Conceptual Safety Design Report Assessment for the Savannah River Plutonium Processing Facility

December 2021

Office of Enterprise Assessments
U.S. Department of Energy

Table of Contents

Acronyms

CSDR	Conceptual Safety Design Report
CW	Collocated Worker
DBA	Design Basis Accident
DOE	U.S. Department of Energy
EA	Office of Enterprise Assessments
EG	Evaluation Guideline
NNSA	National Nuclear Security Administration
OFI	Opportunity for Improvement
SBRT	Safety Basis Review Team
SC	Safety Class
SRFO	Savannah River Field Office
SRL	Safety Review Letter
SRNS	Savannah River Nuclear Solutions, LLC
SRPPF	Savannah River Plutonium Processing Facility
SS	Safety Significant
SSCs	Structures, Systems, and Components

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Summary

Scope
This assessment evaluated the conceptual safety design report (CSDR) and safety review letter for the Savannah River Plutonium Processing Facility (SRPPF) to be constructed at the Savannah River Site. The SRPPF is intended to be capable of providing war reserve plutonium pits for the U.S. nuclear weapons stockpile to meet pit production requirements as defined by the National Nuclear Security Administration.

Significant Results for Key Areas of Interest
The SRPPF CSDR complies with U.S. Department of Energy (DOE) standard DOE-STD-1189-2016, *Integration of Safety into the Design Process*, as demonstrated by the following:

- The preliminary hazard categorization of the SRPPF is appropriately determined.
- The preliminary hazard evaluation includes an appropriately detailed, conservative process hazard analysis and provides a sound basis for control selection and functional classification.
- The accident analysis adequately evaluates an appropriate set of representative and unique design basis accidents derived from the hazard evaluation.
- The selection of safety class hazard controls is appropriate to ensure public protection.
- The approach to meeting the nuclear safety design criteria of DOE Order 420.1C, *Facility Safety*, is adequately described in the CSDR, with no identified exceptions to the order.

The safety review letter documenting the basis for National Nuclear Security Administration approval of the CSDR complies with DOE-STD-1104-2016, *Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents*.

Best Practices and Findings
There were no best practices or findings identified as part of this assessment.

Follow-up Actions
The Office of Enterprise Assessments will review additional SRPPF safety design basis documents to monitor the progress of integrating safety into the design of the facility as the design matures.

Conceptual Safety Design Report Assessment for the Savannah River Plutonium Processing Facility

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) Office of Nuclear Engineering and Safety Basis Assessments, within the independent Office of Enterprise Assessments (EA), conducted an assessment of the conceptual safety design report (CSDR) and safety review letter (SRL) for the Savannah River Plutonium Processing Facility (SRPPF) to be constructed at the Savannah River Site. This assessment, conducted from December 2019 through February 2021, is part of an ongoing effort to conduct independent oversight of high-hazard nuclear facility construction projects, as required by DOE appropriations legislation.

This assessment was conducted in accordance with the *Plan for the Office of Enterprise Assessments Assessment of the Conceptual Safety Design Report for the Savannah River Plutonium Processing Facility Project at the Savannah River Site, Fiscal Years 2019 - 2020*. The scope of this assessment included a review of the preliminary hazard categorization; preliminary hazard analysis; preliminary identification of design basis accidents (DBAs); selection and classification of safety structures, systems, and components (SSCs); and the approach to meeting the nuclear safety design criteria of DOE Order 420.1C, *Facility Safety*. This assessment also included a review of the SRL documenting the basis for National Nuclear Security Administration (NNSA) approval.

Savannah River Nuclear Solutions, LLC (SRNS) is managing the design of the SRPPF under the direction and oversight of the NNSA Office of Acquisition and Project Management; the NNSA Savannah River Field Office (SRFO) is responsible for reviewing the safety design basis documents. The SRPPF Project is a capital asset project intended to meet NNSA-defined pit production requirements by providing war reserve plutonium pits for the U.S. nuclear weapons stockpile. The SRPPF Project will use the reconfigured Building 226-F, originally intended to support the mixed oxide fuel fabrication mission but never commissioned before that mission was canceled. The major processes in the SRPPF will be: material receipt and packaging, unpacking, storage, and shipping; feed preparation; manufacturing; recovery and waste management; and process analytical support.

2.0 METHODOLOGY

The DOE independent oversight program is described in and governed by DOE Order 227.1A, *Independent Oversight Program*, which is implemented through a comprehensive set of internal protocols, operating practices, assessment guides, and process guides. This report uses the terms "best practices, deficiencies, findings, and opportunities for improvement (OFIs)" as defined in the order.

As identified in the approved plan, this assessment considered requirements for the SRPPF CSDR from DOE-STD-1189-2016, *Integration of Safety into the Design Process*; DOE Order 420.1C; and DOE-STD-1104-2016, *Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents*. EA used the relevant sections from EA Criteria and Review Approach Document 31-29, Rev. 1, *Review of Nuclear Facility Safety Design Basis Development*, to guide the assessment. In conducting this assessment of the CSDR, EA considered control strategies applied to the main Rocky Flats Plant plutonium processing facility and the Los Alamos National Laboratory current control strategy for similar pit manufacturing operations.

EA focused on selected aspects of nuclear safety essential to ensuring effective protection of workers and the public. EA examined key supporting documents, including the safety design strategy, the preliminary

consolidated hazard analysis, the preliminary fire hazards analysis, accident analysis calculations, and system design description documents. EA conducted meetings with key SRNS personnel responsible for developing the safety design basis documents and SRFO Safety Basis Review Team (SBRT) members responsible for reviewing the documents. The assessment team members, the Quality Review Board, and EA management responsible for this assessment are identified in appendix A.

EA used a comment and response process to address issues identified during its review. EA provided comments on the preliminary consolidated hazard analysis and CSDR to SRFO at the in-process review draft and final submittal stages and received written responses. When necessary, follow-on discussions among EA, SRNS, and SRFO were conducted to discuss issues. All comments were resolved through adequate responses or changes incorporated into the final CSDR except for one that concerned the order of preference followed in the control strategy, as discussed in section 3.1.1.3.

No items from previous assessments required follow-up during this assessment.

3.0 RESULTS

3.1 Conceptual Safety Design Report

3.1.1 Hazard and Accident Analyses

The objective of the assessment of hazard and accident analyses was to evaluate hazard identification and evaluation, including the designation and safety classification of hazard controls.

3.1.1.1 Preliminary Hazard Categorization

The hazard categorization of the SRPPF is appropriately identified as Hazard Category 2 in accordance with DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, based on the radiological material inventory and the potential for a criticality accident.

SRNS used a hazard identification checklist to systematically document hazards for each process area in the SRPPF. Radiological material, primarily plutonium in a variety of chemical and physical forms, is the main hazard in the facility. The material at risk is conservatively estimated based on the conceptual design processes and is appropriately described in terms of quantity and form. The What-If technique was used to identify hazard events. DOE-STD-3009-2014, *Preparation of Nonreactor Nuclear Facility Documented Safety Analysis*, indicates that the What-If technique is appropriate for analyzing simple processes in Hazard Category 2 facilities, but for more complex processes, a Hazard and Operability Study or Failure Modes and Effects Analysis should be performed. (See **OFI-SRNS-1**.)

Energy sources are appropriately identified for events. Chemicals will not result in releases that exceed the protective action criterion for the public (i.e., PAC-2) and can be adequately managed under a hazardous chemical management program; these chemical hazards are appropriately screened. Chemicals capable of initiating an event resulting in a radiological release are appropriately evaluated. The CSDR adequately identifies and characterizes the SRPPF hazards.

3.1.1.2 Design Basis Accidents

The CSDR includes hazard events related to explosions, fires, loss of confinement, direct radiation exposure, criticality, natural phenomena, and man-made external events. All identified hazard events are tabulated in the CSDR, with columns identifying the events that potentially challenge or exceed the

Evaluation Guideline (EG) to the public or that exceed the consequence threshold for the collocated worker (CW) as defined in DOE-STD-3009-2014. A bounding set of DBAs is analyzed in the CSDR.

The hazard evaluation process appropriately includes hazard screening, hazard evaluation, unmitigated and mitigated consequence/frequency estimation, and hazard control selection. For each hazard event, initiating-event frequencies are qualitatively estimated as anticipated, unlikely, or extremely unlikely, and dose consequences to the public and workers are qualitatively or quantitatively determined. For the selection of safety SSCs, hazard event consequences are evaluated against a radiological consequence threshold of 100 rem to the CW and the EG of 25 rem to the maximally exposed offsite individual.

For each DBA, the accident analysis provides an adequate discussion of scenario development, source-term determination, initiating frequency, radiological consequences, comparison to thresholds, and controls selection, including identification of safety function and defense-in-depth features. For Building 226-F, the bounding radiological consequence DBA is a seismic event resulting in fires and explosions. The unmitigated radiological consequence for this event is approximately 100 rem to the maximally exposed offsite individual. Three other DBAs challenge the EG: a vault fire, a molten plutonium spill in a glovebox, and the loss of offsite power. The CSDR appropriately identifies safety class (SC) controls to mitigate these events to ensure low consequences to the public. Several Building 226-F events and one event on the waste storage pad (a vehicle crash followed by a fuel fire) result in consequences to the CW that exceed 100 rem. The CSDR appropriately recognizes the need for safety significant (SS) controls to protect the CW.

The hazard evaluation addresses an appropriate range of hazardous materials and energy sources and addresses a thorough set of hazard events. Initiating-event frequencies and consequences are conservatively estimated. The accident analysis adequately evaluates an appropriate set of representative and unique DBAs derived from the hazard evaluation. The consequence analysis methodology and associated parameters are conservative.

3.1.1.3 Hazard Controls

For events that challenge the EG, the CSDR identifies appropriate SC controls. The building structure, active confinement ventilation system, and emergency generator are all SC and available to mitigate facility accident scenarios. Additionally, the CSDR classifies the encapsulation of combustible radiological shielding in the vault and fire barriers (walls) as SC to minimize the size of the vault fire. The CSDR also classifies the molten metal catch pan/safety can (and its glovebox to support the pan) as SC to contain molten metal after a spill. These SC controls are sufficient to ensure that mitigated consequences to the public are less than 5 rem for all scenarios.

Several controls are identified as SS to prevent an explosion or mitigate the consequences to the facility worker from an explosion. These controls include an oxygen sensor and alarm for gloveboxes where hydrogen is used, a vessel vent system, pressure protection devices for ion exchange columns, and a furnace design that prevents the interaction of water and molten plutonium. Areas of refuge are identified as SS for temporarily sheltering facility workers, who are assumed to evacuate during many accident scenarios.

During the review, EA expressed a concern that the selection of some controls to protect the worker was inconsistent with the order of preference specified in DOE-STD-1189-2016. Specifically, upon initial review of the SRPPF preliminary consolidated hazards analysis, EA noted that available preventive controls had not been functionally classified as SS for some hazard scenario events associated with glovebox operations. Section 4.1.4 of the standard states that a control strategy shall be based on the following order of preference: SSCs are preferred over administrative controls, passive SSCs are preferred over active SSCs, and preventive controls are preferred over mitigative controls. Further,

section 4.1.4 of the standard notes that controls closest to the hazard may provide protection to the largest population of potential receptors, and that controls that are effective for multiple hazards can be resource-effective.

Plutonium processing represents a significant, well-documented, operational risk, particularly with respect to the pyrophoric nature of plutonium fines and oxides. Fires are anticipated events during work involving pyrophoric material. Gloveboxes, which are largely passive features, provide primary confinement for most plutonium operations and are essential for the protection of workers. The safety design strategy indicates that SRPPF gloveboxes were initially intended to have an SS confinement function. However, the design and conservative assumptions supporting this initial intent were not carried forward to the CSDR.

EA commented that omission of these passive confinement controls in preference to mitigative controls situated further from the hazard did not meet the required control strategy of DOE-STD-1189-2016. SRNS asserted in its responses to EA comments that additional functionally classified controls closer to the hazards would result in a complex control set, with significant cost and operational impact. Further discussions between EA and members of the SRPPF project team did not resolve this concern. EA remains concerned that the functional classification of SSCs currently in the conceptual design may not be adequate to ensure worker safety. The SRPPF project team acknowledged the risk that the evaluation of process-level controls during preliminary design may result in the need to functionally classify additional safety-related controls. Consequently, EA will continue to monitor the functional classification of safety-related controls and the demonstration of control adequacy as the SRPPF design matures.

3.1.2 Nuclear Safety Design Criteria

The objective of the assessment of the CSDR nuclear safety design criteria was to evaluate the approach to meeting the design requirements of DOE Order 420.1C.

The approach to meeting the nuclear safety design criteria of DOE Order 420.1C is adequately described in the CSDR, with no identified exceptions to the order. Applicable design codes and standards are referenced in the system design description documents. The natural phenomena hazard design category for the structure is appropriately identified as NDC-3 in accordance with DOE-STD-1020-2016, *Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities*.

3.1.3 Conceptual Safety Design Report Conclusion

The CSDR comprehensively identifies and evaluates the hazards associated with the SRPPF at a level commensurate with the conceptual design phase. The hazard analysis appropriately addresses hazardous materials and energy sources and postulates an adequate set of hazard events. The identified SC controls are adequate to ensure the safety of the public. The approach to meeting the nuclear safety design criteria and natural phenomena hazard design criteria is adequately described.

3.2 Federal Review and Approval

The objective of the review of the SRL was to determine its adequacy as the approval basis for the CSDR as required by DOE-STD-1104-2016.

The SRFO SBRT used SRPPF-PLN-19-002, *Review Plan for SRPPF Project CSDR*, to ensure the thoroughness of its review. The SBRT consisted of members with appropriate subject matter expertise in nuclear safety, criticality safety, and safety systems oversight. The SBRT determined that the submitted CSDR complies with the requirements and expectations of DOE-STD-1189-2016 and meets the review

criteria of DOE-STD-1104-2016. The SBRT's review concluded that the CSDR is sufficient to continue with the design process.

The SRL addresses the approval bases identified for review in DOE-STD-1104-2016, which include the adequacy of the initial hazard categorization of the facility, verification that the design requirements of DOE Order 420.1C are met, assessment of the need for SC and SS controls, and preliminary assessment of the design criteria for natural phenomena hazards. For each approval basis, the SRL provides a basis for recommending approval of the CSDR.

4.0 BEST PRACTICES

There were no best practices identified as part of this assessment.

5.0 FINDINGS

There were no findings identified as part of this assessment.

6.0 DEFICIENCIES

There were no deficiencies identified as part of this assessment.

7.0 OPPORTUNITIES FOR IMPROVEMENT

EA identified one OFI to assist cognizant managers in improving programs and operations. While OFIs may identify potential solutions to findings and deficiencies identified in assessment reports, they may also address other conditions observed during the assessment process. OFIs are offered only as recommendations for line management consideration; they do not require formal resolution by management through a corrective action process and are not intended to be prescriptive or mandatory. Rather, they are suggestions that may assist site management in implementing best practices or provide potential solutions to issues identified during the assessment.

Savannah River Nuclear Solutions, LLC

OFI-SRNS-1: Consider using a more rigorous method than the What-If technique for hazard event selection, such as a Hazard and Operability Study, when developing the final consolidated hazard analysis.

8.0 ITEMS FOR FOLLOW-UP

EA will review additional SRPPF safety design basis documents to monitor the progress of integrating safety into the design of the facility as the design matures.

Appendix A
Supplemental Information

Dates of Assessment

December 2019 – February 2021

Office of Enterprise Assessments (EA) Management

John E. Dupuy, Director, Office of Enterprise Assessments
William F. West, Deputy Director, Office of Enterprise Assessments
Kevin G. Kilp, Director, Office of Environment, Safety and Health Assessments
David A. Young, Deputy Director, Office of Environment, Safety and Health Assessments
Kevin M. Witt, Director, Office of Nuclear Safety and Environmental Assessments
Charles C. Kreager, Director, Office of Worker Safety and Health Assessments
Jack E. Winston, Director, Office of Emergency Management Assessments
Joseph J. Waring, Director, Office of Nuclear Engineering and Safety Basis Assessments

Quality Review Board

John E. Dupuy
Thomas "Clay" Messer
Robert J. Hailstone
Michael A. Kilpatrick – Advisor to the Quality Review Board

EA Site Lead for Savannah River Site (National Nuclear Security Administration)

Aleem E. Boatright

EA Assessors

Daniel M. Schwendenman – Lead
Halim A. Alsaed
Kevin E. Bartling
Roy R. Hedtke
Katherine S. Lehew
Charles J. March
Alan L. Ramble
Jeffrey L. Robinson
Robert W. Young