equipment, but some process changes do not require procedure or equipment changes. Effectively evaluating process changes relies on assumptions being well documented and evaluated when considering myriad types of changes (e.g., physical, operational, organizational, or programmatic changes).
- Communication between Internal Organizations—It is important to be diligent about ensuring that internal organizations (e.g., operations, engineering, security, etc.) are communicating and sharing data. The more an organization understands about the thresholds for each function, the better it can recognize an opportunity to identify and report potential problems.
- Issues Management—Low priority issues can't be allowed to languish indefinitely, and some monitoring of compounded significance must balance the backlog of low significance items.
- Training—Operations personnel (including operators and supervisors) need to have a thorough understanding of the analysis that underlies the controls for their operations, particularly the assumptions and boundaries of the applicable analysis. An operator should be encouraged to identify potential problems based on a thorough understanding the process constraints, rather than relying solely on threshold quantities identified in applicable operating procedures and postings.

The Office of Environment, Health, Safety and Security (AU), Office of ES&H Reporting and Analysis publishes the Operating Experience Summary to promote safety throughout the Department of Energy (DOE) Complex by encouraging the exchange of lessons-learned information among DOE facilities.

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