DEFENSE NUCLEAR FACILITIES SAFETY BOARD
Washington, DC 20004-2901

July 25, 2019

The Honorable James Richard Perry
Secretary of Energy
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0701

Dear Secretary Perry:

The Defense Nuclear Facilities Safety Board completed a review of the Y-12 National Security Complex (Y-12) Criticality Safety Program and recent Y-12 uranium accumulation discoveries in 2017 and 2018. The review revealed several deficiencies in the Y-12 Criticality Safety Program that indicate an inadequate Y-12 contractor program and revealed inadequate federal oversight by the National Nuclear Security Administration Production Office (NPO). On March 4, 2019, Y-12 and NPO provided a brief to the Board on the status of the Y-12 Criticality Safety Program. However, the Board is still concerned with the deficiencies revealed by the review of the Y-12 Criticality Safety Program. The enclosed staff report reflects the information that the Board's staff was able to obtain during its review.

The Board notes that NPO did not demonstrate that the Y-12 Criticality Safety Program was compliant with applicable national consensus standards and U.S. Department of Energy (DOE) standards on criticality safety. The Board determined that the underlying causes that led to the recently discovered uranium accumulations were linked to systemic issues with the Y-12 Criticality Safety Program. The Y-12 Operations management and staff need to be engaged in the criticality safety process and understand how the assumptions and bases for criticality controls impact the safe operation of their processes in order to improve the Y-12 Criticality Safety Program.

Y-12 is currently managing several significant scope changes, including but not limited to: (1) bringing the Uranium Processing Facility online; (2) major system additions and/or changes to uranium processing (e.g., direct chip melt, electrorefining); (3) decontamination and decommissioning of buildings in accordance with the Y-12 extended life program (ELP); and (4) transfer of equipment and fissile material activities to alternative buildings in support of the Y-12 ELP. Scope changes coupled with an inadequate Y-12 Criticality Safety Program could increase the criticality safety risk to the worker.

The Board encourages the DOE to utilize the enclosed information to address the deficiencies and make improvements in the Y-12 Criticality Safety Program.

Yours truly,

Bruce Hamilton
Chairman

Enclosure

c: Ms. Lisa E. Gordon-Hagerty
Mr. Daniel Sigg
Mr. Joe Olencz

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Report

February 11, 2019

Y-12 National Security Complex Criticality Safety Review

Summary. Members of the Defense Nuclear Facilities Safety Board's (Board) staff conducted a review of the Y-12 National Security Complex (Y-12) Criticality Safety Program (CSP). The staff team conducted process walkdowns of casting, reduction, wet hood, wiped film evaporator, ultrasonic chip cleaning, and chip rinsing systems. From July 29, 2018, to August 2, 2018, the staff team conducted interviews with Y-12 management and staff. The staff used lines of inquiry tied to American National Standards Institute (ANSI)/American Nuclear Society (ANS)-8.19, *Administrative Practices for Nuclear Criticality Safety Programs* [1], DOE Standard 1158, *Self-Assessment of DOE Contractor Criticality Safety Programs* [2], and the nuclear criticality safety (NCS) best practices, as outlined in the Secretary of Energy sponsored 1999 Department of Energy's (DOE) NCS Workshop [3]. ANSI/ANS 8 series standards, such as ANSI/ANS-8.19, promote safe and efficient operations of process plants with respect to criticality safety. In accordance with DOE Order 420.1C, "The CSP document must describe how the contractor will satisfy the requirements of the ANSI/ANS-8 series of nuclear criticality safety standards" and "…must include an explanation as to why any recommendation in applicable ANSI/ANS-8 standards is not implemented."[4]

The staff team identified three potential safety items: (1) inability of the NCS organization to adequately maintain the Y-12 CSP; (2) lack of operations personnel participation, cooperation with, and ownership of criticality safety at Y-12 and the NCS organization; and (3) inadequate interface between the Y-12 CSP and support programs. Based on these three potential safety items, the staff has concluded that Y-12 has an inadequate CSP.

Consolidated Nuclear Security, LLC (CNS) is the contractor for the Y-12 National Security Complex. The National Nuclear Security Administration (NNSA) Production Office (NPO) provides federal oversight of CNS activities and safety programs.

Background. The Board has a long standing interest in criticality safety at Y-12. Two examples of Board correspondence directed to Y-12 are Recommendation 94-4 and the January 2009 letter to NNSA on inadequate criticality safety evaluations at the Highly Enriched Uranium Materials Facility (HEUMF). In September 1994, the Board issued Recommendation 94-4, *Criticality Safety Deficiencies at Oak Ridge Y-12 Plant* [5]. The Board noted that over a four month period, numerous operational safety requirement and other safety violations occurred at Y-12, including a substantial violation of NCS limits within a special nuclear material storage vault. Y-12 did not perform the immediate corrective actions required by its procedures to address the NCS violation once the violation was identified. A subsequent review of compliance with NCS safety limits at Y-12 revealed widespread non-compliance.

In January 2009, the Board issued a letter to the NNSA Administrator (NA-1). The Board noted that "NCS evaluations for HEUMF failed to comply with requirements of applicable American National Standards Institute (ANSI)/ American Nuclear Society (ANS) consensus standards, Department of Energy (DOE) directives, and Y-12 NCS program procedures in two major areas:" (1) "credible abnormal conditions for operations were not analyzed and shown to be subcritical because the double contingency principle was misapplied;" and (2) "upset conditions deemed unlikely to occur do not meet the definition of 'unlikely' found in both DOE Standard 3007-2007 and Y-12 NCS program procedures [6]." The Board requested a briefing from NNSA to cover actions taken or planned to be taken to address the staff's observations and results of any extent-of-condition (EOC) evaluations performed to determine whether other Y-12 NCS evaluations met applicable requirements. Y-12 NCS management briefed the Board on October 27, 2010. The site conducted an EOC review on 137 criticality safety evaluations (CSE) including the casting, reduction, and ultrasonic chip cleaning CSEs [7]. In the casting CSE, the EOC review identified potential to accumulate mass in certain areas as an issue that could not be described as unlikely. The site committed to include all issues with CSEs, identified in the EOC, in the CSE upgrade plan [8]. In addition, the site updated the Y-12 NCS Program [9] and CSE development and approval procedures [10] with increased emphasis on process analysis. As this report will show, between 2010 to present day minimal progress has been made on improvement actions. Furthermore, this report will show that efforts made in 2010 to increase emphasis on process analysis, while proceduralized, were not sufficiently implemented resulting in the recent uranium accumulations events starting in May 2017.

In May 2017, Y-12 NCS engineers identified unexpected quantities of accumulated uranium in the sand recycling system that supports the Building 9212 reduction system [11, 12]. Uranium accumulation in the sand separator was an unanalyzed abnormal condition. CNS conducted an EOC review to evaluate the root causes of the event and identify other processes where unexpected uranium accumulation may be present. Subsequent to the issuance of the EOC report, Y-12 NCS engineers identified four additional unanalyzed uranium accumulations between December 2017 and April 2018:

- **December 1, 2017** [13, 14] – In support of the EOC review, NCS engineers reviewed uranium accumulation in non-destructive assay (NDA) reports from the September 2017 semi-annual inventory. NDA results revealed a combination of uranium oxide, uranium metal, and graphite accumulated under the casting hood in four distinct locations. The highest mass retrieved from any of the four locations contained approximately 9 kg of U-235.

- **Week of February 5, 2018** [15] – NCS engineers identified several historical violations of an NCS limit applicable to the Holden Gas Furnace system. Operators clean out material from the furnace on a quarterly basis to ensure that no more than 500g of U-235 would accumulate in certain areas of the furnace.

- **Week of March 30, 2018** – NCS engineers discovered uranium accumulation in several areas of the casting line, most notably in the lower vessel heads of two separate casting furnaces.

- **April 2018** [16, 17] – During walkdowns related to the EOC review, NCS engineers found a black color liquid in the ultrasonic chip cleaning phase separator tanks. Operations personnel stated the black color, assumed to be related to a gel-like substance that had been forming in the tanks since the cleaning solvent was changed in 2013, had gotten progressively worse over the last several years. Following subsequent NDA measurements in June 2018, CNS determined that uranium had accumulated in the phase separator tanks and tank header piping.

The staff concludes that underlying causes that led to the recently discovered uranium accumulations are linked to systemic issues with the Y-12 CSP and signify an inadequateY-12 CSP.

Staff Identified Potential Safety Items. The staff team's objective during this review was to evaluate Y-12 CSP's compliance with DOE requirements derived from ANSI/ANS 8.19-2014 and supporting ANSI/ANS-8 series standards. The staff team's evaluation of the Y-12 CSP included effective implementation of program requirements in nuclear CSEs. Based on the results of this review, the staff team has identified three potential safety items discussed below.

Inability of the NCS Organization to Adequately Maintain the Y-12 Criticality Safety Program—The Y-12 NCS organization lacks sufficient qualified staff to perform both CSP continuous improvement activities and Operations-directed work. As shown in Figure 1, approximately 52 percent of the engineers in the Y-12 NCS organization are qualified (including subcontractors identified as staff augmentation), the remainder are in-training. Qualifications for in-training NCS engineers have been delayed for various reasons, including delays in obtaining DOE security clearances. As of November 2018, the number of qualified NCS engineers does not match the number of NCS engineers required to meet the scope of work budgeted for a given fiscal year. Additionally, the site struggles to retain qualified engineers. On average the number of new NCS engineers hired has equaled the number of NCS engineers lost in a given fiscal year since FY 2015 [18-21].

Y-12 has authorized NCS management to hire 20 new NCS engineers by the end of FY 2019. The NCS organization hired five NCS engineers in FY 2018 and ten NCS engineers in FY 2019. Y-12 has stated that newly hired NCS engineers will be entry-level and will require security clearances. At the same time, Y-12 acknowledges that retention remains an issue for the NCS organization. Y-12 has planned to complete 12 CSE updates and two container CSE upgrades in FY 2019. Y-12 no longer uses CSE update plans to track CSE updates. Currently, Y-12 employs a prioritization metric for CSEs based on the age of the CSE revision, complexity of the CSE, and number of technical issues with the CSE. Y-12 combines these categories in to an overall rating for the CSE. The 12 CSEs scheduled for update in FY 2019 represent CSEs with higher risk ratings (i.e., the oldest, most complex CSEs with the most technical issues).

The staff team acknowledges recent Y-12 efforts to increase NCS staffing. However, the staff team is concerned that the NCS organization cannot sufficiently staff both its commitments to Operations and to perform continuous improvement work on the CSP (e.g., updating/upgrading CSEs) until the number of qualified NCS engineers is increased. The staff team concludes the challenge of retaining NCS engineers will continue to put a strain on the

ability of the NCS organization to meet NCS and Operations work priorities while training a continuous stream of new replacement NCS engineers. The staff notes that the Y-12 Nuclear Criticality Safety Committee is monitoring NCS staffing.

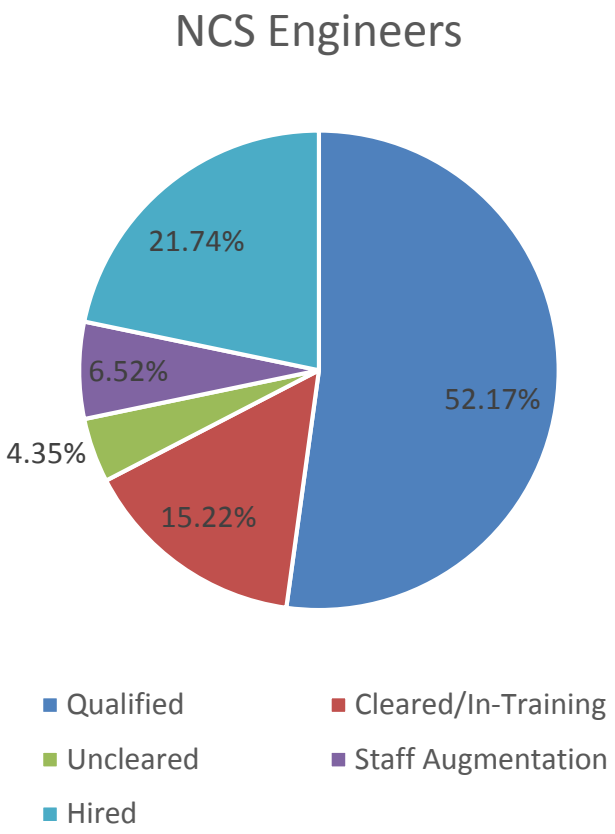

Figure 1. NCS Organization Staffing as of January 2019

Additionally, Y-12 NCS management does not have sufficient control over the NCS organization's scope of work and funding allocations for that work. The 1999 DOE NCS Workshop, sponsored by the Secretary of the Energy, recommended that a criticality safety organization should have approximately 30 percent of full time NCS engineers' full time equivalent (FTE) hours' worth of funding allocated directly to NCS management for CSP self-sustainment related work [3]. Interviews with Y-12 staff and document reviews led the staff team to conclude that over the last three fiscal years, approximately 65 percent of FTE hours were dedicated to Operations directed work, while approximately 5 percent of FTE hours were dedicated to NCS improvements (e.g., CSE updates and upgrades). The remaining FTE hours were allocated for overhead work (e.g., training)[1]. This trend has continued into FY2019.

[1] Y-12 provided a breakdown of NCS hour allocation for FY2015-FY2019. The "burden" category encompassed multiple items including training and conferences. The staff team requested an itemization of the "burden" category to analyze the amount of time actually allocated to NCS related burden activities which would have counted toward the 30 percent value recommendation in the 1999 DOE NCS Workshop. At the time of this report, the staff had not received this information.

Y-12 staff stated that NCS engineers cannot update a CSE outside of the scope and/or direction of Operations when Operations is funding only a revision. Y-12 staff further stated that the NCS organization must fund CSE updates directly, and the updates cannot impact the deadline for issuing a revised CSE requested by Operations.

The stated purpose of CSE *updates*, as defined by CNS Y-12 CSE development procedure, is to "validate that the control set is still adequate, update the CSE process description and related analysis to reflect current process conditions, and to make timely modifications to the analysis and controls [10]." The purpose of CSE *upgrades* is to revise a CSE to be in compliance with DOE Standard 3007. The purpose of a CSE *revision*, as defined to the staff team by Y-12 NCS management, is to make changes to a CSE that are not specifically an upgrade or update, and are usually requested and funded by Operations. Furthermore, Y-12 NCS management stated that when Operations requests CSE revisions, the NCS organization cannot combine these requests with any known CSE updates or upgrades due to how work hours are funded and the potential to delay a CSE revision important to Operations.

Y-12 personnel stated that many of the CSEs that require updates or upgrades have been revised in recent years. However, of the 134 active CSEs that require an update or upgrade, only 47 had been updated at the time of the staff's review. Most of the 47 CSEs were updated prior to FY2011 even though the effort to update CSEs has been underway for more than 20 years. Additionally, the CNS Y-12 CSE development procedure recommends CSEs be updated every five years. Of the 134 active CSEs, 17 are container CSEs identified by Y-12 for upgrade as of 2014 [22], but the NCS organization has not completed any container CSE upgrades.

Y-12 implemented the current *NCS Systems Analysis* [23] in September 2016. It identified a total of 51 improvement actions. Y-12 started work on the first six actions in FY2017. The staff team notes that the most recent annual update to the *NCS Systems Analysis* [23] does not contain due dates or a schedule for the remaining 45 action items. Following the recent uranium accumulations events, Y-12 identified several actions related to the Y-12 CSP, which derived from a 2018 root causal analyses on the recent uranium accumulation events. These actions were identified by Y-12 as the *Nuclear Materials Stewardship Site-wide Initiative*. Y-12 safety management expressed concern with the ability of the NCS organization to support work on both the *NCS Systems Analysis* CSP improvement actions and the newly identified site-wide initiative actions. Y-12 stated that the current approach is for the NCS organization to complete the first six actions from the *NCS Systems Analysis* and pause work on the remaining 44 to support efforts tied to the new *Nuclear Materials Stewardship Site-wide Initiative* actions. As of November 2018, the NCS organization had completed all six strategic initiative actions [20].

The slow progress of CSE updates and upgrades is mainly because of the lack of qualified NCS engineers and the lack of institutional funding directly available to Y-12 NCS management. The staff team has concluded that CNS is unlikely to successfully achieve their goal of updating CSEs every five years, outlined in CNS Y-12 CSE development procedure, given the slow progress to date and the lack of sufficient qualified staff and institutional funding to support the CSE update/upgrade effort.

Y-12 CSE's have sometimes failed to take into account all available information and sometimes failed to account for, analyze and incorporate process changes [12, 13, 17, 24]. ANSI/ANS-8.1 Section 4.1.2, *Process Analysis* [19], ANSI/ANS-8.19 Section 8, *Process Evaluation for Nuclear Criticality Safety* [20], and DOE Order 420.1C (and earlier versions), Attachment II, Chapter 3, *Criticality Safety*, Paragraph 3.f [4] require DOE defense facilities to provide CSEs to show that an entire process involving fissionable material will remain subcritical under normal and credible abnormal conditions. DOE defines "credible" as something that is "believable on the basis of commonly acceptable engineering judgment [25]." Failure to adequately capture normal and credible abnormal conditions for a process can either invalidate existing criticality controls or result in an incomplete set of criticality controls for a process. During the review, the staff has observed that CNS has not performed sufficient analysis to determine that all credible abnormal conditions are subcritical for several of its CSEs. Additionally, NPO [26] and CNS [27] also have noted inadequacies with CSEs that are at least 10 years old, not evaluated to new hazard changes, and do not document criticality control assumptions. For example, NDA reports and Inadvertent Accumulation Prevention Program (IAPP) reports had identified two of the six recent uranium accumulation discoveries more than 10 years earlier, but the uranium accumulations were never incorporated into the applicable CSEs. The 2007 IAPP report identified uranium accumulation in furnace bowls and under casting line enclosures. The IAPP report outlined NDA results and recommended that Y-12 conduct an NCS analysis of these findings as credible abnormal conditions and consider including them in the Uranium Holdup Survey Program (UHSP) [28].

The staff team acknowledges that Y-12 has made efforts to improve how the Y-12 NCS organization prioritizes CSE updates. However, the staff team concludes that the lack of Y-12 NCS management control over the Y-12 NCS organization's work scope coupled with the lack of sufficient direct NCS funding allocation for NCS improvements has not been adequately addressed. The staff team is concerned that these issues will continue to adversely impact the Y-12 NCS organization's ability to perform CSP continuous improvement activities. A June 2018 review of the Y-12 CSP, commissioned by CNS, identified the lack of mission independent funding sources for criticality safety improvement initiatives [20]. The staff notes that Y-12 has not incorporated into the CSP the need to have sufficiently independent funding as part of implementing the ANSI/ANS 8.19 Section 4.4 "administrative independence" clause. This is based on the staff's review of FTE hour allocation for non-Operation directed work versus NCS improvements. The staff team concludes funding independence is needed and this is supported by DOE best practices [3, 29]. In the staff team's interactions with Y-12 management, Y-12 management maintains organizational independence is all that is required to meet the ANSI/ANS-8.19 administrative independence clause. The staff team disagrees. To meet the intent of ANSI/ANS-8.19 Section 4.4, an organization should be adequately staffed with qualified NCS engineers to support both the demands of Operations and the continuous improvement of the NCS program. In addition, the NCS organization should have sufficient independent funding to support NCS continuous improvement activities. This funding should be directly available to the Y-12 NCS management to ensure adequate NCS control of work scope. Currently, the staff team concludes that the Y-12 CSP does not meet the ANSI/ANS-8.19 Section 4.4 requirements.

Due to CNS's insufficient analysis of credible conditions to determine subcriticality, the staff team concludes Y-12 has not met the requirements of ANSI/ANS-8.19, ANSI/ANS-8.1, and DOE Order 420.1C. The failure of Y-12 Operations to report process deviations to the NCS organization indicates a failure of the Y-12 CSP to meet the requirements of ANSI/ANS-8.19 Section 8.7 [1]. The staff team concludes the operational reviews are not sufficient to meet ANSI/ANS-8.19, Section 8.7 requirement.

Lack of Operations Personnel Participation, Cooperation with, and Ownership of Criticality Safety at Y-12 and the NCS Organization—In accordance with the Y-12 Safety Analysis Report (SAR)[2] the "Primary responsibility for NCS rests with the operating organization, with technical support provided by the Safety Analysis Engineering (SAE) organization [30]." The Introduction to ANSI/ANS-8.19 states that "An effective nuclear criticality safety program…includes cooperation among management, supervision, nuclear criticality safety staff, and workers." ANSI/ANS-8.19, Section 7.1.1 states, "Normal and credible abnormal conditions shall be determined with input from operations or other knowledgeable individuals." Operations personnel's participation in CSE development is not a listed responsibility in the Y-12 *Nuclear Criticality Safety Program* document [9]. Y-12 claims it meets the ANSI/ANS-8.19 Section 7.1.1 requirement by recommending Operation's involvement in the CSE development procedure [10, 31]. In the staff team's opinion, answers provided during staff interviews indicated that Operations personnel familiar with a process are often not involved with development of CSEs. The Operations supervisors interviewed by the staff team did not consider participation in CSE development part of their job description. Additionally, the staff notes a normalization of deviations within Operations that in part contributed to the recently reported uranium accumulation in several processes going undetected and unanalyzed for years. Overall, the staff is concerned that this is an inherent lack of ownership of criticality safety throughout the Operations organization at Y-12 the result of which is inadequate criticality safety implementation in Y-12 processes.

In the staff team's opinion, answers given during Y-12 staff interviews indicated a lack of sensitivity to process deviations that do not directly tie to an existing criticality safety control. The staff team observed that operators and supervisors interviewed did not understand the importance of communicating process deviations to NCS personnel. Operations personnel only were aware that deviations from known criticality safety controls or NCS limits should be reported to NCS personnel. For two of the six recent uranium accumulation discoveries, prolonged process deviations went unreported to the NCS organization. These process deviations invalidated assumptions in the process CSEs that had originally assumed these deviations to be incredible and contributed to the uranium accumulation discoveries in 2017 and 2018.

- CNS made a cleaning solvent change in 2013. A chemical reaction between the new solvent and mineral oil created a black gel-like substance, which accumulated in the ultrasonic chip cleaning process tanks and piping. Since the phase separator tanks are constructed of a clear material [32], the gel-like substance is visible to the naked eye.

[2] Since the conclusion of this review, the chapter in the Y-12 SAR on the Y-12 Criticality Safety Program has been superseded by the issuance of the E-SD-2026, *Enterprise Wide Criticality Safety Program*. The statement of responsibility of criticality safety from the Y-12 SAR is reiterated in the E-SD-2026 document.

Y-12 Operations personnel were aware of the buildup of the black gel-like substance in the phase separator tanks and that it had gotten progressively worse over the last several years, [17] eventually completely covering the phase separator tanks. In June 2018, through NDA, CNS identified uranium accumulation in the phase separator tanks and headers [16, 17]. Currently, the Ultrasonic Chip Cleaning system is not operating. Y-12 is evaluating plans to clean out the phase separator tanks. The staff team concludes that, following the phase separator tank clean out, the gel-like substance should be analyzed to determine if the uranium was trapped in the gel-like substance or if the uranium participated in the chemical reaction (e.g., catalysis) with the solvent and mineral oil to produce the gel-like substance. Analysis will also determine if the gel-like substance represents creation of a new uranium compound (e.g., uranium-organic complex) formed between the uranium, solvent, and mineral oil reactants.

- In part, the sand separator uranium accumulation resulted from two process deviations: (1) degradation in the quality of uranium buttons generated in the reduction process; and (2) a halt to periodic emptying of the accumulation can under the slag chute. Over time, the quality of the uranium buttons generated in the reduction system had degraded, resulting in more uranium mixed with slag than had been normally found during the knockout process. As a result, more uranium fell into the sand separator, slag chute, and accumulation can through the exposed openings in the knockout hood [33]. Combined with failure to periodically empty the accumulation can, this led to a buildup of uranium accumulation in the sand separator, slag chute, and accumulation can. The emptying of the accumulation can was an assumption in the Reduction CSE [32].

- Y-12 NCS engineers and criticality safety officers (CSOs) perform periodic assessments of systems to comply with ANSI/ANS-8.19 Section 8.6, and "verify that procedures are being followed and that process conditions have not been altered so as to affect the nuclear criticality safety evaluation [1]." The Y-12 operational reviews do not provide real time feedback for process changes, and operational reviews do not assess the entire process in one review. The staff team reviewed the last five years of operational reviews on the ultrasonic chip cleaning, casting, and reduction processes. None of these operational reviews noted uranium accumulation, blacked out phase separator tanks, or process steps inconsistent with NCS assumptions (i.e., accumulation can). In most cases the portion of the process being reviewed did not include the area where the accumulation events occurred. The staff team observed during process walkdowns in November 2017 and November 2018 that certain process deviations were easily visible regardless of the process being reviewed (i.e., ultrasonic chip cleaning phase separator tanks), but the reviewer still did not identify them in the operational review paperwork.

CSOs are members of the Operations organization. CSOs have several roles and responsibilities, including being liaisons between the CSP and operators (e.g., time on the floor), training operators, and implementing criticality controls [9]. In recent years, as the number of new CSEs and revisions for Operations have increased, the Operations organization has used

CSOs more for processing paperwork related to implementing criticality controls than any other responsibilities. Throughout the staff's interviews, management, supervisors, CSOs, and operators, consistently referred to the CSOs as "paper pushers." Routing paperwork related to implementing criticality controls and CSEs takes up a majority of CSOs' time to the detriment of the CSOs' other duties and responsibilities. The site has stated this is due to a combination of CSOs being understaffed and the large number of Operations driven CSE revisions requiring implementation.

The lack of participation by Operations personnel in the development of CSEs adversely affects criticality safety by: (1) impacting the quality and effectiveness of criticality controls; and (2) fostering a lack of understanding of the basis for the criticality controls. A reduction in the quality and effectiveness of criticality controls can result in CSE rework and a lack of Operations' ownership of criticality controls potentially leading to violations of control sets. In the staff team's opinion, answers provided during staff interviews revealed issues with CSE rework due to lack of Operations buy-in of criticality controls. The failure of Y-12 Operations personnel to participate in CSE development indicates a failure of the Y-12 CSP to adequately meet the requirements of ANSI/ANS-8.19 Section 7.1.1 [1]. The staff team concludes Operations personnel's insufficient understanding of the bases for criticality controls and CSEs can lead to an insensitivity to the NCS impact of process deviations, as evident in the underlying causes of the six recent uranium accumulation events.

The staff team notes that Y-12 is working actively to address this issue and formalize a corrective action. Since FY2017, the NCS organization has been working on "establish[ing] a collaborated hazard evaluation process" that would include involvement by Operations personnel (i.e., supervisors, CSOs, systems engineers, and process engineers) [23]. Y-12 currently is formalizing this process in the procedure governing CSE development [10]. According to Y-12, Operations involvement in CSE related hazard evaluations has improved recently during piloting of the new hazard evaluation process. Additionally, Y-12 states it has recently increased its CSO staffing back to its required level. However, the staff team is concerned that Y-12 does not have a plan for how to balance administrative responsibilities with the operational and safety responsibilities of CSOs.

In the staff team's opinion, if an implemented action, process step, or condition is not explicitly prohibited by a posted criticality safety control or tied directly to a CSE, Operations personnel typically do not consider whether such actions, process steps, or conditions would affect criticality safety, even when there are deviations from normal operating conditions. This is due in part to a lack of training, but also to an emphasis by senior Y-12 management and Operations management that production is the only mission. The staff observed from senior management, Operations management, NCS management, and subordinate personnel in both Operations and NCS that the mission is production. The staff did not observe proper awareness or appreciation for the important role of safety, in this case criticality safety, to the proper execution of the mission of production. This mentality and lack of ownership of criticality safety has led to an insufficient questioning attitude among Operations personnel which has resulted in numerous issues in Y-12 processing facilities, as evidenced by the uranium accumulation events. Operators are the first line of defense in criticality safety [3] and encouraging operators to identify deficiencies is consistent with good NCS practices and

ANSI/ANS-8.19. Operators should be empowered to identify concerns or circumstances that could adversely impact NCS in accordance with ANSI/ANS-8.19 Section 8.8 [1]. That information should be properly transmitted to the NCS organization for evaluation. Operators should be trained to understand that any deviation from normal processes could adversely impact controls derived in CSEs. It is important to identify deviations from normal processes early to avoid a loss of institutional knowledge due to operator attrition. Delays in reporting, failure to report, or waiting for NCS engineers to find all process deviations is not consistent with good criticality safety practices and could increase the criticality safety risk to the worker.

Inadequate Interface of Y-12 CSP with Support Programs—The Y-12 CSP relies on 14 separate programs, including the IAPP, Conduct of Operations Program, and Nuclear Materials Control and Accountability (MC&A) program [30]. In the staff team's opinion, answers provided during interviews revealed that the IAPP and MC&A support programs lacked adequate understanding of NCS expectations and NCS lacked an understanding of the support programs' limitations, in part due to the prolonged nature of the recent uranium accumulations discoveries. Y-12 refers to this issue as "stovepiping" of programs and has begun to address it via cross-functional periodic meetings. The staff team is not aware of any formally documented corrective actions to address the issue of "stovepiping" at the programmatic level.

- IAPP is credited with meeting the DOE Order 420.1C requirement to develop "procedures for detecting and characterizing accumulations [4]." The IAPP organization performs reviews and issues reports to the NCS organization before a new fissile material activity or a change to an existing fissile material is started. However, Y-12 does not track recommendations from IAPP reports in any common database or repository. The IAPP reports are historical documents, which are not updated with revised evaluation data unless the NCS organization determines a new IAPP review is required based on a change to the fissile material activity in the process [34]. The December 2007 Reduction IAPP report [35] evaluated the sand separation system, but did not note any uranium accumulation. There are no other documented IAPP assessments of the Reduction process prior to the May 2017 uranium accumulation discovery.

- Y-12 requires the MC&A program to account for and control fissile material. The Y-12 CSP relies on the MC&A program to identify potential errors in material characterization or relocation [30]. The uranium accumulation discovered under the casting line enclosures was part of MC&A's September 2017 semi-annual inventory cleanout. MC&A personnel did not report the NDA results to the NCS organization because they were not aware of the NCS importance of the NDA results, according to Y-12 senior management including the Senior Director of Nuclear Safety.

The staff team has concluded that the way these programs are currently relied on in the Y-12 CSP and supporting procedures is insufficient to meet the needs of a robust CSP at Y-12. In addition, the staff team concludes that cross-functional meetings alone are not sufficient to resolve the interface issues identified from recent uranium accumulation events. The programs relied upon by NCS can provide valuable information, above what is currently credited in the

Y-12 SAR[3] [30] if the NCS organization communicates those requirements and their rationale, and Y-12 CSP and supporting procedures formally document the requirements. Furthermore, information that support programs already collect and maintain should be communicated to the NCS organization.

Conclusions. Since 1953, 22 process-related criticality accidents have occurred at facilities in the United States, Russian Federation, United Kingdom, and Japan [36]. Since the issuance of the first ANSI/ANS 8 standard (ANSI/ANS-8.1) in 1964, the rate of process related criticality accidents has dropped significantly. Over an 11 year period between 1953 and the issuance of the first ANSI/ANS 8.1 standard in 1964, there were 14 process related accidents resulting in six worker fatalities worldwide. Two of those six fatalities were in the United States. Between 1964 to present day, there have been eight process related criticality accidents resulting in three worker fatalities worldwide, and none within the United States. Each of these accidents "resulted from a failure to anticipate conditions that might arise [37]." The ANSI/ANS 8 series standards provide the basis on which a CSP is built. The measure of an adequate CSP is proper adherence to ANSI/ANS 8 series standards' requirements, including but not limited to, analysis of all normal and credible abnormal process conditions, NCS organizational independence, and adequate implementation of criticality safety in operations. Based on the staff team's review of the Y-12 CSP summarized in the three potential safety items, the staff team has concluded that Y-12 has an inadequate CSP. The staff team concludes that:

1. The Y-12 CSP does not demonstrate compliance with ANSI/ANS-8.19 and ANSI/ANS-8.1 requirements in accordance with DOE Order 420.1C, *Facility Safety* [21] and the NPO-approved ANSI/ANS 8 Series Implementation Matrix [31].

2. The underlying causes that led to the recently discovered uranium accumulations are linked to systemic issues with the Y-12 CSP and signify an overall inadequate Y-12 CSP of which the uranium accumulation events were a symptom.

3. The Y-12 Operations management and staff are not adequately engaged in the criticality safety process and do not know how the assumptions and bases for criticality controls impact the safe operation of their processes.

CNS currently is managing several significant scope changes, including but not limited to: (1) bringing the Uranium Processing Facility online; (2) major system additions and/or changes to uranium processing (e.g., direct chip melt, electrorefining); (3) decontamination and decommissioning of buildings in accordance with the Y-12 extended life program (ELP); and (4) transfer of equipment and fissile material activities to alternative buildings in support of the Y-12 ELP. Scope changes are a major cause of instability in a CSP [29]. Based on the scope changes underway at Y-12 and planned in the

[3] E-SD-2026, *Enterprise Wide Criticality Safety Program,* has superseded the Y-12 SAR Chapter 6, *Criticality Safety Program,* since the conclusion of this review. The programs relied upon by NCS listed in the Y-12 SAR are also listed in E-SD-2026 for Y-12.

near to mid-term (i.e., next five to ten years), the staff team is concerned that the underlying issues described in the three potential safety items will exacerbate an already inadequate Y-12 CSP. Scope changes coupled with an inadequate Y-12 CSP could increase the criticality safety risk to the worker.

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