Office of Enterprise Assessments
Assessment of the
Y-12 National Security Complex
Uranium Processing Facility
Preliminary Documented Safety Analysis

January 2018

Office of Nuclear Safety and Environmental Assessments
Office of Environment, Safety and Health Assessments
Office of Enterprise Assessments
U.S. Department of Energy

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Acronyms

ANS	American Nuclear Society
CAAS	Criticality Accident Alarm System
CLW	Co-Located Worker
CSPS	Criticality Safety Process Study
DID	Defense-in-Depth
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
EA	Office of Enterprise Assessments
FPS	Fire Protection System
HEUMF	Highly Enriched Uranium Materials Facility
IOI	Item of Interest
MEXLO	Low Metal Oxidation
MPB	Main Process Building
NCS	Nuclear Criticality Safety
NNSA	National Nuclear Security Administration
NPH	Natural Phenomena Hazards
NPO	NNSA Production Office
PDSA	Preliminary Documented Safety Analysis
PFHA	Preliminary Fire Hazards Analysis
PHA	Preliminary Hazard Analysis
SAB	Salvage and Accountability Building
SAC	Specific Administrative Control
SBRT	Safety Basis Review Team
SC	Safety Class
SDRS	Safety Detection and Response System
SER	Safety Evaluation Report
SIL	Safety Integrity Level
SOX	Special Oxide
SS	Safety Significant
SSC	Structure, System, or Component
UPF	Uranium Processing Facility
UPO	UPF Project Office
Y-12	Y-12 National Security Complex

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EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) Office of Nuclear Safety and Environmental Assessments, within the independent Office of Enterprise Assessments (EA), conducted an assessment of the preliminary documented safety analysis (PDSA) and safety evaluation report (SER) for the Uranium Processing Facility (UPF) at the Y-12 National Security Complex. This assessment focused on selected aspects of the UPF's highest hazard building, the Main Process Building, and sampled a spectrum of hazards and controls for general conformance to the requirements of DOE-STD-1189-2008, *Integration of Safety into the Design Process*. This assessment is part of a series of targeted safety basis assessments of nuclear facility design and construction projects at selected DOE sites.

The assessment evaluated the conformance of the UPF PDSA and SER to the requirements of DOE-STD-1189-2008, DOE Order 420.1C, *Facility Safety*, and DOE-STD-1104-2016, *Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents*, for the development, review, and approval of safety design basis documents. The review encompassed selected aspects of the PDSA and supporting hazard analyses. EA examined the summary of the hazards analyses in the PDSA, along with key documents including the preliminary fire hazards analysis, preliminary hazard analysis (PHA), and criticality safety process studies (CSPSs). EA also examined the safety functions, functional classifications, functional requirements, performance criteria, and the identification of applicable design requirements for selected safety structures, systems, and components (SSCs).

Overall, the PDSA conforms to the requirements of DOE-STD-1189-2008 and DOE Order 420.1C and adequately supports the completion of the UPF safety design. The comprehensive site and general information, hazard identification and screening, and process descriptions support a thorough hazard evaluation. The hazard evaluation includes an appropriately detailed, conservative set of PHAs and CSPSs and provides a sound basis for control selection and functional classification of safety significant SSCs. The calculated consequences do not challenge the consequence thresholds; therefore, the PDSA identifies no safety class or safety significant SSCs for the protection of the public or collocated workers and focuses appropriately on protection of facility workers from criticality and energetic/explosion events. The multi-layered criticality control strategy ensures that the UPF design meets the double contingency requirement and that workers are protected by measures preventing criticality events. The selected hazard controls adequately address the identified UPF hazards, and their safety functions and functional requirements are generally appropriate and adequately evaluated. The preliminary fire hazards analysis results in a comprehensive suite of fire safety controls, focused on equipment important to the criticality safety strategy, that reduce the worker risk associated with fires and explosions.

During the review, EA provided comments on revision 0 of the PDSA. After the UPF project team's review of and response to the comments, discussions resulted in resolution of all EA comments in revision 1 of the PDSA or committed actions for the documented safety analysis.

The SER was completed by a National Nuclear Security Administration Production Office Safety Basis Review Team (SBRT) that included appropriate subject matter experts. Overall, the SER addresses the approval bases, includes resolution of the SBRT's safety concerns, and appropriately concludes that there is no remaining impediment to proceeding to Critical Decisions 2 & 3 (Approve Performance Baseline/Approve Start of Construction).

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1.0 PURPOSE

The U.S. Department of Energy (DOE) Office of Nuclear Safety and Environmental Assessments, within the independent Office of Enterprise Assessments (EA), conducted an assessment of the preliminary documented safety analysis (PDSA) and safety evaluation report (SER) for the Uranium Processing Facility (UPF) at the Y-12 National Security Complex (Y-12). The assessment evaluated selected aspects of the UPF preliminary safety design basis and also evaluated, using a sampling basis, the principal products of the design process, such as design media and calculations. This assessment, conducted during the summer and fall of 2017, is part of a series of targeted safety basis assessments of nuclear facility design and construction projects at selected DOE sites.

2.0 SCOPE

This assessment covered the development of the UPF safety design basis, which consists of the PDSA and supporting documents, including the preliminary fire hazards analysis (PFHA) and selected criticality safety process studies (CSPSs). The assessment concentrated on the Main Process Building (MPB), which contains the majority of hazards, and focused on selected active safety controls for a variety of processes. The assessment also included the review and approval of the PDSA by the National Nuclear Security Administration (NNSA) Production Office (NPO), which is documented in the SER.

3.0 BACKGROUND

Consolidated Nuclear Security, LLC, the management and operating contractor for Y-12, is designing and constructing the UPF. One of its Senior Vice Presidents, who reports to the Office of the President and Chief Executive Officer, heads the UPF project team that is responsible for development of the safety design basis documents. The NNSA UPF Project Office (UPO) provides management and oversight of the project for NNSA. NPO provides direct support to UPO for independent review and approval of the safety design basis. The NPO Manager is the Safety Basis Approval Authority.

The UPF project team is implementing the requirements and processes established in DOE Order 420.1C, *Facility Safety*, and DOE-STD-1189-2008, *Integration of Safety into the Design Process*, for the development, review, and approval of the facility's safety design basis. The PDSA, SER, and supporting analyses collectively comprise the UPF safety design basis.

The UPF project's approach to uranium processing incorporates a multi-building strategy to replace a set of Y-12 Building 9212 processing capabilities. The set of Building 9212 processing capabilities planned for installation in the UPF includes highly enriched uranium casting, special oxide (SOX) production, chemical recovery, and support operations (e.g., maintenance shop, decontamination, and packaging). The multi-building layout of the UPF complex segregates the processes into buildings according to the magnitude of the nuclear safety and security risks, with the MPB containing the most hazardous processes. The Salvage and Accountability Building (SAB), next to the MPB, will house medium-risk support processes and services needing only a moderately robust structure. The Personnel and Support Building, connecting the MPB and SAB, will provide a material transfer area, a loading dock, an enclosed dock, and a personnel monitoring station to support transferring material and personnel to and from the complex and between buildings within the complex. A separate, standard industrial building, called the Mechanical/Electrical Equipment Building, will contain most of the supporting utility equipment. Finally, the Highly Enriched Uranium Materials Facility (HEUMF) Connector will physically connect the MPB to the HEUMF.

The project received Critical Decision-1 (approval of the alternate selection and cost range) reaffirmation of the conceptual design in June 2012 and subsequently commenced preliminary design activities. In May and August 2015, NPO approved the UPF conceptual safety design report and revision 10 of the Safety Design Strategy, respectively. In December 2016, NPO approved the preliminary safety design report and revision 11 of the Safety Design Strategy. The UPF project team submitted the PDSA for NNSA review and approval on July 14, 2017. NPO provided comments to the UPF project team; the resolution of comments resulted in a revised PDSA (revision 1) submitted on October 31, 2017. NPO approved revision 1 of the PDSA on November 9, 2017.

4.0 METHODOLOGY

The DOE independent oversight program is described in and governed by DOE Order 227.1A, *Independent Oversight Program*. EA implements the independent oversight program through a comprehensive set of internal protocols, operating practices, assessment guides, and process guides. Organizations and programs within DOE use varying terms to document specific assessment results. In this report, EA uses the terms “deficiencies, findings, and opportunities for improvement” as defined in DOE Order 227.1A. In accordance with DOE Order 227.1A, DOE line management and/or contractor organizations must develop and implement corrective action plans for deficiencies identified as findings. In this report, less-significant issues that, if left unresolved, could rise to a deficient condition are defined as “discrepancies.”

As identified in the approved EA plan (*Plan for the Office of Enterprise Assessments Targeted Assessment of the Y-12 Site Uranium Processing Facility Preliminary Safety Basis*, July 2016), this assessment considered requirements for the UPF preliminary safety design basis documents from Title 10 Code of Federal Regulations Part 830, *Nuclear Safety Management*; DOE Order 420.1C; DOE-STD-1189-2008; and DOE-STD-1104-2016, *Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents*. For the PDSA and SER review, EA selected objectives and criteria from EA Criteria and Review Approach Document 31-29, *Review of Nuclear Facility Preliminary Safety Basis Development*, Rev. 0, to guide the assessment, particularly the lines of inquiry in the General Information, Hazard Analysis, and Preliminary Design sections of the first criterion.

EA independent oversight assessments focus strategically on selected aspects of nuclear safety essential to ensuring effective protection of workers and the public. By performing a vertical slice sampling review of selected aspects of the PDSA and supporting hazard analysis, the assessment addressed line management preparation, review, and approval processes intended to ensure integration of safety into design. EA examined key documents, such as the PFHA, preliminary hazard analysis (PHA), and CSPSs. EA also conducted meetings with key UPF project team personnel responsible for developing the safety design basis documents. Appendix A lists the members of the EA assessment team, the Quality Review Board, and EA management responsible for this assessment. Appendix B provides a detailed list of the documents reviewed, personnel interviewed, and observations made during this assessment relevant to the discrepancies and conclusions.

EA generally uses a comment and response process to address issues identified during its review of safety design basis and safety basis documents. During the review, EA provided comments on the PDSA to the UPF project team, and received written responses. Follow-on discussion of the comments in subsequent meetings resulted in closure of a number of the initial comments. Most comments were resolved by either acceptable comment responses or by changes incorporated into revision 1 of the PDSA. Of the 38 comments, three discrepancies remain open and have committed actions for adequate resolution.

EA did not identify any deficiencies or findings during this assessment. Attachment 1 summarizes the discrepancies discussed in this report.

EA conducted a previous assessment of the preliminary safety design report for the UPF in summer and fall 2016, but did not identify any findings. Therefore, there were no items for follow-up during this assessment.

5.0 RESULTS

Criterion: *The PDSA will demonstrate the adequacy of the hazard analyses and the selection and classification of hazard controls, including consideration of the application of the principles associated with the hierarchy of controls. (DOE-STD-1189-2008, Section 6.3)*

This section presents the results of the review of the PDSA and SER. Per the expectations of DOE-STD-1189-2008, Appendix I §I.2, the PDSA should demonstrate the adequacy of the hazards analyses as well as the selection and classification of the hazard controls based on the maturity of the design, apply the principles associated with the hierarchy of controls, and include important safety design aspects in the design. It is intended that the content of a PDSA be commensurate with the stage of Safety-in-Design process. The PDSA would be expected to include activity level hazards.

The safety design aspects covered in the PDSA include:

- Site information that can affect nuclear safety
- Summary of the hazard analyses, including process hazards evaluation, fire hazards analysis, and criticality safety evaluation
- Identified safety structures, systems, and components (SSCs) and their safety function, functional classification, and required seismic and other natural phenomena hazards (NPH) design criteria and applicable design code of record
- Safety functions, functional requirements, and performance criteria (including applicable safety design requirements from supporting guides and standards) for safety class (SC) and safety significant (SS) SSCs
- Documentation of implementation of the nuclear safety design criteria of DOE Order 420.1C, Chapter 1.

Sections 5.1 and 5.2 below present the assessment results for these safety design aspects of the PDSA. Section 5.3 presents the assessment results for the Federal review and approval of the PDSA per DOE-STD-1104-2016.

5.1 Hazard Analysis

5.1.1 General Information

EA reviewed the general information and the site characteristics in the PDSA to verify that the information is sufficient to support the hazard identification and evaluation.

At 90 percent design, the general information and site characteristics described in the PDSA provide an appropriate level of information to support the hazard identification and hazard evaluation. The PDSA and associated references provide important information, such as material-at-risk bases for processes, general arrangement drawings, process flow diagrams, piping and instrumentation diagrams, and pertinent calculations for the fire protection system (FPS). The PDSA also adequately describes nearby Y-12 facilities and their interfaces with UPF. The site, facility, and process design information is sufficient to understand the hazards associated with operations at UPF, as well as NPH, external manmade hazards, and site environmental considerations affecting the safety design basis.

5.1.2 Hazard Identification

EA reviewed the preliminary hazard identification and screening for compliance with the requirements in DOE-STD-1189-2008. The PDSA identified the hazards at UPF assuming the relocation of the current Building 9212 processes to UPF and the implementation of some new technologies for process improvements.

The results of the hazard identification and screening, documented in RP-OP-801768-A007, *Hazardous Material Estimates for the PDSA*, are summarized in RP-EF-801768-A066, *Preliminary Hazard Identification and Screening for the Uranium Processing Facility*. The hazard identification and screening considers radiological and chemical hazards, uncontrolled energy sources, and standard industrial hazards.

The hazardous material estimates, derived from drawings, process flow diagrams, piping and instrumentation diagrams, and planned processes based on the 90 percent design, are conservative. The chemical hazard screening complies with DOE-STD-1189-2008, Appendix B. Additionally, the PDSA considers the hazardous chemical properties of several uranium forms, including aqueous and organic solutions and solids (e.g., alloys and precipitates). Table 2.5-1 of the PDSA lists the hazardous materials retained for further analysis and is consistent with Table A.1 of RP-EF-801768-A066. The hazard identification and screening implementation is adequate.

5.1.3 Hazard Evaluation

EA reviewed the hazard analysis to determine whether it evaluated an appropriate spectrum of facility and process normal, abnormal, and upset conditions. EA examined the analyzed hazard scenarios and potential effects of events related to fires, explosions, criticality events, and earthquakes, as well as the supporting calculations, to verify that the unmitigated consequences for workers and the public were appropriately conservative. For certain MPB SS SSCs associated with the casting and SOX processes, EA evaluated the hazard events to determine the adequacy of the hazard control suite.

The UPF project team prepared an appropriate set of PHAs to support the PDSA, including an integrating PHA, building-specific PHAs, and process-specific PHAs. The integrating PHA provides an overview of the UPF hazard analysis process, describes the hazard identification and screening process and the hazard analysis tools and techniques, and lists potential engineered controls. The MPB PHA contains three building sections (MPB, HEUMF Connector, and Utilities and Services) that suitably cover the facility-level hazard events, including earthquake, flooding, criticality events, and fire. Finally, process-specific PHAs appropriately evaluate each process system through a “what-if” analysis or hazard and operability analysis for fires, explosions, loss of confinement, criticality accidents, external hazards, and NPH events. The hazard analysis tables in the PHAs demonstrate a thorough, questioning analysis. The selective use of hazard and operability analysis aids in the repeatability and transparency of the process. Table 3.8-1 of the PDSA summarizes the hazard events, including the event description, summary of causes, frequency/consequences, and both SS and defense-in-depth (DID) controls.

An appropriately conservative set of consequence calculations supports the hazard analysis and SSC functional classification. DAC-EF-801768-A024, *Consequence Calculations for the Uranium Processing Facilit*y, documents the calculations supporting the consequence binning of hazard event scenarios (e.g., fires, spills, nuclear criticality accidents) in the hazard analysis. Notably, the potential hazard events in the MPB result in low radiological or toxicological consequences to the public; therefore, the PDSA identifies no SC SSCs or design basis accidents. The most significant postulated hazards are fires, explosions, and criticality events, which result in moderate consequences to the co-located worker (CLW) or high consequences to the facility workers. A UPF seismic event causing explosions, spills, fires, and an inadvertent criticality event presents the highest consequences (78 rem) to the CLW, which is below the CLW threshold for designation of SS controls (100 rem). Consequently, the hazard evaluation emphasizes protection of facility workers from criticality and explosion events.

In summary, the hazard evaluation is adequate. The PHAs use an appropriately conservative approach and identify SS controls to prevent and mitigate hazardous events. For the analyzed hazard scenarios, the PHAs provide a detailed sequence of events, a statement of the required SSCs' safety functions, the rationale for the hazard control suite, and technical justification of the acceptability of the residual risk. Controls contributing to DID are identified and discussed. The methodology and criteria for functionally classifying the SSCs are appropriate.

The PDSA provides a sufficiently detailed hazard analysis. The safety SSCs and their functional classification identified in the PDSA are consistent with the logic in the hazard analysis. The SSCs that are elevated to the SS functional classification are suitably described and appropriately classified, and their NPH design bases are provided.

5.1.4 Nuclear Criticality Safety

EA reviewed the documentation supporting the identification of nuclear criticality safety (NCS) controls related to the reviewed processes in the MPB for conformance to DOE-STD-3007-2007, *Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear Facilities*. Criticality accidents can pose a significant hazard to facility workers due to high radiation exposure. EA's review focused on the completeness of selected CSPSs, the NCS multi-layered protection strategy, and the functional classification of those SSCs identified as SS criticality safety controls.

CSPSs, which were completed for each process system in the MPB, analyze the potential for nuclear criticality accidents and identify controls for preventing a nuclear criticality accident for normal operations and for credible abnormal and contingency events. The order of preference for NCS controls follows DOE-STD-3007-2007: (1) passive design features, (2) active design features, and (3) administrative controls. The CSPSs that EA reviewed were well documented and contained thorough analyses with appropriate control suites.

UPF uses the term "NCS item of interest (IOI)" to identify equipment/components vulnerable to thermal impacts that could adversely affect the multi-layer strategy for criticality safety. Failures of IOIs due to fire do not result in an inadvertent criticality event. RP-EN-801768-B002, *UPF Criticality Control Review*, evaluates the SSC controls identified in the CSPSs for elevation to the safety basis – i.e., SS SSCs or specific administrative controls (SACs) – against the criteria in Appendix K of Y70-68-001, *Criticality Safety Approval/Requirements Development, Review, and Approval*, and provides adequate technical bases for the control selection decisions. Controls to prevent inadvertent criticality are appropriately functionally classified. The process for identifying and classifying criticality controls is well defined, and the integration of the NCS controls into the PDSA is adequate.

The strategy for criticality safety includes multiple layers of protection to prevent or mitigate the unintended release of radioactive materials to the environment, consistent with the requirements of DOE Order 420.1C. The multi-layered approach for the UPF combines passive and active engineered features and administrative controls. Preventive controls include the SS safety detection and response system (SDRS), passive and active design features (e.g., fissile solution piping, glovebox door interlocks, and explosion prevention controls), and process controls for NCS parameters. Mitigative controls include the SS criticality accident alarm system (CAAS), which prompts evacuation and thereby provides protection for facility workers. Administrative programs (e.g., criticality safety, emergency management, configuration management) provide additional protection. The design aspects important to criticality safety are well-documented and complete. The information related to criticality safety for the reviewed process systems and associated SS NCS controls is sufficient and complete.

UPF also applies multiple layers to prevent major fire events that could impact IOIs. This strategy is documented in RP-EN-801768-B003, *Application of Defense-in-Depth Control Strategy for NCS Regarding Major Fire Events.* In the fire protection safety strategy, the protective layers for the IOIs consist of an inner layer of general fire-resistant construction, a middle layer of administrative building-wide controls, and an outer layer of wet pipe sprinklers. Failure of all layers of fire controls may lead to thermal exposure to NCS IOIs. Additional preventive controls for IOI protection, specific to the design basis fire events, include, for example, an organic solution interlock, fire resistive hydraulic fluids, and electric mobile equipment. The controls to protect IOIs are appropriate, given the fire exposure evaluations and supporting analyses.

In summary, the UPF project team conservatively evaluated criticality safety using a combination of detailed analyses and bounding calculations consistent with American Nuclear Society (ANS) Series 8 standards, such as American National Standards Institute (ANSI)/ANS-8.1-1998, *Nuclear Criticality Safety in Operations with Fissionable Material Outside Reactors*. The multi-layered control strategy, based on the comprehensive NCS evaluations, ensures that the UPF design meets the double contingency requirement and that workers are protected by measures preventing criticality events.

5.2 Preliminary Design

5.2.1 Safety System Functional Classification and Design Criteria

EA reviewed the PDSA to verify that the functional classification of selected safety SSCs is appropriate and adequate design criteria for these systems are identified. EA primarily selected preventive SSCs for a set of representative hazard events: NPH, explosions (steam, carbon monoxide, hydrogen), fire (internal, external, building-wide), and criticality. The review encompassed SS controls related to facility-wide and process-specific hazard events to assess whether the safety functions, functional requirements, and performance criteria are adequate.

PDSA Section 3.2.4 describes the methodology and criteria for safety functional classification of hazard controls, including controls that protect against radiological and chemical hazardous releases. Its discussion of the functional classification of hazard controls adequately incorporates the criteria and requirements of DOE-STD-1189-2008.

The PDSA clearly identifies the safety functions for SS systems and provides the criteria for evaluating whether the safety systems can perform their safety functions when required. In most cases, PDSA Chapter 4 describes the safety functions, functional requirements, performance criteria, and any open technical issues, including planned changes to the design. Chapter 4 also appropriately describes salient attributes of the controls required to support the safety functions identified in the hazard and accident analyses and to support subsequent derivation of the technical safety requirements. The safety functions of SS controls are consistent with the hazard analysis. The functional design requirements adequately address the nuclear safety-related hazards that they prevent or mitigate, and the system evaluations adequately assess control performance. Conservative design features are generally noted in the evaluation of performance criteria for each control. The PDSA provides adequate descriptions of the support systems and interfaces for each control.

EA examined the PDSA's treatment of interlocks and passive SS controls related to the low metal oxidation (MEXLO) furnaces in the casting process and the SOX oxide material production conversion furnaces and gloveboxes. Each of the interlocks is appropriately designated as safety integrity level (SIL)-2, and the supporting preliminary calculations provide evidence that the completed designs will be able to achieve the desired reliability. The system evaluations and their supporting documentation provide appropriate justifications for concluding that the safety functions will be met when needed. However, in revision 0 of the PDSA, some of the functional requirements, performance criteria, and associated control evaluations were incomplete or incorrect. Revision 1 of the PDSA resolved the identified concerns associated with incorrect burst pressure for the alternate purge path rupture disk and incorrect setpoint for the exhaust and diluting gas flow interlock. However, EA identified one discrepancy for the MEXLO combustion airflow limiting device control. The PDSA Chapter 4 system evaluation omits discussion of a manual bypass valve around an SS airflow limiting device (orifice) that, if opened, could allow operation above the lower flammability limit and subsequent explosion. The UPF project team's commitment to resolve this discrepancy in the documented safety analysis (DSA) is appropriate.

EA also examined some active criticality controls. For these controls, the safety functions, functional requirements, and performance criteria identified in the CSPSs and the *Criticality Control Review* (RP-EN-801768-B002) are accurately carried forward into the PDSA. Each of the interlocks is appropriately designated as SIL-1 (based on multiple layers of protection identified in the CSPSs), and the supporting preliminary calculations provide evidence that the completed designs will be able to achieve the desired reliability. For the most part, the system evaluations provide an appropriate justification for concluding that the safety functions will be met when needed. However, in the case of the charge mass verification interlock, the control evaluation and supporting SIL calculations do not account for the interlock possibly being left in the bypass position after testing (bypass does not result in an interlock trip). The UPF project team committed to resolve this discrepancy in the DSA.

Finally, EA evaluated the SDRS, which serves two important safety functions. First, the SDRS provides seismic detection and interlocks to prevent post-seismic explosions and/or criticality as a support to a number of interlocks in process systems. The SDRS also provides safety logic, signal paths, and loop power to support process system interlocks that protect facility workers from explosions (and the possible resulting criticality). The system description provides an adequate overview of the system design, along with a discussion of some of the principal design features (e.g., the incorporation of triple modular redundancy, use of two-out-of-three logic, and specification of SIL-3 for the system). The functional requirements are appropriate for the SDRS safety functions. EA identified concerns in PDSA revision 0, but they were adequately resolved in revision 1. Although PDSA Table 4.3-3 does not fully list specific performance criteria, the system evaluation and supporting documentation adequately address the detection and actuation of the seismic interlock and overall support to the process interlocks.

In summary, the safety functions and functional requirements for the hazard controls are generally appropriate and are adequately evaluated in the PDSA to support the completion of design. Some discrepancies existed in the description of the functional requirements, performance criteria, or evaluation of MPB SS controls in revision 0 of the PDSA. These discrepancies were resolved in revision 1 of the PDSA or by committed actions for the DSA.

5.2.2 Fire Protection

EA reviewed the PFHA, along with the supporting design documents, to evaluate the fire hazard identification, evaluation, and resulting fire hazard controls. EA also evaluated the FPS, which is classified as a DID SSC.

EA reviewed the analyzed fire scenarios, including earthquake-induced fires, and potential effects of fire events leading to explosions or IOI impacts. The PFHA adequately analyzes and evaluates major fire hazards and proposes a broad set of fire hazard controls implementing the multi-layer fire safety strategy (general fire-resistant construction, administrative building-wide controls, and wet pipe sprinklers) in support of UPF processes. The PFHA is comprehensive, identifies appropriate fire safety requirements, is consistent with the requirements of DOE Order 420.1C, and provides for a sufficient level of protection to prevent loss of SSC functions due to thermal effects from fire.

The FPS is an integral part of the multi-layer fire safety strategy for reducing risk associated with fires. It is designed to mitigate fires by providing a sufficient water supply (e.g., sufficient flow and pressure). The fire protection SSCs include automatic wet pipe sprinkler systems designed to minimize the size of the fire, two-hour fire barriers designed for life safety and structural integrity purposes, and a dedicated fire water ring main providing redundancy through two independent water supplies. Generally, the safety functions, functional requirements, and performance criteria (identified in Chapter 3 of the PDSA) for the MPB FPS are appropriate and are adequately evaluated in the PDSA.

EA identified two concerns in revision 0 of the PDSA. The first, relating to missing performance criteria to ensure an unobstructed pathway for fire water, was resolved in revision 1 of the PDSA. The second concern is identified as a discrepancy involving the glovebox hybrid suppression system. The gloveboxes protected with the hybrid fire system are described as having class A, B, C, and D materials. The hybrid fire system (water/nitrogen fog) is not approved for mitigating class C and D fires, both of which are postulated in the PFHA. Consistent with the revised PFHA, the UPF project team committed to revise the Contractor Authority Having Jurisdiction Determination to address the use of the hybrid fire suppression system in specific gloveboxes involving class C and class D fires.

EA evaluated the fire protection strategy and controls to protect IOIs and determined that these controls are appropriate, based on fire exposure evaluations and analyses. However, EA identified several instances where the multi-layer IOI fire protection safety strategy was inadequate, including concerns about sprinkler system effectiveness, analysis of pool fires, and analyses of fires under gloveboxes. Revision 1 of the PDSA and revision 3 of the PFHA resolved these concerns.

The fire hazard analysis, including supporting calculations and extensive fire modeling, resulted in a comprehensive suite of fire safety controls, such as the DID FPS and preventive controls focusing on thermal impacts to IOIs. These controls are adequate to reduce the worker risk associated with fires.

5.3 Safety Evaluation Report

Criterion: *The PDSA is, in part, to ensure that DOE and the contractor agree that safety has been adequately integrated into the design before construction begins. (DOE-STD-1104-2014, Section 8.6)*

EA reviewed the SER to determine its adequacy as the approval basis for the PDSA, as required by DOE-STD-1104-2016.

The NPO Safety Basis Review Team (SBRT) included members with appropriate subject matter expertise in nuclear safety, criticality safety, fire protection, systems engineering, and operations. The SBRT concluded that the PDSA presents sufficient information for the design, meets the format and content requirements of DOE-STD-1189-2008, and acceptably resolves SBRT comments. Based on that review, the SBRT recommended approval of the UPF PDSA.

The SER addresses the approval bases identified for review in DOE-STD-1104-2016, including verification that the design requirements of DOE Order 420.1C are met, assessment that the PDSA presents a viable design solution based on the safety functions identified in the hazard analysis, and confirmation that the appropriate design criteria are identified. For each approval basis, the SER provides a satisfactory basis for recommending approval of the PDSA, including a summary of the contents of the PDSA. The SER also identifies that the three-open conditions of approval generated during previous reviews are closed. No new conditions of approval were identified in the SER.

The SBRT recorded more than 300 comments on the PDSA, categorized them according to significance, and formally transmitted them to the UPF project team for resolution. After the transmittal, the SBRT held meetings with UPF project team management and staff to resolve comments and develop a path forward. Comment resolution discussions led to a revision of the PDSA. Significant changes incorporated into revision 1 include updated performance criteria and system evaluations in Chapter 4. The SER adequately summarizes the important issues raised in the SBRT comments, which were resolved in revision 1 of the PDSA, and includes the agreed-on resolutions to specific SBRT comments as an enclosure.

Overall, the SER discusses the approval bases, includes resolution of the SBRT's safety concerns, and appropriately concludes that there is no remaining impediment to proceeding to Critical Decisions 2 & 3 (Approve Performance Baseline/Approve Start of Construction).

6.0 FINDINGS

EA identified no findings during this assessment.

7.0 OPPORTUNITIES FOR IMPROVEMENT

EA identified no opportunities for improvement during this assessment.

8.0 ITEMS FOR FOLLOW-UP

EA will review the DSA and Technical Safety Requirements to verify closure of the discrepancies.

Appendix A
Supplemental Information

Dates of Assessment

Offsite Assessment: August 7-25, 2017
Onsite Assessment: September 11-15, 2017

Office of Enterprise Assessments (EA) Management

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Appendix B
Key Documents Reviewed and Interviews

Documents Reviewed

- CSPS-EN-801768-1CART-B001, *Nuclear Criticality Safety Process Study of Containers, Handling and Storage*, Rev. 0, February 2017
- CSPS-EN-801768-3CAN-B001, *Nuclear Criticality Safety Process Study of Handling of the #3 Inner and Outer Can*, Rev. 0, March 2017
- CSPS-EN-801768-ARAY-B001, *Nuclear Criticality Safety Process Study of Floor Storage*, Rev. 0, February 2017
- CSPS-EN-801768-ARC-B001, *Nuclear Criticality Safety Process Study of ARC Melt Furnace Operations*, Rev. 0, November 2016
- CSPS-EN-801768-BMU-B001, *Nuclear Criticality Safety Process Study of Batch Makeup*, Rev. 0, February 2017
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Meetings/Interviews

Consolidated Nuclear Security, LLC

UPF Project

- Safety Analysis Engineer
- Facility Safety Engineer
- Manager of Engineering
- UPF Design Authority (Engineering Oversight & Authorization Director)
- Deputy Manager of Engineering
- Project Engineering Manager, Nuclear Safety Engineering
- Deputy Nuclear Safety Engineering Manager
- Fire Protection Engineers (4)
- Mechanical Engineer – Fire Protection
- Chief Plant Nuclear Criticality Safety Engineer
- Deputy Chief Plant Nuclear Criticality Safety Engineer
- Criticality Safety Engineer
- Instrumentation & Control Supervisor
- Operations Supervisor

NPO/UPO

- NPO Safety Basis Review Team Lead
- NPO SBRT Senior Advisor
- UPO Chief Engineer
- UPO Assistant Chief Engineer

Attachment 1
Summary of Discrepancies Pending Closure in the DSA

1. The PDSA Chapter 4 system evaluation for the MEXLO combustion airflow limiting device control omits discussion of a manual bypass valve around an SS orifice that, if opened, could allow operation above the lower flammability limit and subsequent explosion.
2. The control evaluation and supporting SIL calculations for the charge mass verification interlock do not account for the interlock possibly being left in the bypass position after testing (bypass does not result in an interlock trip).
3. The hybrid fire suppression system (water/nitrogen fog) is not approved for mitigating class C and D fires, both of which are postulated in the PFHA.