5. INTEGRATED SAFETY ANALYSIS

This chapter presents the Safety Assessment of the Design Basis (SA) for the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF). This chapter discusses the site, facility, and processes; the SA team; the chemical standards employed; the SA methods and results; the principal structures, systems, and components (SSCs); and the Integrated Safety Analysis (ISA) elements and commitments.

The intent of the SA is to satisfy the applicable requirements of 10 CFR §70.22(f) and 10 CFR §70.23(b).

SA and ISA Overview

As defined in 10 CFR §70.4, an ISA is a systematic analysis to identify plant internal and external hazards and their potential for initiating event sequences; the potential event sequences; their likelihood and consequences; and the SSCs and activities of personnel that are relied on for safety (i.e., items relied on for safety [IROFS]). The ISA identifies the following:

- Radiological hazards related to possessing or processing licensed material at the facility
- Chemical hazards of licensed material and hazardous chemicals produced from licensed material
- Facility hazards, natural phenomena hazards (NPHs), and external man-made hazards (EMMHs) that could affect the safety of licensed material
- Potential event sequences involving internal or external hazards
- The consequence and the likelihood of potential event sequences, and the methods used to determine the consequences and likelihoods
- IROFS and the characteristics of their preventive, mitigative, or other safety function, and the assumptions and conditions under which the item is relied upon to support compliance with the performance requirements of 10 CFR §70.61.

The ISA demonstrates that the IROFS will perform their intended safety functions when necessary. The ISA is a living process and is performed during all phases of the life cycle of the facility, including the following:

- Preliminary design phase (Construction Authorization Request [CAR]/Safety Assessment)
- Detailed design phase (License Application/ISA Summary)
- Construction and operation phases (living ISA utilized throughout the life of the facility).

The ISA process may be viewed as a developmental process starting with the SA in support of the CAR that progressively becomes more sophisticated in support of the License Application/ISA Summary. Initially, a broad set of hazards are identified and analyzed in a general fashion to most efficiently identify and evaluate events. As solutions that satisfy the requirements of 10 CFR §70.61 are identified, events are dispositioned and not analyzed further.

Progressive layers of more detailed analysis are performed until the risk of all identified events satisfy the requirements of 10 CFR §70.61. The ISA is then used and maintained during facility operation.

The objective of the SA is to identify (1) the hazards and events associated with the MFFF design and operations, and (2) the principal SSCs required to mitigate or prevent these events, and their specific design bases. To accomplish this objective, tasks are performed in a systematic, comprehensive, and documented form as follows:

- Identify the hazards and corresponding events resulting from these hazards that may exist at the MFFF
- Identify unmitigated consequences for event sequences
- Identify bounding events
- Formulate a safety strategy to reduce the risk associated with bounding events to a level consistent with 10 CFR §70.61
- Identify principal SSCs and their associated design bases to implement the safety strategy at a system level
- Determine the mitigated consequences for bounding events, where applicable
- Identify support systems necessary for the principal SSCs to perform their safety function
- Determine NPH requirements for the principal SSCs
- Provide a general description of the principal SSCs.

Furthermore, the SA provides reasonable assurance that the identified principal SSCs can reduce the risk to a level consistent with 10 CFR §70.61 through the adoption of a general design philosophy, design bases, system designs, and commitments to appropriate management measures. These elements are based on and consistent with standard nuclear industry experience and practices. They ensure that applicable industry codes and standards are utilized, adequate safety margins are provided, engineering features are utilized to the extent practicable, the defense-in-depth philosophy is incorporated into the design, and the principal SSCs will be maintained and operated appropriately. A general discussion of the MFFF design philosophy is provided in Section 5.5.5. Specific implementation of this philosophy, the design bases, and design description of the principal SSCs where applicable are provided in Chapters 5, 6, 7, 8, 10, and 11. Management measures are described in Chapter 15.

In contrast, the main purpose of the work performed subsequent to the SA is to identify IROFS to implement the principal SSCs and demonstrate that the specific IROFS are sufficiently robust and that the reliability and effectiveness of these features are sufficient to ensure that the risk for all events is in accordance with the requirements of 10 CFR §70.61. To accomplish this goal, the ISA performs the following tasks:

- Identify and describe IROFS at the component level.
- Demonstrate that IROFS are sufficiently effective, reliable, and available to meet the specified design basis and consequently demonstrate that the event sequence satisfies the

performance requirements of 10 CFR §70.61. This task is accomplished through the preparation of a likelihood analysis, criticality analysis, shielding analysis, structural analysis, fire hazard analysis (FHA), and other specific evaluations.

- Identify specific operating requirements.

During the operation phase, the ISA is used to evaluate changes to facility design or operations to ensure that they satisfy the requirements of 10 CFR §70.72.

The focus of the ISA and SA is on the identification of IROFS (principal SSCs in the SA). The identified IROFS are the necessary and sufficient set of design features and administrative controls to be implemented in the final design to satisfy the performance requirements of 10 CFR §70.61. To provide an additional safety margin and satisfy the requirements of 10 CFR §70.64(b), the MFFF employs defense-in-depth practices. These features ensure that multiple layers of risk reduction exist. The principal SSC and defense-in-depth designations are made on an event/receptor basis. An SSC designated as a principal SSC to protect the facility worker for any given event may also be designated as a defense-in-depth feature to protect the site worker and public for the same event (definition for dose receptors are found in Section 5.4.4). SSCs designated as defense-in-depth are also principal SSCs (and fall under the 10 CFR 50 App B, NQA-1 QA program), but are not required or credited in the analysis for the event/receptor to meet the performance criteria of 10 CFR §70.61.

The MFFF also incorporates additional protection features into the facility design and operation. These features provide additional protection by reducing the challenges to the IROFS and defense-in-depth features.

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5.1 SITE AND FACILITY DESCRIPTIONS

Other chapters of the CAR contain information used for the SA with respect to site, facility, and system descriptions. Chapter 1 describes the MFFF site and provides an overview of the facility and processes. Chapter 6 describes the criticality safety systems and Chapter 7 describes the fire protection systems. Chapter 8 describes the chemical processes. Chapter 11 describes the MFFF facilities, processes, systems, and design bases. Chapter 15 describes management measures.

Radiation and environmental protection during normal operation and anticipated occurrences (i.e., non-accident conditions) are related to facility safety and are described in Chapters 9 and 10, respectively.

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5.2 SAFETY ASSESSMENT TEAM DESCRIPTION

To ensure a thorough and effective SA, a team of individuals experienced in hazard identification, hazard evaluation techniques, accident analysis including dose consequence assessment, and probabilistic analysis was assembled. The team members possess operational experience at similar facilities, specific discipline knowledge (e.g., mechanical; electrical; heating, ventilation, and air conditioning [HVAC]), and specific knowledge of the processes. In addition, the team has MOX-specific (both MOX process [MP] and aqueous polishing [AP]) safety analysis experience.

Engineering resources from the following disciplines are used, as appropriate, throughout the ISA process to provide specific expert input:

- Radiochemical Process
- Chemical Processes (i.e., aqueous polishing)
- Civil Structural/Geotechnical
- HVAC
- Glovebox Design
- Nuclear Safety
- Nuclear Criticality Safety
- Electrical
- Fire Protection
- Instrumentation and Control (I&C)
- Mechanical
- MOX Fuel Process
- Radiation Protection.

The MFFF Licensing & Safety Analysis Manager has overall responsibility for preparation of the Construction Authorization Request licensing document, and directs the development of the Integrated Safety Analysis (including the initial SA required as part of the CAR). The ISA Manager has overall responsibility for preparation of the SA, and reports to the MFFF Licensing & Safety Analysis Manager. Key roles of the ISA Manager include providing overall SA direction for the analysis, organizing and executing analysis activities, and facilitating team meetings that may be held as part of the SA activities. The ISA Team Leader(s) reports to the ISA Manager and is responsible for the technical analysis supporting the SA. The ISA Team Leader(s) ensures the use of appropriate analysis methodologies and technical information. The ISA Team Leader(s) is knowledgeable in the specific ISA methodologies chosen for the hazard and accident analyses and has an understanding of process operations and the hazards under evaluation.

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5.3 CHEMICAL STANDARDS AND CONSEQUENCES

Chemical standards for chemical consequences associated with acute exposures are contained in Chapter 8. The evaluation of chemicals is also provided in Chapter 8.

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5.4 SAFETY ASSESSMENT OF DESIGN BASIS METHODOLOGY

The SA is the first step in the development of the ISA. To accomplish the SA objective as described in Section 5.0, a hazard assessment and a preliminary accident analysis are performed. Hazard assessment includes the identification of specific hazards and the evaluation of those hazards through the development of event scenarios. Accident analysis consists of further analyzing events identified in the hazard assessment, establishing the principal SSCs (including administrative controls and their associated design basis), and providing a basis for the selection of those SSCs.

Figure 5.4-1 provides a flow diagram of the ISA process. As shown, the ISA consists of two parts: (1) the SA documented in this submittal, and (2) the latter phase of the ISA to be submitted as part of the license application for possession and use of special nuclear material (SNM).

The first step of the SA is to identify the hazards applicable to the MFFF. The identification of hazards is based on the MFFF preliminary design (Chapter 11). Hazards related to natural phenomena and external man-made events are identified based on the site description of the MFFF (Chapter 1). For fire-related hazards, a Fire Hazards Analysis (FHA), described in Section 7.4, is performed. The FHA is part of the ISA. At this stage of the MFFF design, a Preliminary Fire Hazards Analysis is performed in order to identify the specific fire hazards and to propose fire protection features that will function as principal SSCs in order to limit the consequences from fire events. The process by which the hazards have been identified is described in Section 5.4.1, and the resulting identified hazards are listed in Section 5.5.1. Within this identification process, NPHs established to be not credible, as defined in Section 5.4.3, are screened and removed from further consideration.

After the applicable hazards have been identified, a hazard evaluation is performed to develop event scenarios. Hazard evaluation is the process of linking hazards, identified during the hazard identification process, with postulated causes to produce event scenarios. The process by which this evaluation is performed is described in Section 5.4.1.2. These events are then characterized as event types, which are described in Section 5.4.1.2.1.

Once the event types have been established, a preliminary accident analysis is performed to assess the unmitigated consequences to the facility worker, site worker, public, and the environment. For the site worker, public, and the environment, conservative quantitative consequences are established. For the facility worker, conservative qualitative consequences are estimated. The process of evaluating these consequences is detailed in Section 5.4.4.

Events with unmitigated consequences that are less than "intermediate" (defined as "low" in this analysis), as defined by 10 CFR §70.61, are screened and do not require further evaluation. These events are discussed in Section 5.5.2.11. A safety strategy is then established for the remaining events. Section 5.4.2 describes the process by which the safety strategy is established, and Section 5.5.2 presents the implemented safety strategies by event type. Note that within the safety strategy (Section 5.4.2.3), events with common safety strategies, and hence common principal SSCs, are grouped together into event groups, thereby reducing the amount of repetition in the discussion of the safety strategy. For fire-related events, a fire safety strategy is formulated for each respective fire area of the facility. This fire safety strategy is based on a consequence analysis for each of the respective fire areas and an assessment of the feasibility of implementing the selected fire safety strategy.

From the established safety strategies, principal SSCs (including administrative controls) required to implement the safety strategy are specified. For the SA, specification of these principal SSCs is limited to structure- and system-level items (component-level items will be specified in a latter phase of the ISA) and administrative controls. For each of the specified structures and systems, the design bases are determined, as well as the potential support functions required to ensure the effectiveness/availability of these items during the hypothesized (analyzed) event. The process by which these items are identified and evaluated is described in Section 5.4.2.

The final step performed in the SA is to establish the mitigated consequences for the bounding event for each event type. Section 5.4.4 presents the methodology used to establish these consequences, and Section 5.5.3 presents the results. These mitigated consequences are used to establish performance requirements for the principal SSCs to ensure that the performance requirements of 10 CFR §70.61 are satisfied. Section 5.4.5 describes the "Latter Phase of the ISA" portion of Figure 5.4-1.

5.4.1 Hazard Assessment Methodology

The purpose of the hazard assessment is to identify and evaluate hazards associated with the MFFF. Accordingly, hazard assessment is comprised of two tasks: hazard identification (Section 5.4.1.1) and hazard evaluation (Section 5.4.1.2). Hazard assessment provides the basis for identifying events and determining risk.

The MFFF hazard assessment was performed in accordance with guidance provided in Draft NUREG-1513, *Integrated Safety Analysis Guidance Document* (U.S. Nuclear Regulatory Commission [NRC] 1999), and *Guidelines for Hazard Evaluation Procedures* (AIChe 1992). The hazard assessment methodology was selected based on the guidance provided in NUREG-1513 to perform the hazard assessment of the MFFF because it is well suited to the preliminary phase of the MFFF design.

5.4.1.1 Hazard Identification

Hazard identification is the process of identifying hazards that could impact MFFF operations. To facilitate the hazard identification process, the MFFF was divided into workshops and further subdivided into process units within each workshop. This segmentation of the facility allows the analyst to focus on a specific section of the overall process and ensures a thorough and comprehensive hazard identification. The grouping of process units by workshop is presented in Section 5.5.1, and the process units are described in Chapter 11.

Utilizing these workshops, radioactive and hazardous material associated with MFFF operations, hazardous energy sources associated with MFFF operations, NPHs that could impact MFFF operations, and EMMHs that could impact MFFF operations were identified. Each of these constituent elements of the hazard identification process is described in the following sections.

5.4.1.1.1 MFFF Radioactive and Hazardous Material and Hazardous Energy Sources

Internal hazards are those hazards that exist on the MFFF site. The Checklist Analysis method (AIChe 1992) was utilized to identify internal hazards associated with MFFF processes and operations. The MFFF hazards checklist is based on a generic list of hazardous materials and energy sources modified to reflect the systems and processes at the MFFF. In performing hazard identification, the systems and operations of a specific process area are reviewed and the applicable hazards are checked. The following were used in the identification of MFFF hazards:

- Schematics, process flow diagrams, design drawings, lists of process equipment, and design descriptions for the MFFF
- Facility tours of the MELOX and La Hague facilities
- Relevant industry experience.

In this manner, the facility hazards were systematically and comprehensively identified.

5.4.1.1.2 Natural Phenomena Hazards

NPHs are those hazards that arise from natural processes such as extreme wind and tornadoes. Applicable NRC and U.S. Department of Energy (DOE) documents are used to develop the initial list of NPHs (see Chapter 1 for supporting information).

A screening process is performed on the comprehensive list of NPHs to identify those NPHs that have the potential to affect MFFF operations. NPHs that are not credible at the Savannah River Site (SRS) or that cannot affect MFFF operations are removed from further evaluation and are not considered in the MFFF design or operations. Those NPHs that could impact MFFF operations are further evaluated in the hazard assessment and preliminary accident analysis and accounted for as necessary in the MFFF design and operations. The screening process is detailed in Section 5.5.1.

5.4.1.1.3 External Man-Made Hazards

EMMHs are those hazards that arise from the operation of nearby public, private, government, industrial, chemical, nuclear, and military facilities and vehicles. The locations of these facilities and transportation corridors nearby the MFFF, along with applicable NRC and DOE documents, are used to develop the initial list of EMMHs.

A screening process utilizing NRC Regulatory Guides 1.78 and 1.91 (NRC 1974, 1978b) is performed on the comprehensive list of EMMHs to identify those hazards that have the potential to affect MFFF operations. Those EMMHs that could impact MFFF operations and that are not bounded by other events are further evaluated in the hazard assessment and preliminary accident analysis and accounted for as necessary in the MFFF design and operations. The screening process is detailed in Section 5.5.1.

5.4.1.2 Hazard Evaluation

Hazard evaluation is the process of linking hazards identified during the hazard identification process with postulated causes to produce event scenarios. Event scenarios are postulated as general events or system failures that could lead to an event. No credit is taken for engineering or administrative controls in this initial evaluation. These events are then characterized as event types (Section 5.4.1.2.1). The rationale for identifying event scenarios based on general events or system failures is based on the concept of progressively developing the detail of the event sequence. In subsequent analyses, additional detail is provided (e.g., development of detailed event scenarios with specific causes) as necessary.

The following information is used in postulating MFFF event scenarios:

- Results from the hazard identification process
- Relevant industry experience
- A review of NRC regulatory requirements, NRC guidance (NUREGs, Regulatory Guides) DOE Standards, DOE Orders, and Safety Analysis Reports representing a wide array of facilities.

For each of the identified events, the following information is determined:

- Event type designation
- Unmitigated event description
- Postulated causes
- Unmitigated likelihood estimate
- Unmitigated consequence estimate
- Unmitigated risk designation.

These items are described in the following sections.

5.4.1.2.1 Event Type Designation

Each postulated event is categorized by event type. This categorization enhances the ability to evaluate similar events across the entire facility. The event types are as follows:

- **Loss of Confinement/Dispersal of Nuclear Material** – Events that lead to the dispersion of radioactive material from one confinement area to an interfacing system or the environment. These events exclude events initiated by load handling, explosion, or fire.
- **Fire** – An event that may result in the release of radioactive material through a thermal release mechanism.
- **Load Handling Event** – An event that results in the release of radioactive material through a drop or crush release mechanism.
- **Explosion** – Events resulting in the release of radioactive material via an explosive release mechanism.

- **Criticality** – The attainment of a self-sustaining fission chain reaction potentially resulting in the release of a large amount of energy over a short time period.
- **Natural Phenomena** – Initiating events caused by NPHs.
- **External Man-Made Events** – Initiating events caused by EMMHs.
- **External Exposure** – Events producing a direct radiation dose from radiation sources external to the body.
- **Chemical Release** – Events that result in a pure chemical release that may affect nuclear safety, a chemical release of a chemical produced from licensed material, or a chemical release in conjunction with a radiological release.

5.4.1.2.2 Unmitigated Event Description

The unmitigated event description provides information concerning the event scenario, including the hazardous material involved in the scenario, operating mode of the affected process units, specific process unit or location, causes, and major effects of the event. The unmitigated event description does not credit or describe SSCs that prevent or mitigate the event. The event description provides the basis for assessing unmitigated event likelihood, consequence, and risk.

To avoid repetition, events common to process units within a workshop are presented as one event. Events applicable to a specific process unit are presented separately. For example, a leak from a glovebox through a seal is presented once for all gloveboxes, but an oxygen-fed fire is presented for the calcining furnace only since it is the only process unit connected to the oxygen supply system.

5.4.1.2.3 Postulated Causes

Causes are the means by which hazards create postulated events. Therefore, a single cause in conjunction with an identified hazard is a necessary and sufficient condition to create an event. The major causes for each postulated event are identified. Causes are based on the level of design information available and can be specific or general. The general class of causes identified includes mechanical or electrical failure of equipment, human errors, NPHs, or EMMHs.

It should be noted that all causes are not required or identified in the hazard assessment. At this juncture, the objective of the analysis is to simply determine the feasibility of events in given locations.

5.4.1.2.4 Unmitigated Likelihood Estimate

During the SA, the likelihood of all events generated by internal hazards was conservatively assumed to be Not Unlikely as defined in Section 5.4.3. Consequently, no internal event was screened due to likelihood considerations. The event initiator is assumed to occur for all events (excluding natural phenomena events exceeding the design basis events).

5.4.1.2.5 Unmitigated Consequence Estimate

The unmitigated consequence assessment to the public, site worker, facility worker, and environment is based on conservative estimates for the material at risk, release fractions, and dispersion factors. Application of conservative estimates for each of these factors ensures a large margin in the reported consequences. Section 5.4.4 and Chapter 8 present the methodology for calculating radiological and chemical consequences, respectively.

The consequence severity levels that are used in the hazard evaluation are based on 10 CFR §70.61 and are provided in Table 5.4-1.

5.4.1.2.6 Unmitigated Risk Designation

Risk is the product of the event likelihood and consequence. Table 5.4-2 identifies when principal SSCs are applied, as a function of the unmitigated event risk, to satisfy the performance requirements of 10 CFR §70.61.

5.4.2 Preliminary Accident Analysis Methodology

The major purpose of the preliminary accident analysis is to identify principal SSCs and their associated design bases. A secondary purpose is to provide bounding consequence calculations as necessary. These purposes are accomplished by performing further analysis of all events identified in the hazard assessment. The analysis consists of the following major steps:

- Event screening
- Identification of event groups
- Development of safety strategy
- Selection of principal SSCs
- Design bases of principal SSCs
- Support functions related to principal SSCs
- Bounding mitigated consequence analysis.

The analysis is an iterative process involving these steps until the preferred acceptable solution is reached. Thus, these steps are not necessarily performed in a step-by-step manner for all events. Each of these respective steps in the preliminary accident analysis is described in the following sections. In addition, it is important to recognize that during the preliminary accident analysis, the multi-disciplinary team evaluates safety alternatives to ensure that competing risks are adequately addressed. In this manner, the multi-disciplinary team arrives at a final safety strategy that will ensure that events satisfy the performance requirements of 10 CFR §70.61. Thus, the ISA process ensures that the proposed means to address a given event are compatible with the safety strategies formulated to address all other events.

5.4.2.1 Event Screening

Events whose consequences have been determined to be low require no further evaluation and are screened. Justification for the screening of events is provided in Section 5.5.2.11. The remaining events are the subject of the preliminary accident analysis presented in Sections 5.5.2.1 through 5.5.2.10.

5.4.2.2 Identification of Event Groups

Each event is characterized by a given event type. The unscreened events within a given event type are reviewed by the SA team, in conjunction with the process and engineering disciplines. Within each event type, events for which common features may be utilized to prevent/mitigate common events are segregated into event groups. The rationale for segregating events within a given event type is to simplify the analysis by allowing for the development of common safety strategies and principal SSCs for multiple events. Utilizing the collective engineering judgment of the SA team and supporting organizations, a decision is made regarding the feasibility of incorporating sufficient features into the design to mitigate or prevent multiple events under a given event type.

5.4.2.3 Development of Safety Strategy

Concurrent with the determination of the event groups, a safety strategy is formulated by the SA team and supporting organizations. The safety strategy defines the means by which the performance requirements of 10 CFR §70.61 will be satisfied. In general, the safety strategy is defined either as prevention or mitigation.

Although the safety strategy in most cases relies upon either mitigation or prevention features to satisfy the performance requirements of 10 CFR §70.61, this reliance does not fully describe the complete safety inherent in the system. Defense-in-depth and additional protection features further serve to reduce the likelihood and consequences of events, thus increasing the safety margin.

5.4.2.4 Selection of Principal SSCs

Principal SSCs are identified to implement the safety strategy for each event group. These features will be utilized to provide the required level of risk reduction in accordance with 10 CFR §70.61. The identified principal SSCs are the design features/administrative controls to be implemented in the final design to satisfy the performance requirements of 10 CFR §70.61.

5.4.2.5 Design Bases of Principal SSCs

Design bases are developed for each principal SSC. These design bases identify the safety functions and the specific values and ranges of values chosen for controlling parameters as reference bounds for the design necessary to satisfy the performance requirements of 10 CFR §70.61.

5.4.2.6 Support Functions Related to Principal SSCs

A support system evaluation is performed to determine the requirements (e.g., seismic, utilities) necessary to support the identified principal SSCs. In this manner, the importance of support systems is determined.

The methodology employed to perform this analysis involves three steps: (1) determining the dependencies between plant systems (i.e., system-to-system support functions), (2) establishing how support system functions support specific plant systems, and (3) establishing which support system functions must be designed for specific event types. The first and second steps are based on the plant system descriptions of principal SSCs or non-principal SSCs (see Chapter 11). The final step is accomplished by establishing which of the support systems are required to ensure that principal SSCs, as established by the safety strategy, are functional for a specific event type.

5.4.2.7 Bounding Mitigated Consequence Analysis

The methodology for performing mitigated radiological consequence analysis is given in Section 5.4.4. The methodology for establishing chemical consequences is provided in Chapter 8. Mitigated consequences are established for each event within an event group that utilizes principal SSCs to mitigate an event. These mitigated consequences are used to establish requirements on the effectiveness of the mitigation features to satisfy the performance criteria as established in Table 5.4-1. Mitigated consequences for event type bounding events are presented in Section 5.5.3.

5.4.3 Likelihood Definitions

The definition of the event likelihoods and the method by which they are assigned to the assessed events are provided in the SA. As previously discussed, likelihood has not been utilized as a basis for screening unmitigated internally generated events. Rather, all events were conservatively assumed to have a likelihood of Not Unlikely.

The following qualitative definitions are used in assessing the likelihood per event:

- **Not Unlikely** – Events that may occur during the lifetime of the facility.
- **Unlikely** – Events that are not expected to occur during the lifetime of the facility but may be considered credible.
- **Highly Unlikely** – Events originally classified as Not Unlikely or Unlikely to which sufficient principal SSCs are applied to further reduce their likelihood to an acceptable level (see discussion below).
- **Credible** – Events that are not "Not Credible."
- **Not Credible** – Natural phenomena or external man-made events with an extremely low initiating frequency and process events that are not possible.

These definitions will be utilized during the next phase of the ISA to demonstrate that the risk of a given event sequence has been adequately reduced to a level consistent with 10 CFR §70.61.

Deterministic methods will be utilized for those events where risk reduction is required to satisfy the requirements of 10 CFR §70.61. To ensure that all event sequences with consequences exceeding the low consequence threshold of 10 CFR §70.61 meet the likelihood requirements identified in 10 CFR §70.61, the following deterministic design criteria commitments will be applied to those events and the associated principal SSCs (and IROFS in the ISA):

- Application of the single failure criterion or double contingency principle
- Application of 10 CFR 50 Appendix B, NQA-1
- Application of industry codes and standards
- Management measures including IROFS failure detection (IROFS failure detection and repair or process shutdown capability.)

The first deterministic design criterion, application of the single failure criterion or double contingency principle, is the most important attribute in providing adequate risk reduction for event sequences, and consequently ensuring that each respective event sequence is ultimately rendered highly unlikely. This design criterion ensures that even in the unlikely event of a failure of a single contingency, another unlikely, independent, and concurrent failure or process change is required prior to the occurrence of the event. This design criterion ensures that redundant means are provided to protect against an event that could exceed the requirements of 10 CFR §70.61, including an inadvertent nuclear criticality. Additional information related to the single failure criterion and the double contingency principle is provided in CAR Section 5.5.5.

The second deterministic design criterion, application of recognized nuclear industry codes and standards, provides confidence in the ability of IROFS to perform their function. The codes and standards provide the foundation for ensuring that principal systems, structures, and components (PSSCs)/IROFS are robust and incorporate lessons learned from the nuclear, mechanical, electrical, and instrumentation and control disciplines. Thus, they provide an effective set of engineering and procedural guidelines utilized to design, construct and operate the PSSCs/IROFS. DCS has provided these specific commitments to industry codes and standards applied to PSSCs throughout the CAR. This information provides preliminary assurance that the controls utilized to implement the single failure criterion or double contingency principle will be sufficiently reliable.

The third deterministic design criterion, application of the 18 criteria of 10 CFR 50 Appendix B, ensures that the requirements for IROFS are correctly translated into specifications, drawings, procedures, and instructions. These measures include provisions through the application of management measures and design procedures to assure that the appropriate quality standards are specified and included in design documents and that deviation from such are controlled. Application of the 10 CFR 50 Appendix B criteria assures that approved procedures are used for the selection and review of materials, parts, equipment, and processes that perform safety related functions. Application of the 18 criteria assures that IROFS are purchased of the requisite caliber and that adequate inspections of activities affecting the quality will be performed. Application of these criteria assures that a test program will be established and that testing required to demonstrate the effectiveness of IROFS is performed in accordance with written test procedures that incorporate the requirements and acceptance limits contained in applicable design documents. Additional information related to quality assurance is provided in CAR Section 15.1.

The fourth deterministic design criterion, application of Management Measures, is particularly important in the context of IROFS failure detection. The term IROFS failure detection is meant to include detection of IROFS failures and repair of the IROFS or process shutdown. As described in NUREG 1718, IROFS failure detection can significantly reduce the likelihood of an accident scenario. For an accident scenario to proceed to completion, failure of one IROFS must occur, its failure must go undetected, then the second IROFS must fail. The combination of IROFS failure detection and the application of the single failure criterion or the double contingency principle provide the designer with multiple options to satisfy the requirements of 10 CFR §70.61.

Effective application of these deterministic criteria will ensure that event sequences are highly unlikely. The application of the single failure criterion or double contingency principle and IROFS failure detection ensure that multiple undetected failures are required for an accident sequence to proceed to conclusion. Application of appropriate codes and standards and an NQA-1 QA program ensure that IROFS will be designed, operated, and maintained in a reliable manner. The application of these deterministic design criterion ensure that adequate risk reduction is achieved to satisfy the requirements of 10 CFR §70.61. This methodology and conclusion is consistent with the guidance provided in NUREG 1718.

To demonstrate that these criteria are effectively implemented, a number of evaluations are performed as part of the ISA. Initially, PrHA techniques (HAZOP and What-If techniques) are utilized as the means of identifying in a systematic and comprehensive manner event sequences and the controls necessary to implement the single failure criterion or double contingency principle. In a subsequent step, the adequacy of the IROFS to perform their intended safety function is evaluated through an analysis whose objectives are to:

1. Document that the specified controls adequately implement the single failure or double contingency principle.

2. Document that the specified controls are effective and that an adequate margin is provided.

3. Document that the specific conditions presented by the process will not compromise the ability of the specified controls to perform their intended safety function.

To meet these objectives, DCS will include (as appropriate) the following during these evaluations:

- Environmental design considerations (such as temperature, chemical effects, humidity, pressure, radiation fluence, etc. that might be imposed on specific systems, structures, or components under normal, off-normal, and accident conditions). Equipment qualification (EQ) requirements will also be discussed as needed.

- Protection from natural phenomena hazards

- Protection against fires and explosions

- Identification of means to detect failures

- Analysis of failure modes and common mode failures
- Special inspection, testing, and maintenance requirements
- Management measures applied to the item and the basis for grading
- Safety parameters controlled by the item, safety limit on the parameter
- Assessment of the impact of non-safety features on IROFS ability to perform their function.

These analyses will be applied to each event sequence with the potential to exceed 10 CFR §70.61 requirements. The analyses verify that single failure criterion or double contingency principle is effectively applied, that there are no common mode failures, that the IROFS will be effective in performing their intended safety function, that the conditions that the IROFS will be subjected to will not diminish the reliability of the IROFS, and also identify and verify appropriate IROFS failure detection methods. Each of the event sequences and the accompanying specific measures provided by the aforementioned deterministic criteria will be documented in the ISA and summarized in the ISA summary. This combination of analyses will demonstrate that the likelihood requirements of 10CFR70.61 are satisfied.

In conjunction with (but separate from) the safety/licensing basis to provide additional confidence in the demonstration of the adequacy of these deterministic design criteria, a supplemental likelihood assessment will be conducted for events (excluding NPH events) that could result in consequences that exceed the threshold criteria for the site worker or the public. This supplemental assessment will be based on the guidance provided in NUREG 1718 and will demonstrate a target likelihood comparable to a "score" or -5 as defined in Appendix A of NUREG 1718.

5.4.4 Methodology for Assessing Radiological Consequences

The methodology for assessing radiological consequences for events releasing radioactive materials is based on guidance provided in NUREG/CR-6410, *Nuclear Fuel Cycle Facility Accident Analysis Handbook* (NRC 1998b). The methodology for evaluating the consequences of a criticality event is described in Section 5.5.3.4. In this section, the methodology used to calculate radiological consequences is provided for the unmitigated and mitigated cases. Unmitigated results established from the application of this methodology are used to establish a safety strategy. Mitigated results established from the application of this methodology are presented in Section 5.5.3.

The radiological consequences for the facility worker, site worker, member of the public, and the environment are assessed for events identified in the hazard evaluation. The facility worker is considered to be within the MFFF located inside a room near a potential accident release point. The site worker is considered to be 328 ft (100 m) from the MFFF building stack. The member of the public is considered to be located near the controlled area boundary at approximately 5 mi

(8 km) from the MFFF building stack. The controlled area is defined as an area outside of a restricted area but inside the site boundary to which access can be limited by the licensee for any reason. The nearest site boundary is 5.4 miles (8.8 km) and the nearest SRS controlled access point is 5.1 miles (8.1 km). A restricted area is an area to which access is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. The MFFF restricted area is coincident with the protected area, an area encompassed by physical barriers and to which access is controlled and is located at 170.6 ft (52 m) from the MFFF building stack. Radiological consequences to the environment -are assessed outside the MFFF restricted area (i.e., at the Restricted Area Boundary).

Radiological releases are modeled as instantaneous releases to the facility worker and are conservatively modeled for the site worker, the public, and the environment using a 0- to 2-hour 95^{th} percentile dispersion χ/Q. No evacuation is credited for the assessment of the unmitigated radiological consequences.

5.4.4.1 Quantitative Unmitigated Consequence Analysis to Site Worker and Public

For each identified event sequence in the hazard evaluation, a bounding consequence for that event sequence is calculated. The bounding consequence is established by determining the applicable locations and locating the specific materials at risk from Tables 5.5-3a and 5.5-3b. The applicable, bounding material-at-risk values are then established from the identified values by selecting the maximum value for each form and each compound. Values for each form and compound are conservatively selected due to the dependence of the airborne release fraction, the respirable fraction, the specific activity, and the dose conversion factors.

5.4.4.1.1 Source Term Evaluation

The first step in the evaluation of the unmitigated consequences is to determine the source term. The source term is determined based on the five-factor formula as described in NUREG/CR-6410 (NRC 1998b). The five-factor formula consists of the following parameters:

- MAR – Material At Risk
- DR – Damage Ratio
- ARF – Airborne Release Fraction
- RF – Respirable Fraction
- LPF – Leak Path Factor.

These parameters are multiplied together to produce a source term (ST) representative of the amount of airborne respirable hazardous material released per a bounding scenario, as follows:

$$[ST] = [MAR] \times [DR] \times [ARF] \times [RF] \times [LPF] \qquad (5.4\text{-}1)$$

Applicable, bounding quantities are established for each of these factors. Note that for entrainment events, the airborne release fraction is replaced with the airborne release rate (ARR) multiplied by the entrainment duration (i.e., ARF = ARR x duration). It has been assumed that the duration of the entrainment release is one hour, assuming no evacuation. The unmitigated consequences associated with entrainment events are orders of magnitude below those associated with the bounding events. A longer duration of release up to the entire MAR involved in the event would not impact the safety strategy and the mitigated consequences would still be acceptable.

The LPF in all unmitigated cases is conservatively assumed to be one (i.e., no credit is taken for leak paths). A discussion crediting LPFs in mitigated radiological consequence evaluations is provided in Section 5.4.4.4.

Applicable ARF and RF values are established for the material forms (i.e., powder, solution, pellet, rod, and filter), the material types available at the MFFF, and the release mechanisms that could potentially occur at the MFFF from values presented in NUREG/CR-6410 and DOE-HDBK-3010, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities* (DOE 1994). Bounding ARF and RF values are then established for each material form per release mechanism by maximizing the product of these two factors of the potential material types found at the MFFF (i.e., maximizing ARF x RF for each form and per release mechanism). Thus, the result is applicable bounding ARF and RF values for specific release mechanisms for specific material forms.

For some events identified in the hazard evaluation, the identified event may encompass a number of release mechanisms. In these cases, the bounding product of the ARF and RF, per material form, will be applied to the MAR. The bounding products considered are based on the entrainment, explosive detonation, explosive overpressurization, fire/boil, and drop/crush release mechanisms for materials of a specific form.

A DR of one (1.0) is conservatively utilized to determine the radiological consequences for most material forms and events. Exceptions include fuel rods and pellets for an explosive over-pressurization event, fires in select storage areas, and the drop of fuel assemblies.

5.4.4.1.2 Dose Evaluation

The source term is used to calculate the total effective dose equivalent (TEDE). TEDE values are calculated for exposure via the inhalation pathway to a site worker (S) and a member of the public offsite (P). Other potential pathways (e.g., submersion and ingestion) are not considered to contribute a significant fraction to the calculated TEDE. The following expression is used to calculate the TEDE for potential radiological releases at the MFFF:

$$[TEDE]^{S,P} = [ST] \times [\chi/Q]^{S,P} \times [BR] \times [C] \times \sum_{X=1}^{N} [f]_X \times [DCF]_{effective,X} \qquad (5.4\text{-}2)$$

where:

ST	=	source term unique to each event
$[\chi/Q]^{S,P}$	=	atmospheric dispersion factor unique to the site worker and member of the public
BR	=	breathing rate
C	=	unit's conversion constant

f_x	=	includes the specific activity and the fraction of the total quantity of the MAR that is the radionuclide X
$DCF_{effective,X}$	=	effective inhalation dose conversion factor for the specified radionuclide X
N	=	total number of inhalation dose-contributing radionuclides involved in the evaluated event.

Table 5.4-3 lists the radionuclide composition of common materials located in the MFFF that have been evaluated for potential release in the hypothesized accident events.

Atmospheric dispersion factors (χ/Q) for the site worker and a member of the public were established from SRS data using the MACCS2 and ARCON96 computer codes. These codes are briefly discussed in Section 5.4.4.1.3.

The breathing rate (BR) is conservatively assumed to be 3.47 x 10^{-4} m^3/sec (20.8 L/min). This value is from Regulatory Guide 1.25 (NRC 1972) and is equivalent to the uptake volume (10 m^3) of a worker in an 8-hour workday.

The inhalation dose conversion factors (DCFs) are taken from Federal Guidance Report No. 11 (EPA 1989), based on the form of the potential releases from the MFFF when received by the dose receptor. For the MFFF, dose receptors are conservatively assumed exposed to oxides of unpolished plutonium, polished plutonium, and/or uranium, and/or elemental americium. The oxides have specific activities (molecular) that are greater by a factor of 2 than those of other potential release forms (e.g., plutonium oxalates and nitrates). For many radionuclides, Federal Guidance Report No. 11 provides dose conversion factors for more than one chemical form (or solubility). The multiple forms are represented by transportability classes. For the MFFF, Y class DCFs have been used for all radionuclides except americium, which only has a W class DCF. Releases of soluble materials are bounded by those of the insoluble form because the amount of MAR in the bounding events for soluble releases is smaller than the amount of MAR for the insoluble releases.

Once unmitigated radiological consequences are established for each event identified in the hazard assessment, events are grouped and bounding events are established for each of these groupings under each event type. Unmitigated radiological consequences established for each bounding event are then compared to the limits in Table 5.4-1. Based on this comparison and potential prevention and/or mitigation features available to each event grouping, the safety strategy is established for each bounding event within an event type.

5.4.4.1.3 Atmospheric Dispersion Evaluation

5.4.4.1.3.1 MACCS2

The MACCS2 (MELCOR Accident Consequence Code System for the Calculation of the Health and Economic Consequences of Accidental Atmospheric Radiological Releases) computer code was used to compute the downwind relative air concentrations (χ/Q) for a 1-hour ground-level release from the MFFF. The relative concentration (atmospheric dispersion factors) (χ/Q) is the dilution provided relative to site meteorology, elevation of release, and distance to the receptor(s). MACCS2 simulates the impact of accidental atmospheric releases of radioactive materials on the surrounding environment. A detailed description of the MACCS2 model is available in NUREG/CR-6613 (NRC 1998a).

A MACCS2 calculation consists of three phases: input processing and validation, phenomenological modeling, and output processing. The phenomenological models are based mostly on empirical data, and the solutions they entail are usually analytical in nature and computationally straightforward. The modeling phase is subdivided into three modules. ATMOS treats atmospheric transport and dispersion of material and its deposition from the air utilizing a Gaussian plume model with Pasquill-Gifford dispersion parameters. EARLY models consequences of the accident to the surrounding area during an emergency action period. CHRONIC considers the long-term impact in the period subsequent to the emergency action period.

The receptor of interest includes the maximally exposed offsite individual (MOI) at the controlled area boundary. The input into the MACCS2 code included SRS meteorological data files. The SRS meteorological data files are composed of hourly data for SRS for each calendar year from 1987 through 1996. No credit is taken for building wake effects. The release is assumed to be from ground level at the MFFF, without sensible heat, over 1 hour. For conservatism, no wet or dry deposition has been assumed.

The dose incurred by the MOI is reported at the 95th percentile level without regard to sector. The MOI is assumed to be located at the closest site boundary to the MFFF. The one-hour atmospheric dispersion factor (χ/Q) for ground-level releases to a member of the public located at the controlled area boundary (approximately 5 mi [8 km] from the MFFF stack) was computed by MACCS2 to be 3.7 x 10^{-6} sec/m^3.

5.4.4.1.3.2 ARCON96

The ARCON96 computer code was used to compute the downwind relative air concentrations (χ/Q) for the site worker located within 328 ft (100 m) of a ground-level release from the MFFF to account for low wind meander and building wake effects.

ARCON96 implements a normal straight-line Gaussian dispersion model with dispersion coefficients that are empirically modified from atmospheric tracer and wind tunnel experimental data to account for low wind meander and aerodynamic effects of buildings on the near-field wind field (e.g., wake and cavity regions) (NRC 1997). Hourly, normalized concentrations (χ/Qs) are calculated from hourly-averaged meteorological data. The hourly values are averaged to develop χ/Qs for five periods ranging from 2 to 720 (i.e., 0 to 2 hr, 2 to 8 hr, 8 to 24 hr, 1 to 4 days, and 4 to 30 days) hours in duration. Of these time periods, only the 0 to 2 hr interval is used for dose calculations. ARCON96 accounts for wind direction as the averages are formed. To ensure that the most conservative χ/Q was selected for dose calculations, χ/Q determinations were made for 16 different wind directions. As a result, the averages account for persistence in both diffusion conditions and wind direction. Cumulative frequency distributions are prepared from the average relative concentrations. Relative concentrations that are exceeded no more than

5% of the time (i.e., 95th percentile relative concentrations) are determined from the cumulative frequency distributions for each averaging period.

The two-hour atmospheric dispersion factor (χ/Q) for ground-level releases to the site worker at 328 ft (100 m) was calculated by ARCON96 to be 6.1 x 10^{-4} sec/m^3.

5.4.4.2 Consequence Analysis for the Facility Worker

For the facility worker, conservative consequences are qualitatively estimated. The facility worker is assumed to be at the location of the release. Thus, for events evaluated in the preliminary accident analysis involving an airborne release of plutonium or americium, principal SSCs are deterministically applied. For events involving the release of uranium, the unmitigated consequences are estimated to be low and principal SSCs are not applied.

5.4.4.3 Environmental Consequences

A 24-hour average effluent concentration (EC) is calculated for a release to the environment of each of the released radionuclides using the following expression:

$$[EC]^X = \frac{[ST]/[RF] \times [\chi/Q]^{RA} \times [f]_X}{(3600 - sec/hr)(24 - hr)} \tag{5.4-3}$$

where:

$[\chi/Q]^{RA}$ = atmospheric dispersion factor unique to the restricted area boundary

The 24-hour average atmospheric dispersion factor $(\chi/Q)^{RA}$ for ground-level releases at the restricted area boundary (171 ft [52 m]) was calculated to be 2.79 x 10^{-04} sec/m^3 by ARCON96.

Since the radiological consequences to the environment are limited to an airborne effluent concentration and not a respirable quantity, the respirable fraction (RF) in Equation 5.4-3 corrects the source term (Equation 5.4-2) such that the source term reflects an airborne quantity.

Table 5.4-3 lists the radionuclide composition of common materials located in the MFFF that have been evaluated for potential release in the hypothesized accident events.

Values for EC are compared to 5,000 times the values specified in Table 2 of Appendix B to 10 CFR Part 20, which are listed in Table 5.4-3. The ratios of the calculated value to the modified 10 CFR Part 20 value for each radionuclide are summed to ensure that the cumulative limit is satisfied, as follows:

$$\text{Total EC Ratio} = \sum_{X=1}^{N} \frac{[EC]^X}{5000 \times [EC]^X_{10CFR20}} < 1.0 \tag{5.4-4}$$

Once unmitigated environmental consequences are established for each event identified in the hazard assessment, events are grouped, and bounding events are established for each of these groupings under each event type. Unmitigated environmental consequences established for each bounding event are then compared to the limits in Table 5.4-1. Based on this comparison and potential prevention and/or mitigation features available to each event grouping, the safety strategy is established for each bounding event within an event type.

5.4.4.4 Quantitative Mitigated Consequence Analysis

The methodology used to establish the mitigated radiological consequences closely follows the methodology used to establish the unmitigated consequences. Mitigated consequences are calculated for those bounding events representing an event grouping in which mitigation features will be utilized to reduce the risk in accordance with 10 CFR §70.61.

To perform the mitigated consequence analysis, the consequence analysis methodology described in the previous section is utilized with the following modification: applicable bounding leak path factors (LPF) are used for the principal SSCs providing mitigation. This LPF is associated with the fraction of the radionuclides in the aerosol that are transported through some confinement deposition or filtration mechanism. There can be many LPFs for some events, and their cumulative effect is often expressed as one value that is the product of all leak path multiples. Inclusion of these multiples in a single LPF is done to clearly differentiate between calculations of doses without mitigation (where the LPF is assumed equal to one) and calculations of doses with mitigation (where the LPF reflects the dose credit provided to the controls). In this manner, the LPF represents the credit taken for the mitigating principal SSCs at the MFFF.

In some cases, a mitigating principal SSC is capable of preventing radiological consequences, and hence, the LPF can be equated to zero. For example, drops involving 3013 canisters are hypothesized to occur at the MFFF. In this case, the 3013 canister is qualified for drops from specific heights, and thus, although the event (i.e., the drop) is not necessarily prevented, a qualified container prevents the consequences, thereby setting the LPF to zero.

In other cases, a ventilation system may be designed and credited to be operable following an accident and provide filtration of any potential releases. In this case, the applicable bounding values for the LPF are established from NUREG/CR-6410 (NRC 1998b). The undamaged tested final HEPA filter units with the upstream filter elements are normally expected to provide an overall LPF of approximately 10^{-8} or better. The Safety Assessment conservatively credits a LPF of 10^{-4} to allow for uncertainties. This is based on two filter banks in series as described in Section 11.4.

Table 5.4-4 identifies conditions that can affect the efficiency of the HEPA filters. The MFFF is designed and operated to protect the HEPA filters from these conditions. Analyses based on final design are in progress to demonstrate that the HEPA filters are protected from these conditions and to demonstrate that the ventilation systems' LPF is 10^{-4} or better. Section 11.4 provides a description of the MFFF ventilation systems.

5.4.5 Transition from Safety Assessment of the Design Basis to the ISA

This section provides an overview of the transition from the Safety Assessment of the Design Basis documented in the CAR to the development of the ISA for the License Application for possession and use of SNM. Figure 5.4-1 outlines the steps to be performed in this "latter phase of the ISA."

Subsequent to the SA phase of the ISA and in preparation for the license application, IROFS are identified at the component level to implement the identified principal SSCs specified by the safety strategy established in the SA. Where appropriate, the ISA will increase the specificity of the locations of these principal SSCs from the general process areas to a specific system unit. To address these tasks, evaluations, such as hazards and operability studies (HAZOPs), nuclear criticality safety evaluations (NCSEs), failure modes and effect analyses (FEMAs), fire hazards analyses (FHAs), and nuclear safety evaluations (NSEs) will be utilized. These evaluations will identify specific causes of events and associated prevention and mitigation features (IROFS) at the component level. Software failures including communication failures, common mode failures, and human errors will be included in these analyses. Specific causes to be evaluated will include faults (caused by operation of a support system outside of normal operating ranges) in systems interfacing with the support system in question.

The safety strategies and resulting principal SSCs established in the SA are based on the preliminary design of the MFFF. Changes made during the final design phase will be evaluated for effects on these principal SSCs, effects on the safety strategies, and ability to produce additional hazards.

Once the IROFS have been established, the ISA will demonstrate that these IROFS can perform their intended safety function when required to satisfy the performance requirements of 10 CFR §70.61. Included will be analyses to demonstrate the capability of the IROFS and analyses to demonstrate the reliability and availability of the IROFS. Safety limits associated with the IROFS will be identified and incorporated as necessary into the license application for possession and use of SNM.

Tables

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Table 5.4-1. Consequence Severity Categories Based on 10 CFR §70.61

Consequence Category	Workers	Offsite Public	Environment
3: High (H)	TEDE > 1 Sv (100 rem) > AEGL3, ERPG3	TEDE > 0.25 Sv (25 rem) >30 mg soluble U intake >AEGL2, ERPG2	
2: Intermediate (I)	0.25 Sv < TEDE ≤ 1 Sv (25 rem < TEDE ≤ 100 rem) > AEGL2, ERPG2 but < AEGL3, ERPG3	0.05 Sv < TEDE ≤ 0.25 Sv (5 rem < TEDE ≤ 25rem) > AEGL1, ERPG1 but < AEGL2, ERPG2	radioactive release > 5000 x (Table 2 in Appendix B of 10 CFR Part 20)
1: Low (L)	Events of lesser radiological and chemical exposures to workers than those above in this column	Events of lesser radiological and chemical exposures to the public than those above in this column	Radioactive releases producing effects less than those specified above in this column

TEDE – Total Effective Dose Equivalent (see Section 5.4.4.1)
AEGL – Acute Exposure Guideline Level (1, 2, 3 refers to the severity level, see Chapter 8)
ERPG – Emergency Response Planning Guideline (1, 2, 3 refers to the severity level, see Chapter 8)

Note: In the calculation of chemical consequences, AEGLs and ERPGs do not currently exist for all the chemicals used at the MFFF. Therefore, Temporary Emergency Exposure Limits (TEELs) issued by DOE were used. Chapter 8 details these concentration limits and discusses the chemical consequences in general.

Table 5.4-2. Event Risk Matrix

CONSEQUENCE		Highly Unlikely (1)	Unlikely (2)	Not Unlikely (3)
	High (3)	3 No Principal SSCs Applied	6 Principal SSCs Applied	9 Principal SSCs Applied
	Intermediate (2)	2 No Principal SSCs Applied	4 No Principal SSCs Applied	6 Principal SSCs Applied
	Low (1)	1 No Principal SSCs Applied	2 No Principal SSCs Applied	3 No Principal SSCs Applied

LIKELIHOOD

Table 5.4-3. Radionuclide Composition of Potentially Released MAR

Radionuclide	Effluent Concentration (μCi/mL)	Isotopic Fractions		
		Unpolished PuO_2	Polished PuO_2	Depleted UO_2
Pu-236	6.0×10^{-14}	4.07×10^{-17}	4.10×10^{-17}	0.0000
Pu-238	2.0×10^{-14}	3.95×10^{-4}	3.98×10^{-4}	0.0000
Pu-239	2.0×10^{-14}	9.20×10^{-1}	9.27×10^{-1}	0.0000
Pu-240	2.0×10^{-14}	6.14×10^{-2}	6.18×10^{-2}	0.0000
Pu-241	1.0×10^{-12}	1.00×10^{-2}	1.01×10^{-2}	0.0000
Pu-242	2.0×10^{-14}	1.00×10^{-3}	1.00×10^{-3}	0.0000
Am-241	2.0×10^{-14}	7.00×10^{-3}	0.0000	0.0000
U-235	6.0×10^{-14}	0.0000*	0.0000	2.50×10^{-3}
U-238	6.0×10^{-14}	0.0000*	0.0000	9.97×10^{-1}

* Values for uranium in unpolished plutonium are assumed to be negligible as the contribution to the overall dose from uranium is negligible with respect to that of plutonium.

Table 5.4-4. Adverse HEPA Filter Environmental Conditions

• Moisture: 95-100% relative humidity. • Hot air: greater than 450 °F. • Fire: direct fire or high concentrations of particulate matter produced by fire. • High pressure: 10 in. of water, gauge (in. wg) internal or differential across filter media. • Corrosive mist: dilute moist or moderately dry concentrations of acids and caustics. • Any acid and some caustics will attack uncoated aluminum separators. • Hydrofluoric acid will attack the media. • Nitric acid will attack wooden boxes making highly flammable nitrocellulose. (Wooden boxes are prohibited in systems subject to nitric acid fumes.) • Shock pressures.

Note: MFFF filter housings are mounted indoors and the housing is never exposed directly to outdoor environments.

Figures

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Safety Assessment of the Design Basis

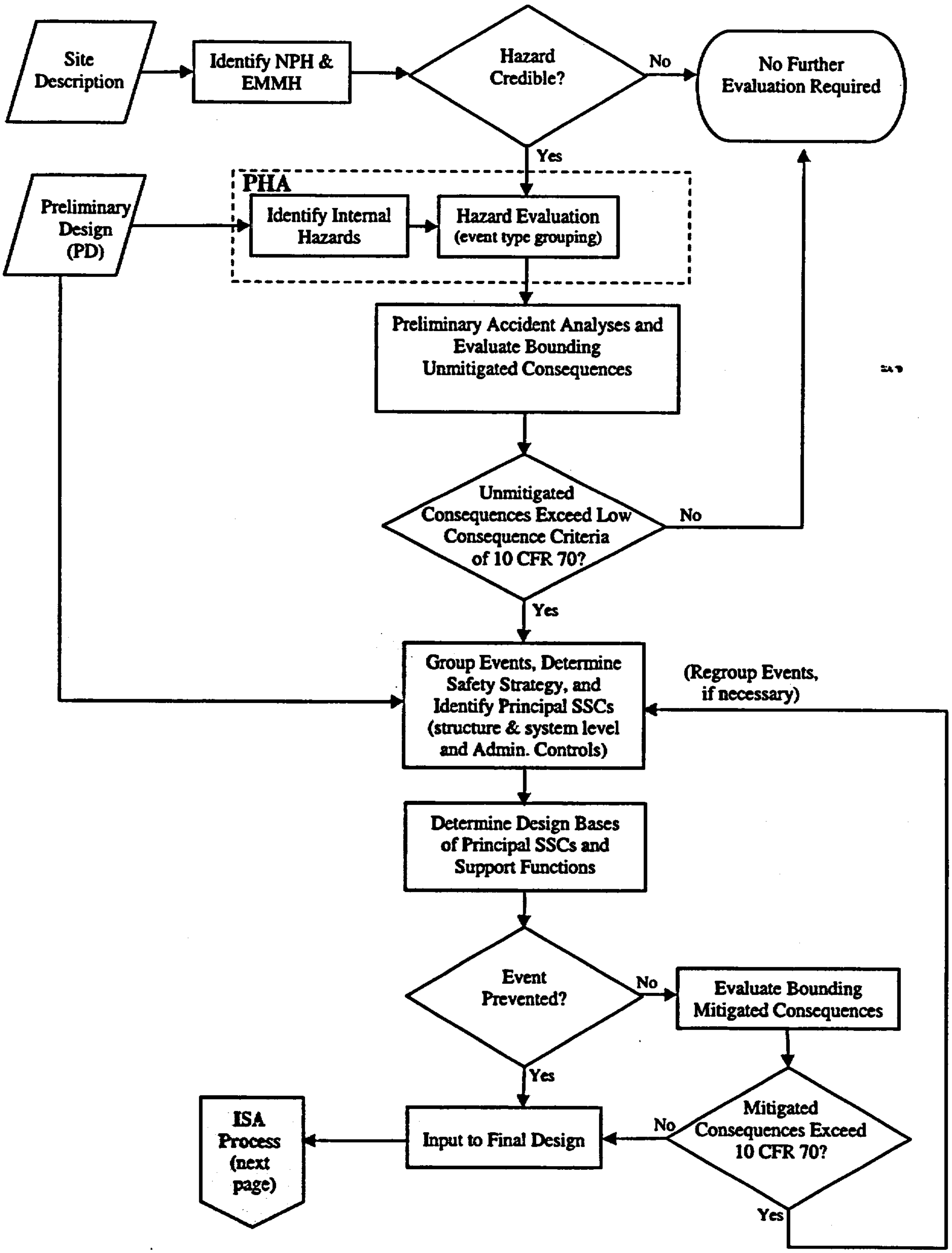

Figure 5.4-1. ISA Flow Chart (Safety Assessment)

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Latter Phase of Integrated Safety Analysis

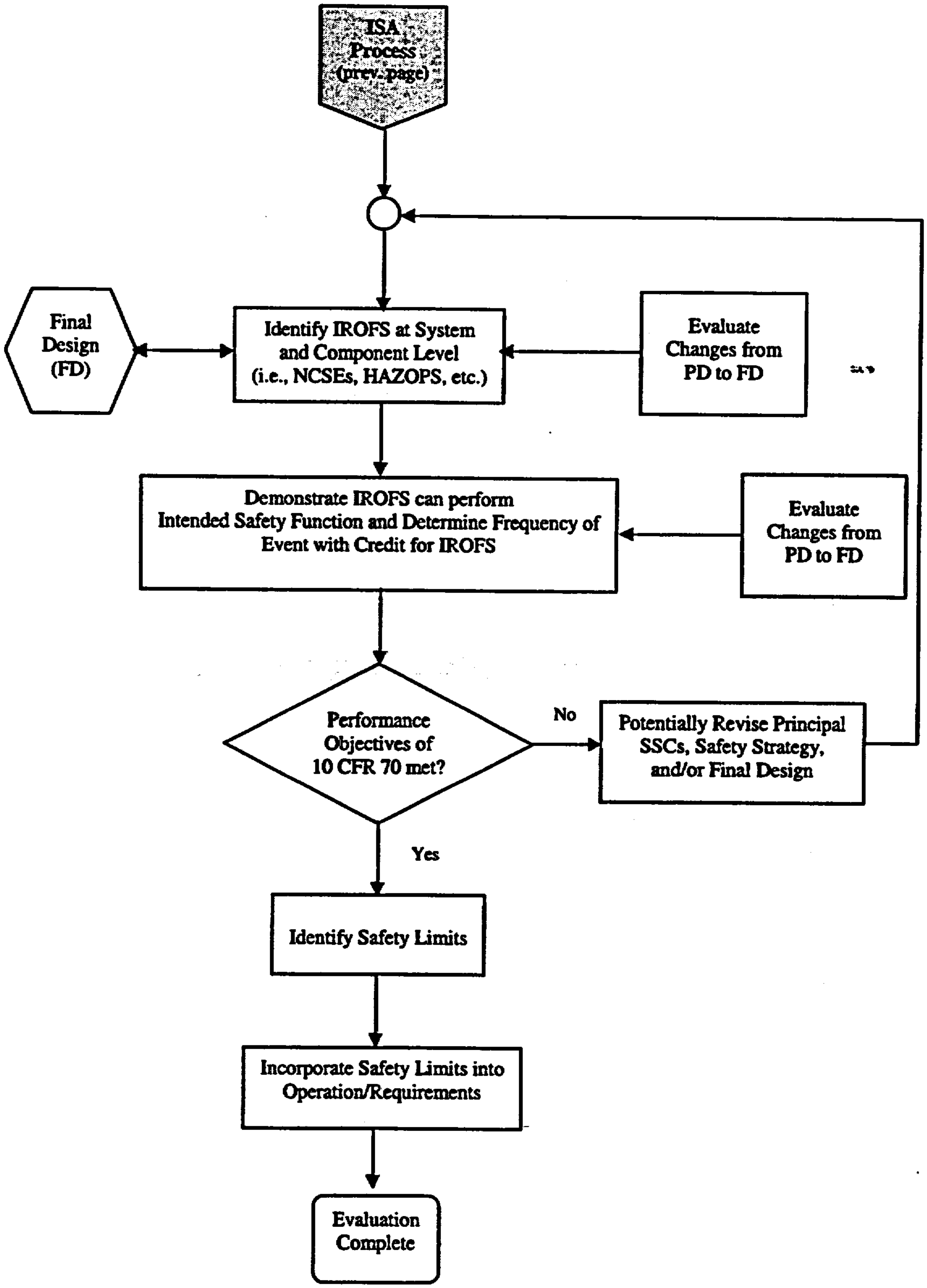

Figure 5.4-1. ISA Flow Chart (Latter Phase of ISA) (continued)

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5.5 SAFETY ASSESSMENT RESULTS

This section provides the results of hazard and accident analyses performed to identify the MFFF principal SSCs that provide protection against NPHs, EMMHs, and internally generated events in accordance with the performance requirements of 10 CFR §70.61.

5.5.1 Hazard Assessment

The hazard assessment was performed to identify and evaluate the hazards posed by the MFFF and its associated support facilities. The analysis identified facility hazards, including the locations and quantities of hazardous materials (chemical and radioactive). Events involving the identified hazards were developed and evaluated to estimate unmitigated event likelihood and consequence in accordance with the methods discussed in Section 5.4. Analyses were also performed to identify NPHs and EMMHs that could adversely impact the MFFF.

5.5.1.1 Hazard Identification

This section provides the results of the MFFF hazard identification, including the hazards posed by natural phenomena and external man-made events.

5.5.1.1.1 MFFF Internal Hazards

The hazards associated with the MFFF processes and operations were identified using the Checklist Analysis method as described in Section 5.4.1. To facilitate the hazard identification process, the MFFF was divided into workshops and further subdivided into process units within each workshop. Tables 5.5-1 and 5.5-2 list the workshops, process units, and process support units considered in the MFFF internal hazard assessment. Tables 5.5-3a and 5.5-3b lists the radioactive material quantities by facility location and fire area, respectively. The hazardous chemicals used at the MFFF are identified in Table 8-2. Table 5.5-4 summarizes the results of the hazard identification process. General hazardous chemical characteristics and incompatibilities with the associated materials/process conditions are identified for AP and MP process chemicals in Chapter 8 (Table 8-4).

5.5.1.1.2 Natural Phenomena Hazards

NPHs are those MFFF external hazards that arise from natural processes. These hazards are not the result of man-made operations.

A screening process was performed on a comprehensive list of NPHs to identify those NPHs that have the potential to affect MFFF operations. For the purpose of this evaluation, the period of facility operation is conservatively modeled as 50 years. NPHs that are not possible at SRS, or that cannot affect MFFF operations, are screened from further evaluation and are not considered in the MFFF design or operations. NPHs that have a frequency of occurrence of less than 1×10^{-6} per year are designated as beyond design basis, are screened from further evaluation, and are not considered in the MFFF design or operations.

Table 5.5-5 provides a comprehensive list of NPHs initially evaluated, and Table 5.5-6 summarizes the applicable NPHs that could impact MFFF operations. Applicable NPHs are further evaluated and accounted for as necessary in the MFFF design and operations as described in Section 5.5.2.6.

5.5.1.1.3 External Man-Made Hazards

EMMHs are those hazards that arise outside of the MFFF site from the operation of nearby public, private, government, industrial, chemical, nuclear, and military facilities and vehicles. Chapter 1 identifies and describes the location of the facilities and transportation corridors near the MFFF. SRS information, along with a comprehensive set of NRC and DOE documents, is used to develop the initial list of EMMHs.

The major events that result from EMMHs and the potential effects they could have on MFFF operations are as follows:

- A release of radioactive material resulting in exposures to MFFF personnel
- A release of hazardous chemicals resulting in exposures to MFFF personnel
- Explosions that could directly impact MFFF principal SSCs
- Events that result in a loss of offsite power
- Events that result in a fire (and/or resulting smoke) that spreads to the MFFF.

A screening process was performed on the EMMHs to identify those EMMHs that have the potential to affect MFFF operations. Guidance for the screening of EMMHs is based on the information provided in NUREG/CR-4839 (NRC 1992). Table 5.5-7 provides the screening criteria. Table 5.5-8 summarizes the EMMHs identified and the results of the screening process. The applicable EMMHs that could impact MFFF operations are further evaluated and accounted for as necessary in the MFFF design and operations as described in Section 5.5.2.7.

5.5.1.2 Hazard Evaluation

Following hazard identification, hazards were evaluated to identify potential events and to determine the effects of unmitigated events on the facility worker, site worker, public, and the environment.

Tables 5A-1 through 5A-14 in Appendix 5A summarize unmitigated events postulated from the identified hazards. These events are sorted by workshop and event type. The events in Appendix 5A apply for each process unit or workshop identified in the item labeled "specific location." Events that impact individual locations are evaluated for each glovebox, AP vessel, or other sub-unit within the specified process unit or workshop based on the MAR provided in Table 5.5-3a. For example, in fire events, the evaluation is based on the total MAR within a given fire area, as provided in Table 5.5-3b. These unmitigated events are evaluated and discussed in Section 5.5.2 according to the event type, except for low consequence events. Events in Tables 5.5-9, 5.5-12, 5.5-15, 5.5-18, 5.5-23, and 5.5-25 are subsets of the total list of events from the hazard assessment in Appendix 5A. Low consequence events are identified in Table 5.5-25 and discussed in Section 5.5.2.11.

The following assumptions were made in the unmitigated event evaluation:

- No credit is taken for prevention or mitigation design features in the determination of unmitigated event frequencies and consequences.
- The site worker is located 328 ft (100 m) away from the facility and is not evacuated during the event.
- The MOI is located at the controlled area boundary, approximately 5 mi (8 km) from the release point and is not evacuated during the event.
- The quantities and location of radiological and chemical inventories are presented in Tables 5.5-3a, 5.5-3b, and 8-2.
- Storage and shipping containers involved in accidents are assumed to contain the maximum allowable quantity of radioactive material.
- For unmitigated events involving the airborne release of plutonium, americium, or highly toxic chemicals to the facility worker's environment, no credit is taken for evacuation of the immediate facility worker, and the unmitigated event consequences to the facility worker are assumed to require principal SSCs.
- The structural integrity of a shipping or storage container is not considered in assessing consequences from an unmitigated event involving a container.
- Passive heat removal provides adequate cooling for decay heat removal for all facility locations, except the 3013 canister storage area. This assumption has been validated by preliminary calculations.

5.5.2 Accident Analysis

This section presents the results of the analysis performed on the event sequences identified in the hazard assessment. Hazard assessment events are categorized by their unmitigated consequences into one of two categories: (1) low consequence, or (2) above low consequence. The consequence threshold is based on the performance criteria of 10 CFR §70.61 described in Section 5.4.1.2.5. For low consequence events, no principal SSCs are required or identified. For events whose consequences have the potential to exceed the low consequence criteria of 10 CFR §70.61, principal SSCs and the associated design bases that will be utilized to satisfy the requirements of 10 CFR §70.61 and 10 CFR §70.64(b) are identified.

The accident analysis methodology is described in Section 5.4. The events are sorted and organized by event type from the hazards assessment provided in Appendix 5A, as described in the following sections. Quantitative bounding mitigated consequences are provided in Section 5.5.3.

5.5.2.1 Loss of Confinement/Dispersal of Nuclear Material Events

5.5.2.1.1 General Description

The MFFF handles plutonium in the form of solutions, powders, green pellets, and sintered pellets. Fuel rods and fuel assemblies are also handled at the MFFF. A dispersal hazard arises from the possible migration of plutonium particles from a primary confinement (e.g., process equipment, gloveboxes, fuel rods, transfer containers, 3013 canisters, welded process equipment, MOX fuel transport cask, 3013 transport cask) into the workplace or the environment.

Confinement of radioactive materials is ensured by the use of static confinement boundaries, generally in conjunction with ventilation systems. Static confinement boundaries restrict leakage out of the confinement boundary. The associated dynamic confinement system maintains a negative pressure with respect to adjacent areas and ensures that airflow is from areas of lower potential contamination into areas of higher potential contamination. For those cases in which dynamic confinement is not utilized in conjunction with static confinement, confinement boundaries are provided by sealed systems (e.g., 3013 containers, transfer containers, and fuel rods). Additional information regarding the confinement systems utilized within the MFFF is contained in Section 11.4.

Events included in this event type include leaks/breaches from primary confinement types into interfacing systems. This section does not include loss-of-confinement events that result from drop events. Drop events resulting in loss-of-confinement events are discussed in Section 5.5.2.3. Other events that may ultimately lead to loss-of-confinement events include fire, explosion, external man-made events, and natural phenomena. These events are treated based on the nature of the initiating event, namely fire, explosion, external man-made phenomena, and natural phenomena, in other parts of Section 5.5.2.

5.5.2.1.2 Causes

Dispersal of radioactive materials may occur if the static boundary of the primary confinement system is damaged, including defects in or damage to the integrity of vessels, pipes, gloveboxes, some process equipment, fuel rod cladding, and nuclear material containers. The following events can cause dispersal of nuclear material or failure of the primary confinement system:

- Failure of negative pressure or a flow perturbation due to failure of the Very High Depressurization Exhaust System
- Breaches of containers or rod confinement boundaries due to confinement handling operations (e.g., by shearing) or process operation failure
- Backflow into lines that penetrate primary and secondary confinement boundaries
- Corrosion-induced confinement failures
- Breaks or leaks of aqueous polishing (AP) process vessels or pipes
- Glove or seal failures on gloveboxes during normal or maintenance operations
- Thermal excursions leading to failure of gloves or seals
- Over- or under-pressurization of gloveboxes or other process equipment due to utility line/flow perturbations.

5.5.2.1.3 Specific Locations

Losses of confinement/nuclear dispersal events are hypothesized to occur in several locations within the MFFF. Each confinement area and confinement type is postulated to fail in the hazard assessment to determine the resulting safety implications.

5.5.2.1.4 Unmitigated Event Consequences

Unmitigated event radiological consequences were established for loss-of-confinement events identified in the hazard assessment. These consequences were used to establish the need for the application of principal SSCs.

5.5.2.1.5 Unmitigated Event Likelihood

The likelihood of occurrence of unmitigated loss-of-confinement events was qualitatively and conservatively assessed: all unmitigated event likelihoods were assumed to be Not Unlikely. Consequently, no postulated internally generated failures were screened due to likelihood considerations.

5.5.2.1.6 Safety Evaluation

This section presents information on event grouping, safety strategies, principal SSCs, and safety function. The event grouping for the loss-of-confinement events is based on the feasibility of employing common prevention/mitigation features to satisfy the performance requirements of 10 CFR §70.61. To adequately account for the facility worker, the loss-of-confinement events were grouped by the unique mechanism (cause) by which the loss-of-confinement event occurs. This event grouping was also utilized for the site worker, the public, and the environment. The following event groupings were utilized:

- Over-temperature
- Corrosion
- Small breaches in a glovebox confinement boundary or backflow from a glovebox through utility lines
- Leaks of AP process vessels or pipes within process cells
- Backflow from a process vessel through utility lines
- Rod-handling operations
- Breaches in containers outside gloveboxes due to handling operations
- Over- or under-pressurization of glovebox
- Excessive temperature due to decay heat from radioactive materials
- Glovebox dynamic exhaust failure
- Process fluid line leak in a C3 area outside of a glovebox
- Sintering furnace confinement boundary failure.

Table 5.5-9 presents a mapping of hazard assessment events to their respective event groups. The event representing the bounding unmitigated radiological consequence for each of the respective event groups is identified. It should be noted that events bounded by the event identified with the largest radiological consequence may require the same safety strategy and analogous principal SSCs to satisfy the performance requirements of 10 CFR §70.61. In this manner, loss-of-confinement events are ensured adequate protection.

The following sections describe the safety evaluation for the respective loss-of-confinement event groups. Tables 5.5-10a and 5.5-11 summarize the results of the evaluation for the facility worker, and the public and site worker, respectively. Table 5.5-10b summarizes the results of the evaluation for the protection of the environment. Principal SSCs listed in Table 5.5-10b are required only to make the hypothesized event unlikely.

5.5.2.1.6.1 Over-Temperature

A loss-of-confinement event is postulated due to an over-temperature event in a given process operation. This event group includes events that involve high temperature process equipment and/or failure of process equipment that potentially result in high temperatures within a glovebox that exceed the glovebox design criteria, damaging the glovebox and resulting in a release of radioactive material. The event with the bounding radiological consequences for this event group has been identified as an excessive temperature of an AP electrolyzer located in a glovebox. The resulting over-temperature is postulated to result in a release of unpolished PuO_2 in solution from the glovebox into the C3b area.

To reduce the risk to the facility worker and the environment associated with this postulated event group, a safety strategy utilizing prevention features is adopted. The principal SSC identified to prevent these events is the process safety control subsystem. The safety function of the process safety control subsystem is to shut down process equipment prior to exceeding a temperature safety limit. This temperature will be established by considering all material limits associated with the glovebox. Final calculations and specific temperature setpoints will be performed during final design based on the codes and standards identified in Section 11.6.7 to assure that subsequent to the shutdown of process equipment, normal convection cooling is sufficient.

To reduce the risk to the public and site worker, a safety strategy utilizing mitigation features is adopted. The principal SSC identified to mitigate this event is the C3 confinement system. The safety function of the C3 confinement system is to provide filtration to mitigate dispersions from the C3 areas.

The prevention features present to protect the facility worker and the environment provide defense-in-depth protection for the site worker and public.

5.5.2.1.6.2 Corrosion

A loss-of-confinement event involving a catastrophic failure of a primary confinement boundary (i.e., a laboratory or an AP glovebox containing corrosive chemicals, AP fluid transport systems, a pneumatic transfer line, or ducting of the C4 confinement system) is postulated due to corrosion. Loss-of-confinement events caused by corrosion within process cells are discussed in

Section 5.5.2.1.6.4. Loss-of-confinement events caused by corrosion of pipes containing process fluids within C3 areas not enclosed within a glovebox are discussed in Section 5.5.2.1.6.11. Corrosion may occur either from within or from the outside of process equipment. The event identified with the bounding radiological consequences for this event group is a corrosion event involving the pneumatic transfer system with PuO_2 in a buffer pot. In this event, corrosion occurs from the outside of the transfer system and potentially results in the failure of the pneumatic tube with subsequent dispersal of PuO_2 to the surrounding area.

To reduce the risk to the facility worker and the environment associated with this event group, a safety strategy to mitigate the effects of corrosion is adopted that prevents catastrophic failures to primary confinement boundaries, such as gloveboxes. The principal SSC identified to implement this safety strategy is the use of material maintenance and surveillance programs as appropriate. The safety function of the material maintenance and surveillance programs is to detect and limit the damage resulting from corrosion (principally to reduce failures associated with corrosion occurring to laboratory and AP gloveboxes containing corrosive chemicals, confinement ducting, and pneumatic transfer lines).

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public and site worker. However, the C4 and C3 confinement systems, and the C2 confinement system passive boundary, provide defense-in-depth protection for the public and the site worker.

5.5.2.1.6.3 Small Breaches in a Glovebox Confinement Boundary or Backflow From a Glovebox Through Utility Lines

A loss-of-confinement event is postulated to arise due to small breaches (e.g., glove failures) in a C4 glovebox or backflow of material within a glovebox to an interfacing system. The event identified with the bounding radiological consequences for this event group is a backflow of radioactive material from a glovebox through an interfacing supply line that is subsequently breached or opened during a maintenance operation.

To reduce the risk to the facility worker and the environment associated with this event group, a safety strategy utilizing mitigation features has been adopted. The C4 confinement system is identified as the principal SSC preventing this event sequence from impacting the facility worker and the environment. The safety function of the C4 confinement system is to maintain a negative glovebox pressure differential between the glovebox and interfacing systems. The system also maintains inward flow through a small glovebox breach to ensure that no significant quantity of radioactive material escapes the glovebox.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public or the site worker. However, the C3 confinement system provides defense-in-depth protection for the public and the site worker.

5.5.2.1.6.4 Leaks of AP Process Vessels or Pipes Within Process Cells

A loss-of-confinement event is postulated due to a leak inside a process cell. The event identified with the bounding radiological consequences for this event group is a leak of tanks/vessels inside the process cell containing a portion of the purification cycle.

To reduce the risk to the facility worker associated with this postulated event group, a safety strategy utilizing mitigation features is adopted. The principal SSC identified to implement this safety strategy is the process cell. The safety function of the process cell is to contain leaks within the process cells (prevention of corrosion in process cells and a resulting corrosion allowance is not required for safety because the unmitigated consequences of a leak are low to the site worker, environment, and the public, and the process cell protects the facility worker).

Process cell entry controls are also identified as a principal SSC. The safety function of the process cell entry controls is to prevent the entry of personnel into process cells during normal operations and to ensure that workers do not receive a radiological exposure in excess of limits while performing maintenance in the AP process cells.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public, the site worker, or the environment. However, the process cell ventilation system passive boundary provides defense-in-depth protection for the public, site worker, and the environment.

5.5.2.1.6.5 Backflow From a Process Vessel Through Utility Lines

A loss-of-confinement event is postulated to occur due to backflow of material from a process vessel to an interfacing system. The event identified with the bounding radiological consequences for this event group is a backflow of radioactive material from a waste tank containing americium through an interfacing supply line that is subsequently breached or opened during a maintenance operation.

To reduce the risk to the facility worker, site worker, and the environment associated with this event group, a safety strategy utilizing prevention features has been adopted. Backflow prevention features (such as hydraulic seals and gravitational head differences) are identified as the principal SSCs preventing this event sequence from impacting the facility worker, the site worker, and the environment. The safety function of the backflow prevention features is to ensure a pressure boundary exists between process fluids and interfacing systems (e.g., reagent systems) to prevent process fluids from back-flowing into interfacing systems.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public. However, the C2 confinement system passive boundary provides defense-in-depth protection for the public, as well as for the site worker and the environment for this event group.

5.5.2.1.6.6 Rod Handling Operations

A loss-of-confinement event is postulated due to a breach of one or multiple fuel rods while utilizing fuel rod handling equipment. This event group is utilized to characterize those cases where the engineering design of the primary confinement type (fuel rod) may not sufficiently prevent a radioactive material release from occurring. The event identified with the bounding radiological consequences involves mishandling a tray of fuel rods.

To reduce the risk to the facility worker associated with this event group, both prevention and mitigation features are utilized to implement the safety strategy. The principal SSCs utilized to prevent this event from occurring are the material handling equipment and material handling controls. The safety function of the material handling equipment is to limit damage to fuel rods/assemblies during handling operations. The safety function of the material handling controls is to ensure the proper handling of primary confinement types outside of gloveboxes. To mitigate potential releases from impacting the facility worker, facility worker action is identified as a principal SSC. The safety function of this principal SSC is to ensure that facility workers take proper actions to limit radiological exposure as the result of a rod handling event.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public, the site worker, or the environment. However, the C2 confinement system passive boundary provides defense-in-depth protection for the public, site worker, and the environment.

5.5.2.1.6.7 Breaches in Containers Outside Gloveboxes Due to Handling Operations

A loss-of-confinement event is postulated due to a breach in a 3013 canister, transfer container containing plutonium-bearing waste, or other primary confinement types within the C2 or C3 areas outside of a glovebox. The 3013 canisters are used to contain the incoming PuO_2 and are stored in the 3013 storage area. The transfer containers are used to move material removed from gloveboxes during bagout operations from one location in the MFFF to another. Transfer containers are expected to be similar to DOT 7A drums. Other primary confinement types is the term used to describe the bags or other containers used during bagout operations from a glovebox. After removal from the glovebox, these other primary confinement types are placed within the transfer container, then the transfer container is sealed and moved as necessary. These bagout operations occur only in the C3 areas and only sealed transfer containers are moved from a C3 area to a C2 area. The event identified with the bounding radiological consequences is a loss-of-confinement event in which a transfer container containing filters is breached while in the C2 area.

For events associated with this event group occurring within C2 areas, a safety strategy utilizing prevention features is adopted to reduce the risk to the public, site worker, facility worker, and the environment. The principal SSCs identified to implement this safety strategy are the transfer container and the 3013 canister. To ensure that these primary confinement devices are properly handled, material handling controls are also identified as principal SSCs. The safety function of the transfer container and the 3013 canister is to withstand the effects of design basis drops (or an equivalent impact) without breaching. The safety function of the material handling controls is to ensure proper handling of primary confinement types. The C2 system passive boundary provides defense-in-depth protection for the public, site worker, and the environment.

For events associated with this event group occurring within C3 areas, a safety strategy utilizing both prevention and mitigation features is adopted to reduce the risk to the facility worker. The principal SSCs identified to implement this safety strategy are the transfer container, 3013 canister, and facility worker controls. To ensure that the transfer container and the 3013 canister are properly handled, material handling controls are also identified as principal SSCs. The safety function of the transfer container and the 3013 canister is to withstand the effects of design basis drops (or an equivalent impact) without breaching. The safety function of the material handling controls is to ensure proper handling of primary confinement types. In those cases in which other primary confinement types are utilized within C3 areas (e.g., during bagout operations), facility worker controls ensure that facility workers take proper actions prior to commencing bag-out operations to prevent and/or limit their radiological exposure. Precautions associated with the radiation protection program are implemented prior to beginning these operations (such as the use of a mask) to ensure the facility worker is protected in case a release of radioactive material occurs.

For events associated with this event group occurring within C3 areas, a safety strategy utilizing mitigation features is adopted to reduce the risk to the public, site worker, and the environment. The principal SSC identified to implement this safety strategy is the C3 confinement system. The safety function of the C3 confinement system is to effectively filter releases from the C3 area.

The C2 confinement system passive boundary and the preventative features utilized to reduce the risk to the facility worker and the environment provide defense-in-depth protection for the public and site worker.

5.5.2.1.6.8 Over- or Under-Pressurization of Glovebox

A loss-of-confinement event is postulated due to over- or under-pressurization of a glovebox. Two distinct events in which a glovebox is over- or under-pressurized are possible, namely, a slow over- or under-pressurization event and a rapid over- or under-pressurization event. The event identified with the bounding radiological consequence is a rapid over-pressurization of the calcining furnace glovebox.

To reduce the risk to the facility worker associated with rapid over- or under-pressurization events, a safety strategy utilizing prevention features is adopted. To implement this safety strategy, glovebox pressure controls are utilized as the principal SSC. The corresponding safety function is to maintain glovebox pressure within design limits.

A slow pressurization of the glovebox may also occur. To reduce the risk to the facility worker associated with slow pressurization events, a safety strategy utilizing mitigation features is adopted. To implement this safety strategy, the following principal SSCs are utilized:

- Process safety control subsystem
- Facility worker action
- Glovebox pressure controls.

The safety function of the process safety control subsystem is to warn operators of glovebox pressure discrepancies prior to exceeding differential pressure limits. The safety function of facility worker action is to ensure that facility workers take proper actions to limit radiological exposure as the result of glovebox over- or under-pressurization. Events that produce a pressure change will be detected by pressure alarms and would cause immediate operator self-protective action. The safety function of glovebox pressure control is to maintain glovebox pressure within design limits.

To reduce the risk to the environment associated with rapid over- or under-pressurization events, a safety strategy utilizing mitigation features is adopted. The principal SSC identified to implement this safety strategy is the C3 and C4 confinement systems. The safety function of the

C3 and C4 confinement systems is to effectively filter releases to mitigate dispersion from C3/C4 areas.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public or the site worker. However, any release that may occur from a glovebox will be mitigated by the C3 confinement system, thus providing defense-in-depth protection for the public and site worker.

5.5.2.1.6.9 Excessive Temperature Due to Decay Heat from Radioactive Materials

Loss-of-confinement events are postulated due to failures in the surrounding structures attributed to increases in temperatures of operating areas due to decay heat generated by radioactive material.

Preliminary thermal calculations have been performed to evaluate the effects of temperature on confinement structural materials. Maximum material temperatures were calculated for both normal conditions and hypothetical accident conditions (in which the ventilation and equipment cooling systems are assumed to be shut down). The design basis temperature criteria for confinement structural materials are provided in Section 11.4.11, Gloveboxes. Thermal sources considered in the calculations include:

- Radioactive decay of nuclear materials
- Spontaneous heating of UO_2 due to oxidation (burnback, UO_2 to U_3O_8)
- Operation of electrical/mechanical equipment (electrical motors, mixers, etc)
- Process equipment (calcining furnace, etc.)

The thermal power generated by the decay of nuclear material was calculated as follows:

- Unpolished Pu: 2.9 W/kg of unpolished PuO_2 powder
- Polished Pu: 2.2 W/kg of polished PuO_2 powder

The specific power of UO_2 oxidation is taken into account using the following values:

- If $T < 74°C$ (165.2°F) then $P_{ox} = 0$ W/kg (0 W/lb) of UO_2,
- If 74°C (165.2°F)< $T <$ 340°C (644°F) then $P_{ox} = 1.1$ W/kg (0.499 W/lb) of UO_2,
- If $T > 340°C$ (644°F) then $P_{ox} = 4.63$ W/kg (2.1 W/lb) of UO_2

  where T is the powder temperature.

These preliminary calculations have determined that only the 3013 canister storage structure requires long-term cooling to mitigate the effects of decay heat. The specific consequences associated with this event are heating sections of the concrete vault above the concrete design temperature. This event results in reduced capacity for design loads and may require concrete replacement. Even though several days without forced cooling are required for the concrete to exceed its design criteria, principal SSCs are identified to mitigate the potential consequences of this event.

The principal SSC identified to implement this safety strategy is the High Depressurization Exhaust System (part of the C3 confinement system). The safety function of this system is to provide exhaust to ensure that temperatures in the 3013 canister storage structure are maintained within design limits.

5.5.2.1.6.10 Glovebox Dynamic Exhaust Failure

A loss-of-confinement event is postulated due to a loss of negative pressure or a flow perturbation involving the Very High Depressurization Exhaust System. This event could result in a confinement differential pressure reversal. The bounding radiological consequence for this event group could result in the transport of the airborne and entrained material in C4 gloveboxes to leak into the individual process C3 rooms. This material could then ultimately either be filtered by the C3 confinement system or be transported into the C2 area.

To reduce the risk to the facility worker, site worker, and the environment associated with this event, prevention features are utilized. The principal SSC identified to implement this safety strategy is the C4 confinement system. The safety function of the C4 confinement system is to operate to ensure that a negative pressure differential exists between the C4 glovebox and the C3 area and to effectively filter C4 exhaust.

The unmitigated consequences of this event to the public are low and, hence, no principal SSCs are required. However, the principal SSC utilized to protect the facility worker, site worker, and the environment also protects the public, thereby providing defense-in-depth protection. Additionally, the C3 and C2 confinement system passive boundaries provide defense-in-depth protection for the public, site worker, and the environment for this event.

5.5.2.1.6.11 Process Fluid Line Leak In a C3 Area Outside of a Glovebox

A loss-of-confinement event is postulated due to a leak from a line carrying a process fluid in a C3 area outside of a glovebox. Similar loss-of-confinement events within process cells are discussed in Section 5.5.2.1.6.4 and within gloveboxes are discussed in Section 5.5.2.3.6.4. The event identified with the bounding radiological consequences for this event group is a leak from a pipe containing plutonium solution from a dissolution electrolyzer. This leak is assumed to occur outside of an AP glovebox into a C3 area potentially occupied by a facility worker as the line transitions from an AP glovebox to another AP glovebox or to a process cell.

To reduce the risk to the facility worker and the environment associated with this event group, a safety strategy utilizing prevention features is adopted. The principal SSC identified to implement this safety strategy is double-walled pipe containing process fluids (e.g., plutonium bearing fluids) within C3 areas, but outside of gloveboxes. The safety function of this principal SSC is to prevent leaks from pipes containing process fluids from leaking into C3 areas.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public and site worker. However, any release from a pipe into a C3 area will be mitigated by the C3 confinement system, thus providing defense-in-depth protection for the public and the site worker.

5.5.2.1.6.12 Sintering Furnace Confinement Boundary Failure

A loss-of-confinement event is postulated due to a breach in the sintering furnace confinement boundary. The sintering furnace shell forms a primary confinement boundary, which is maintained at a slight overpressure with respect to the process room during normal operations. The sintering furnace confinement boundary is considered to fail in one of two ways, namely a slow leakage through the seals and a rapid overpressure event. The event identified with the bounding radiological consequence is a rapid over-pressurization of the Sintering Furnace.

To reduce the risk to the facility worker and the environment associated with rapid over-pressurization events, a safety strategy utilizing prevention features is adopted. To implement this safety strategy, sintering furnace pressure controls and the sintering furnace are utilized as the principal SSCs. The safety function for the sintering furnace pressure controls is to maintain sintering furnace pressure within design limits. The safety function for the sintering furnace is to provide a primary confinement boundary.

Seal failures are not expected to occur. However, a local seal defect is conservatively postulated to occur resulting in the release of some of the furnace atmosphere to the furnace process area. The safety strategy is to mitigate the consequences of this event. The principal SSC implementing this strategy is the sintering furnace and the safety function is to minimize the consequences of a leak. With this principal SSC in place, the consequences of this event are evaluated to be low based on design of the furnace and the following operational features: (1) the furnace atmosphere is continually changed out, thus it contains low amounts of airborne radioactive material and (2) the internal furnace pressure is low, thus there is very low energy available to make internal surface contamination airborne, respirable, and dispersed outside of the furnace.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public or the site worker. However, any release that may occur from a sintering furnace loss of confinement will be mitigated by the C3 confinement system, thus providing defense-in-depth protection for the public, site worker, and environment.

5.5.2.1.7 Mitigated Event Consequences

Mitigated event consequences for the bounding radiological loss-of-confinement event are addressed in Section 5.5.3.

5.5.2.1.8 Mitigated Event Likelihood

The likelihood of mitigated events is discussed in Section 5.5.4.

5.5.2.1.9 Comparison to 10 CFR §70.61 Requirements

The SA evaluates a comprehensive list of potential loss-of-confinement events. Based on the results of the bounding consequence analysis and the effective application of the principal SSCs identified in Section 5.5.2.1.6, the risks from loss-of-confinement events satisfy the performance requirements of 10 CFR §70.61.

5.5.2.2 Fire Events

5.5.2.2.1 General Description

A fire hazard occurs from the simultaneous presence of combustible materials, an oxygen source, and a sufficient ignition source. The combustion reaction is exothermal and supplies its own energy once started. Combustion is terminated by a lack of combustible material, oxygen, or energy needed to support the fire. A fire can spread from one point to another by conduction, convection, or radiation. The immediate consequence of a fire is the destruction, by combustion or by thermal damage, of elements in contact with the fire.

Fires may result in the following potential consequences:

- Destruction of a confinement boundary (e.g., glovebox walls, vessels walls, rod cladding, HEPA filters)
- Destruction of civil structures (e.g., room walls, building)
- Destruction of equipment contributing to dynamic confinement (e.g., fan, ventilation duct)
- Failure of or damage to utility equipment (e.g., electrical cabinet, fluid pipes)
- Loss of subcritical conditions (e.g., destruction of isolation shields, loss of subcritical geometry, loss of neutron absorber)
- Loss of other principal SSCs
- Release of nuclear and chemical material to the environment.

The magnitude of a fire impact depends on its size and the nature of the resulting damage. Additional information regarding the details of fire areas and fire hazards throughout the MFFF is included in Chapter 7.

5.5.2.2.2 Causes

Causes identified for fire events within the MFFF buildings include the following:

- Short circuits or equivalent events involving electrical equipment (e.g., fans, motor, switch boxes)
- Ignition or combustion of fixed or transient combustibles
- Equipment that operates at high temperatures
- Ignition of a solvent or other flammable/reactive chemical due to an incorrect reagent addition, an external source of ignition, or temperatures that exceed flash points.

5.5.2.2.3 Specific Locations

Fires are postulated to occur in each of the respective fire areas as described in Section 5.5.2.2.4. These fire areas include those areas nearby electrical equipment and/or combustible material and those containing flammable, explosive, and reactive chemicals. Fires are also hypothesized to occur in specific areas where fire accelerants may be present (e.g., combustible solvents). These areas are limited to specific vessels containing solvents in the AP Solvent Recovery Cycle and the AP Purification Cycle. Equipment hypothesized to operate at high temperatures also presents fire hazards. This equipment includes the following:

- Calcination furnace of the AP Oxalic Precipitation and Oxidation Unit
- Electrolyzers of the AP Dissolution Units
- Evaporators of the AP Acid Recovery Unit and the AP Oxalic Mother Liquor Recovery Unit
- Furnace of the MP Sintering Unit
- Welder of the MP Cladding and Decontamination Unit
- Grinder of the MP Grinding Unit
- Torches, heating plates, and evaporators found in the AP/MP laboratory.

In the absence of controls, these areas are more susceptible to an internal fire event than other areas due to their inclusion of at least one of the three elements necessary and sufficient for the development of a fire (i.e., fuel, oxygen, and applied heat). Additional information regarding the locations of fire hazards throughout the MFFF is presented in Chapter 7.

5.5.2.2.4 Unmitigated Event Consequences

Unmitigated event radiological consequences are established for each of the identified hazard events. These consequences are used to establish the need for the application of principal SSCs.

It is conservatively assumed that all of the material at risk within the fire area is involved in the fire. Fire areas are defined as areas that restrict the spread of fires such that they may be modeled as individually isolated areas. Fire areas are isolated through the use of fire barriers.

The radioactive material at risk within each fire area is provided in Table 5.5-3b. The site fire areas (defined in Chapter 7) and the radioactive material within each fire area listed in Table 5.5-3b provide the basis for this radiological consequence analysis. Chapter 7 also provides a general discussion of the criteria and justification for containing fires within the fire areas.

5.5.2.2.5 Unmitigated Event Likelihood

The likelihood of occurrence of unmitigated fire events was qualitatively and conservatively assessed. All unmitigated event likelihoods were assumed to be Not Unlikely. Consequently, no postulated fires resulting from internally generated failures were screened due to likelihood considerations.

5.5.2.2.6 Safety Evaluation

This section presents information on event grouping, safety strategies, principal SSCs, and safety function. The selection of event groupings for fire events is based on the potentially common radiological prevention and mitigation features afforded by specific fire areas, confinement zones, and confinement types (e.g., 3013 canisters). Consequently, the following event groupings are identified:

- AP process cells
- AP/MP C3 glovebox areas
- C1 and/or C2 areas:
  - 3013 canister
  - 3013 transport cask
  - Fuel rod
  - MOX fuel transport cask
  - Waste container
  - Transfer container
  - Final C4 HEPA filter
- Outside the MOX Fuel Fabrication Building
- Facilitywide systems
- Facility.

Table 5.5-12 presents a mapping of hazard assessment events to their respective groups. The event representing the bounding unmitigated radiological consequence for each of the respective event groups is identified. It should be noted that hazard assessment events bounded by the event identified with the largest radiological consequence may require the same safety strategy and analogous principal SSCs to satisfy the performance requirements of 10 CFR §70.61. In this manner, fire events are ensured adequate protection.

The following sections describe the safety evaluation for the respective groupings of fire event groups. Tables 5.5-13a and 5.5-14 summarize the principal SSCs and the safety function for the facility worker, and the public and site worker, respectively. Table 5.5-13b summarizes the results of the evaluation for the protection of the environment. Principal SSCs listed in Table 5.5-13b are required only to make the event unlikely.

The FHA is part of the ISA and is an ongoing process during design. For a description of the relationship between the FHA and the ISA, see Chapter 7.

5.5.2.2.6.1 AP Process Cells

Fires are postulated in the AP process cells due to the presence of solvents and other chemicals with flash points that potentially could be exceeded. The AP process cell containing the dissolution tanks was determined to result in the largest radiological consequence and is thereby taken as the bounding fire event for this event group. Although this cell does not contain any solvent or other combustible materials, a fire was conservatively hypothesized to occur in this cell.

To reduce the risk to the public, site worker, facility worker, and the environment associated with the fire events within the AP process cells, a safety strategy utilizing prevention features is adopted. The principal SSC identified to implement this safety strategy is the use of process cell fire prevention features. The fire prevention features that effectively reduce the likelihood of the fire event in the AP process cells to highly unlikely include the following:

- The elimination of ignition sources within these cells (including the elimination of electrical equipment)
- The earth grounding of vessels and pipes to avoid ignition by static electricity
- The presence of fire barriers (part of the fire area designation) to ensure that fires do not breach these cell areas
- For cells containing only aqueous solutions, the elimination of all combustible materials from the process cells
- For cells containing solvents or other combustible products necessary for the process, the minimization of all combustibles within the process cells (i.e., no combustibles outside of process equipment)
- Temperatures are maintained at levels that prevent the creation of flammable vapors.

The safety function of these process cell fire prevention features is to ensure that the likelihood of the fire within the process cell is highly unlikely.

It is emphasized that all the materials at risk in process cells are isolated from the process cell environments by sealed vessels and pipes, thereby ensuring a barrier to an improbable fire in a process cell. This feature is important for tanks that will contain solvent, which is a flammable material but not a fire threat by itself.

To ensure that the process cells are isolated from potential fire hazards, the process cells themselves are isolated from adjacent rooms/cells by fire barriers associated with the designation of fire areas. Therefore, fire barriers are also identified as a principal SSC. The safety function of the fire barrier is to isolate the process cell from fire hazards. It should be noted that fire barriers are identified in the facility event group (Tables 5.5-13a, 5.5-13b, and 5.5-14) and are implicitly required for all fire events.

The process cell ventilation system passive boundary and the C2 confinement system passive boundary provide defense-in-depth protection to mitigate the potential consequences to the public, site worker, and the environment.

5.5.2.2.6.2 AP/MP C3 Glovebox Areas

Fires postulated to occur in AP/MP C3 glovebox areas, by causes identified in Section 5.5.2.2.2, have been divided into two subgroups based on the quantity of radiological materials present in each fire area. For fire areas containing gloveboxes that store radiological materials (e.g., the sintered and green pellet glovebox stores), the bounding radiological consequence involves a fire within the PuO_2 buffer storage area. Although the storage areas are large and the combustible loading is low, this bounding fire has been assumed to involve all the radioactive materials in the storage area. For other fire areas containing process gloveboxes, the bounding radiological consequence involves a fire within the fire area containing the final dosing and ball milling units.

Although the combustible loading is low in this fire area, all the radioactive materials of the gloveboxes within this fire area have been assumed to be involved in the fire.

<u>All Gloveboxes</u>

To reduce the risk to the public, site worker, and the environment associated with this event group, a safety strategy utilizing mitigation features is adopted. The principal SSC identified to implement this safety strategy is the C3 confinement system. The safety function of the C3 confinement system is to remain operable during a design basis fire and effectively filter any release.

As previously described, the facility is designed to restrict fires to a single fire area. These fire areas are regions within the MOX Fuel Fabrication Building, which ensure that any fire that may occur remains localized and does not spread to other areas of the facility. Thus, these fire areas effectively limit the radioactive material at risk for a fire event, as well as limit the potential quantity of material that could impact the mitigating confinement filters. Therefore, fire barriers are identified as a principal SSC to protect the public, site worker, and the environment. The safety function of the fire barrier is to limit a fire to a single fire area. It should be noted that fire barriers are identified in the facility event group (Tables 5.5-13a, 5.5-13b, and 5.5-14) and are implicitly required for all fire events.

The safety strategy utilized to reduce the risk to the facility worker is to rely upon mitigation features. The principal SSCs identified to implement this safety strategy are facility worker action and facility worker controls. The safety function of facility worker action is to ensure that facility workers take proper actions to limit radiological exposure as the result of fire. The facility worker evacuates the area in the event of a fire. The safety function of facility worker controls is to ensure that facility workers take proper actions prior to commencing maintenance activities to limit radiological exposure, such as utilizing procedures that will ensure that process equipment is devoid of bulk quantities of nuclear materials prior to performing special maintenance activities.

The C2 confinement system passive boundary, and fire detection and suppression systems provide defense-in-depth protection to mitigate the potential consequences for the public, site worker, and the environment.

<u>Storage Gloveboxes</u>

In addition to the mitigation features presented above for all gloveboxes, combustible loading controls have also been identified as a principal SSC for storage gloveboxes to further reduce the risk to the public, site worker, and the environment associated with this event group. The associated safety function of this principal SSC is to limit the quantity of combustibles, through design and administrative controls, in fire areas containing a storage glovebox such that any fire that may occur will not encompass a large fraction of the stored radiological material. Calculations will be performed as part of the ISA to demonstrate that fires in fire areas containing storage gloveboxes will not impact significant quantities of stored radiological materials.

5.5.2.2.6.3 C1 and/or C2 Areas

A fire within a C1 and/or C2 area is postulated due to the various causes identified in Section 5.5.2.2.2. Seven subgroups have been identified within this event group and are discussed below. Note that for all fires within the C2 area, the C2 confinement system passive boundary provides defense-in-depth protection for the public, site worker, and the environment.

<u>3013 Canister</u>

This event group within the C2 area involves a fire affecting 3013 canisters within the 3013 storage area. Although this storage area contains little combustible material, a large fire involving all of the radioactive material in this fire area has been postulated. It should be noted that the storage area is very large and that the radioactive material is sealed within a canning system consisting of three cans, one inside the other. Thus, there are no known mechanisms that could result in a fire that impacts the entire storage area.

To reduce the risk to the public, site worker, facility worker, and the environment, a safety strategy utilizing mitigation features is adopted. The principal SSC identified to implement this safety strategy is combustible loading controls. These controls limit the quantity of combustibles in a fire area containing 3013 canisters to ensure that the canisters are not adversely impacted by a fire.

<u>3013 Transport Cask</u>

A fire within the C1 or C2 area is postulated to affect the 3013 transport cask. These casks contain unpolished plutonium powder within 3013 canisters. To reduce the risk to the public, site worker, facility worker, and the environment associated with this fire event, a safety strategy utilizing mitigation features is adopted. The principal SSC identified to implement this safety strategy is the 3013 transport cask. The corresponding safety function of the 3013 transport cask is to withstand the design basis fire without breaching. Administrative controls may be required to limit the quantity of combustibles in a fire area containing 3013 transport casks to ensure that the cask design basis fire is not exceeded. Therefore, combustible loading controls have also been identified as a principal SSC.

<u>Fuel Rod</u>

A fire within the C2 area is postulated to affect fuel rods. The corresponding bounding radiological consequence for this event group involves a fire in the fuel assembly storage area. Although the storage area is large and the combustible loading is low, the fire has been assumed to involve all the radioactive materials in the storage area. To reduce the risk to the public, site worker, facility worker, and the environment associated with this fire event, a safety strategy utilizing mitigation features is adopted. The principal SSC identified to implement this safety strategy is combustible loading controls. The associated safety function is to limit the quantity of combustibles in a fire area containing fuel rods to ensure that the fuel rods are not adversely impacted by a fire.

MOX Fuel Transport Cask

A fire within the C1 or C2 area is postulated to affect the MOX fuel transport cask. To reduce the risk to the site worker, facility worker, and the environment associated with this event group, a safety strategy utilizing mitigation features is adopted. The principal SSC to implement this safety strategy is the MOX fuel transport cask. The safety function of the MOX fuel transport cask is to withstand the design basis fire without breaching. Administrative controls may be required to limit the quantity of combustibles in a fire area containing MOX fuel transport casks to ensure that the cask design basis fire is not exceeded. Therefore, the combustible loading controls in the fire areas containing MOX fuel transport casks are identified as a principal SSC.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public. However, the principal SSCs utilized to protect the facility worker, site worker, and the environment provide defense-in-depth protection to the public.

Waste Container

A fire within the C1, C2 or C3 area is postulated to affect waste containers. To reduce the risk to the facility worker associated with this event group, a safety strategy utilizing mitigation features is adopted. The principal SSC to implement this safety strategy is facility worker action. The safety function of this principal SSC is to ensure that facility workers take proper actions to limit radiological exposure as the result of fire.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public, site worker, or the environment.

Transfer Container

A fire within the C1, C2 or C3 area is postulated to affect the transfer container. To reduce the risk to the facility worker and the environment associated with this event group, a safety strategy utilizing mitigation features is adopted. The principal SSC identified to implement this safety strategy is combustible loading controls. The associated safety function is to limit the quantity of combustibles in a fire area containing transfer containers to ensure that the container is not adversely impacted by a fire.

Due to the low unmitigated consequences of this event, no principal SSCs are required for the public or site worker; however, combustible loading controls used to protect the facility worker and the environment provides defense-in-depth protection.

Final C4 HEPA Filter

A fire event is postulated to affect the final C4 HEPA filters. Two types of events are possible: (1) a fire in the room containing these filters and (2) a fire in a C4 area venting to these filters. In the first event type, the final C4 HEPA filters are postulated to be impacted by a fire that breaches the HEPA filter housing and allows material from the HEPA filters to pass directly to the stack. The consequences of this event are based on a conservative quantity of material present on the final C4 HEPA filters. In the second event type, a fire in an upstream unit impacts the final C4 HEPA filters. Events associated with this event type are covered in the other event groups covered in this section.

To reduce the risk to the facility worker, site worker, and the environment associated with the first event type in this event group, prevention features are utilized. Combustible loading controls are required to limit the quantities of combustibles in the filter area to ensure that the final C4 HEPA filters are not adversely impacted by a fire in the filter room.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public. However, the principal SSCs applied to the site worker and the environment provide defense-in-depth protection for the public.

5.5.2.2.6.4 Outside the MOX Fuel Fabrication Building

Fires outside the MOX Fuel Fabrication Building, but on the MFFF site, could impact the MOX structures containing radioactive material. To reduce the risk to the public, site worker, facility worker, and the environment associated with these postulated events, a safety strategy utilizing mitigation features is adopted. The principal SSCs identified to implement this safety strategy are the MOX Fuel Fabrication Building structure, the Emergency Generator Building structure, the waste transfer line, and the Emergency Control Room Air-Conditioning System. The safety function of the MOX Fuel Fabrication Building structure and the Emergency Generator Building structure is to ensure that the structure is designed to withstand external fires and protect principal SSCs and support systems. The safety function of the waste transfer line is to prevent damage to the line from external fires. The safety function of the Emergency Control Room Air-Conditioning System is to ensure habitable conditions for operators.

5.5.2.2.6.5 Facilitywide Systems

Fires are postulated in facilitywide systems that contain or handle radioactive material. The bounding radiological consequence for this event is associated with the pneumatic pipe automatic transfer system.

To reduce the risk to the facility worker and environment associated with this event group, a safety strategy utilizing mitigation features is adopted. The principal SSCs identified to implement this safety strategy are facility worker action and combustible loading controls. The safety function of the facility worker action principal SSC is to ensure that facility workers take proper actions to limit radiological exposure as the result of fire. The safety function of the combustible loading controls is to limit the quantity of combustibles in a fire area containing a pneumatic system to ensure that this system is not adversely impacted by a fire.

Due to the low consequences of this event, no principal SSCs are required to protect the public and site worker. However, the C3 confinement system and the C2 confinement system passive boundary provide defense-in-depth protection for the public, site worker, and the environment.

5.5.2.2.6.6 Facility

Fires that may propagate from one fire area to another or that may encompass the entire facility have been postulated. To reduce the risk to the public, site worker, facility worker and the environment associated with these postulated events, a safety strategy utilizing prevention features is adopted. The principal SSC identified to implement this safety strategy is the fire barriers. The safety function of the fire barriers is to ensure that the fire is contained to a fire area. Additionally, as described in Chapter 7, fire suppression and detection systems are provided as necessary to provide defense-in-depth protection. It should be noted that as part of the fire protection program, combustibles are controlled to ensure the fire barrier ratings are adequate. Furthermore, fire propagation through the pneumatic transfer tubes is under evaluation, and IROFS will be added, as appropriate, to prevent the propagation of hot gas/vapor and smoke between interconnected gloveboxes.

In addition, facility worker action is identified as a principal SSC to protect the facility worker. The safety function of this principal SSC is to ensure that facility workers take proper actions to limit radiological exposure as the result of fire.

5.5.2.2.7 Mitigated Event Consequences

Mitigated event consequences for the bounding radiological fire event are addressed in Section 5.5.3.

5.5.2.2.8 Mitigated Event Likelihoods

The likelihood of mitigated events is discussed in Section 5.5.4.

5.5.2.2.9 Comparison to 10 CFR §70.61 Requirements

The SA evaluates a comprehensive list of potential fire-related events. Based on the results of the bounding consequence analysis and the effective application of the principal SSCs identified in Section 5.5.2.2.6, the risks from fire-related events satisfy the performance requirements of 10 CFR §70.61.

5.5.2.3 Load Handling Events

5.5.2.3.1 General Description

A load handling hazard is postulated from the presence of lifting or hoisting equipment used during either normal operations or maintenance activities. A load handling event could occur when either the lifted load is dropped or the lifted load or the loading equipment impacts other nearby items containing radioactive materials.

A load handling event could have the following consequences:

- Possible damage to handled loads, resulting in dispersal of radioactive and/or chemical materials
- Possible damage to nearby equipment or structures, resulting in a loss of confinement and/or a loss of subcritical conditions
- Possible damage to process equipment or structures relied on for safety.

The extent and magnitude of the damage depends on several variables, such as handling height, load weight, and load rigidity.

5.5.2.3.2 Causes

Causes identified for load handling events at the MFFF buildings include the following:

- Failure of handling equipment to lift or support the load
- Failure to follow designated load paths
- Toppling of loads.

5.5.2.3.3 Specific Locations

Load handling events are hypothesized to occur both inside and outside of gloveboxes and in C2 areas where loads may be lifted or moved during both normal operations and potential maintenance activities. These events could also occur in the AP process cells. Finally, load handling events are also hypothesized to occur outside the MOX Fuel Fabrication Building, involving plutonium and MOX fuel in transportation casks, the waste transfer line, and uranium and wastes in containers.

5.5.2.3.4 Unmitigated Event Consequences

Unmitigated event radiological consequences have been established for load handling events identified in the hazard assessment. These consequences were used to establish the need for the application of principal SSCs.

5.5.2.3.5 Unmitigated Event Likelihood

The likelihood of occurrence of unmitigated load handling events was qualitatively and conservatively assessed: all unmitigated event likelihoods were assumed to be Not Unlikely. Consequently, no postulated internally generated failures were screened due to likelihood considerations.

5.5.2.3.6 Safety Evaluation

This section presents information on event grouping, safety strategies, principal SSCs, and safety function. The selection of the event groupings for load handling events is based on the confinement area and confinement type utilized, if applicable. Thus, within the C1 and/or C2 confinement areas, 3013 canisters, 3013 transport casks, fuel rods, MOX fuel transport casks, waste containers, transfer containers, and final C4 HEPA filters are identified as event groups. An additional event group has been identified to represent an impact that could potentially affect multiple confinement areas or types. The event group names are as follows:

- AP process cells
- AP/MP C3 glovebox areas
- C1 and/or C2 areas:
  - 3013 canister
  - 3013 transport cask

  - Fuel rod
  - MOX fuel transport cask
  - Waste container
  - Transfer container
  - Final C4 HEPA filter
- C4 confinement
- Outside the MOX Fuel Fabrication Building
- Facilitywide.

Table 5.5-15 presents a mapping of hazard assessment events to their respective event groups. For each event group, the event representing the bounding unmitigated radiological consequence was identified. It should be noted that hazard assessment events bounded by the event identified with the largest radiological consequence may require the same safety strategy and analogous principal SSCs to satisfy the performance requirements of 10 CFR §70.61. In this manner, load handling events are ensured adequate protection.

The following sections describe the safety evaluation for the respective load handling event groups. Tables 5.5-16a and 5.5-17 summarize the results of the evaluation for the facility worker, and the public and site worker, respectively. Table 5.5-16b summarizes the results of the evaluation for the protection of the environment. Principal SSCs listed in Table 5.5-16b are required only to make the hypothesized event unlikely.

5.5.2.3.6.1 AP Process Cells

A load handling event is postulated within the AP process cells. The event with the bounding radiological consequences for this event group has been identified to occur within the AP cell containing the dissolution tanks. The resulting load handling event is postulated to result in a breach of the AP dissolution tanks and subsequent release of unpolished PuO_2 in solution. The vessels contained in this process cell are assumed to be impacted by either a lifting device or a lifted load causing their contents to drop/spill to the floor.

To reduce the risk to the facility worker associated with this postulated event group, a safety strategy utilizing mitigation features is adopted. The principal SSC identified to implement this safety strategy is the process cell. The safety function of the process cell is to contain fluid leaks (e.g., through the use of drip trays) within the process cells.

Process cell entry controls are also identified as a principal SSC for the facility worker. The safety function of the process cell entry controls is to prevent the entry of personnel into process cells during normal operations, thus no load handling occurs in a process cell during normal operations. Additionally, process cell entry controls ensure that facility workers do not receive a radiological exposure in excess of limits while performing maintenance in the AP process cells.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public, the site worker, or the environment. However, the process cell ventilation system passive boundary provides defense-in-depth protection for the public and site worker, as well as for the environment.

5.5.2.3.6.2 AP/MP C3 Glovebox Areas

A load handling event is postulated in an AP/MP C3 glovebox area. The event with the bounding radiological consequences for this event group has been identified to occur within the gloveboxes that contain Jar Storage and Handling of the MOX Powder Workshop. This load handling event is postulated to result in a breach of a glovebox and the subsequent release of PuO_2 polished powder. This glovebox is assumed to be impacted by either a lifting device or a lifted load outside of the glovebox causing its contents to drop to the floor.

To reduce the risk to the public and site worker associated with this event group, a safety strategy utilizing mitigation features is adopted. The principal SSC identified to implement this safety strategy is the C3 confinement system. The safety function of the C3 confinement system is to provide filtration to mitigate dispersions from C3 Areas.

The safety strategy and corresponding principal SSCs for the facility worker and the environment are given by consideration of the following cases to which the gloveboxes may be subjected:

- During normal operations, load handling events within gloveboxes that could potentially impact the C4 static boundary
- During normal operations, external glovebox load handling events that could potentially impact the C4 confinement system
- During maintenance operations and special operations (e.g., filter changeout) – [Facility Workers only].

Note: An additional case in which a spill/leak occurs in a glovebox without breaching the glovebox is discussed in Section 5.5.2.3.6.4.

To reduce the risk to the facility worker and the environment during normal operations, a safety strategy utilizing prevention features is adopted. The principal SSCs identified to implement this safety strategy are material handling controls, the glovebox, and material handling equipment. The safety function of the material handling controls is to prevent impacts to the glovebox during normal operations from loads handled either outside or inside the glovebox that could exceed the glovebox design basis. The safety function of the glovebox is to maintain confinement integrity for design basis impacts. The safety function of the material handling equipment is to prevent impacts to the glovebox, through the use of engineered equipment to reduce the likelihood of failures leading to glovebox breaches.

To reduce the risk to the facility worker during maintenance operations, facility worker controls based on training and procedures supplements the prevention features discussed above. The safety function of this principal SSC is to ensure that facility workers take proper actions prior to maintenance operations to limit radiological exposure.

The C2 confinement system passive boundary provides defense-in-depth protection for the site worker and the public.

5.5.2.3.6.3 C1 and/or C2 Areas

A load handling event within a C1 and/or C2 area involves an impact to one of the following:

- 3013 canister
- 3013 transport cask
- Fuel rod
- MOX fuel transport cask
- Waste container
- Transfer container
- Final C4 HEPA filter.

An event group is generated to represent the safety strategy utilized to reduce the risk associated with load handling events for each of the aforementioned events.

<u>3013 Canister</u>

Load handling events within the C2 area could involve 3013 canisters. The event identified with the bounding radiological consequences involves the drop of one 3013 canister onto another 3013 canister each containing unpolished PuO_2 in powder form.

To reduce the risk to the site worker, facility worker, and the environment associated with this load handling event group, a safety strategy utilizing mitigation features is adopted. The principal SSCs identified to implement this safety strategy are the 3013 canister and material handling controls. The safety function of the 3013 canister is to withstand the effects of the design basis drop without breaching. The safety function of the material handling controls is to ensure that the design basis lift height of the 3013 canister is not exceeded.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public. However, the 3013 canister and the C2 confinement system passive boundary provide defense-in-depth protection for the public. The C2 confinement system passive boundary also provides defense-in-depth for the site worker and the environment.

<u>3013 Transport Cask</u>

Load handling events within the C1 or C2 area could involve 3013 transport casks. The event identified with the bounding radiological consequences involves the drop of a 3013 transport cask containing unpolished PuO_2 in powder form.

To reduce the risk to the site worker, facility worker, and the environment associated with this load handling event group, a safety strategy utilizing mitigation features is adopted. The principal SSCs identified to implement this safety strategy are the 3013 transport cask and material handling controls. The safety function of the 3013 transport cask is to withstand the effects of design basis drops without release of radioactive material. The safety functions of the material handling controls are to ensure that the design basis lift height of the 3013 transport cask is not exceeded.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public. However, the 3013 transport cask and the C2 confinement system passive boundary, provide defense-in-depth protection for the public. The C2 confinement system passive boundary also provides defense-in-depth for the site worker and the environment.

Fuel Rod

Load handling events within the C2 area could involve fuel rods. The event identified with the bounding radiological consequences involves the drop of a fuel assembly onto another fuel assembly each containing MOX (6%).

To reduce the risk to the facility worker associated with this load handling event group, mitigation features are utilized. The principal SSC identified to implement this safety strategy is facility worker action. The safety function of this principal SSC is to ensure that facility workers take proper actions to limit radiological exposure as the result of a load handling event.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public, site worker, or the environment. However, the C2 confinement passive boundary provides defense-in-depth protection for these potential receptors.

MOX Fuel Transport Cask

Load handling events within the C1 or C2 area could involve MOX fuel transport casks. The event identified with the bounding radiological consequences involves the drop of one MOX fuel transport cask containing up to three MOX fuel assemblies.

To reduce the risk to the facility worker and the environment associated with this load handling event group, a safety strategy utilizing mitigation features is adopted. The principal SSCs identified to implement this safety strategy are the MOX fuel transport cask and material handling controls. The safety function of the MOX fuel transport cask is to withstand the effects of design basis drops without release of radioactive material. The safety function of the material handling controls is to ensure that the design basis lift height of the MOX fuel transport cask is not exceeded.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the site worker or the public. However, the MOX fuel transport cask also provides defense-in-depth protection for the public and site worker.

Waste Container

Load handling events within the C1, C2 or C3 area could involve waste containers (i.e., drums). Waste is packaged inside plastic (e.g., polyethylene) bags, then in drums that are sealed prior to transfer for material accounting, storage, and ultimate shipment. To reduce the risk to the facility worker associated with this load handling event group, a safety strategy utilizing mitigation features is adopted. The principal SSC identified to implement this safety strategy is facility worker action. The safety function of this principal SSC is to ensure that facility workers take proper actions to limit radiological exposure as the result of a load handling event.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public, site worker, or the environment. However, for drops in C2 areas, the C2 confinement passive boundary provides defense-in-depth protection for these potential receptors.

Transfer Container

Load handling events within the C2 area may involve transfer containers. The event identified with the bounding radiological consequences involves the drop of a transfer container containing a HEPA filter with PuO_2 in powder form.

To reduce the risk to the site worker, facility worker, and the environment associated with this load handling event group, a safety strategy utilizing mitigation features is adopted. The principal SSCs identified to implement this safety strategy are the transfer container and material handling controls. The safety function of the transfer container is to withstand the effects of design basis drops without breaching. The safety function of the material handling controls is to ensure that the design basis lift height of the transfer container is not exceeded.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public. However, the C2 confinement passive boundary provides defense-in-depth protection to the public.

Final C4 HEPA Filter

Load handling events could result in damage to the final C4 HEPA filters. In this event, the final C4 HEPA filters are postulated to be impacted by a load that breaches the HEPA filter housing and allows material from the HEPA filters to pass directly to the stack. Even though these filters will contain very little material, principal SSCs are identified.

To reduce the risk to the facility worker, site worker, and the environment associated with this event group, prevention features are utilized. The principal SSC utilized to ensure that load handling events are prevented from impacting the final C4 HEPA filters is material handling controls. The safety function of the material handling controls is to ensure that load handling activities that could potentially lead to a breach in the final C4 HEPA filters do not occur. Administrative material handling controls will ensure that limited load handling activities take place in the vicinity of the C4 final HEPA filters to minimize the possibility of an impact to the filters. There are no cranes or other equipment in the vicinity of the final HEPA filters that could cause a load handling event. As required, necessary precautions will be taken to ensure that no release of radioactive material occurs during maintenance operations.

Due to the low unmitigated consequences of this event, no principal SSCs are required to protect the public. However, the principal SSCs applied to protect the facility worker, site worker, and the environment provide defense-in-depth protection for the public. The C2 confinement system passive boundary provides defense-in-depth protection for the public for load handling events that occur in the C2 area where the final C4 HEPA filters are located.

5.5.2.3.6.4 C4 Confinement

Load handling events are postulated within AP/MP gloveboxes without impacting the glovebox. These load handling events represent a set of off-normal conditions in which spills, leaks, etc., introduce radioactive material into the glovebox environment but do not result in a challenge to the static confinement of the glovebox. The event identified with the bounding radiological consequences involves the spill of unpolished plutonium powder inside a glovebox.

To reduce the risk to the site worker, facility worker, and the environment associated with this event group, a safety strategy utilizing mitigation features is adopted. The principal SSC identified to implement this safety strategy is the C4 confinement system. The safety function of the C4 confinement system is to ensure that C4 exhaust is effectively filtered. The C4 confinement system also functions to maintain a negative glovebox pressure differential between the glovebox and the interfacing system.

Due to the low unmitigated consequences to the public, no principal SSCs are required. However, the C4 confinement system provides defense-in-depth protection to the public.

5.5.2.3.6.5 Outside the MOX Fuel Fabrication Building

A load handling event is postulated outside the MOX Fuel Fabrication Building. The bounding radiological event identified for this event group is a load handling event involving the waste transfer line.

To reduce the risk to the public, site worker, facility worker, and the environment, a safety strategy utilizing prevention features is adopted. The principal SSC identified to implement this safety strategy is the waste transfer line. The safety function of the waste transfer line is to ensure that it is protected from activities taking place outside the MOX Fuel Fabrication Building.

5.5.2.3.6.6 Facilitywide

This event group represents load handling events in which heavy loads or load handling equipment damages principal structures or primary confinement boundaries of the MOX Fuel Fabrication Building or causes damage to the confinement types discussed in Section 5.5.2.3.6.

To reduce the risk to the public, site worker, facility worker, and the environment associated with this postulated event, a safety strategy utilizing prevention features is adopted. The principal SSCs identified to implement this safety strategy are the MOX Fuel Fabrication Building structures and material handling controls. The safety function of the MOX Fuel Fabrication Building structures is to ensure that structures are qualified for load drops that could potentially impact radioactive material. The safety function of the material handling controls is to prevent load handling events that could breach primary confinements.

5.5.2.3.7 Mitigated Event Consequences

Mitigated event consequences for the bounding radiological load handling event are addressed in Section 5.5.3.

5.5.2.3.8 Mitigated Event Likelihood

The likelihood of mitigated events is discussed in Section 5.5.4.

5.5.2.3.9 Comparison to 10 CFR §70.61 Requirements

The SA evaluates a comprehensive list of load handling events. Based on the results of the bounding consequence analysis and the effective application of the principal SSCs identified in Section 5.5.2.3.6, the risks from load handling events satisfy the performance requirements of 10 CFR §70.61.

5.5.2.4 Explosion Events

5.5.2.4.1 General Discussion

Explosive events within the MFFF could result from the presence of potentially explosive mixtures (H_2, H_2O_2, hydroxylamine nitrate [HAN], tributyl phosphate [TBP] and its degradation products, solvents, azides, hydrazoic acid, plutonium VI oxalate), steam over-pressurizations, and other potential over-pressurization events. These explosion/overpressurization events could either directly or indirectly involve radioactive material (i.e., an explosion may occur in a tank containing radioactive material or in a surrounding tank, which may impact the radioactive material). These events have the potential to release radioactive material and to damage nearby equipment relied on for safety. The major consequences of explosive events are as follows:

- Release of nuclear materials or chemicals to the environment
- Damage to a confinement boundary
- Damage to equipment contributing to dynamic confinement
- Loss of subcritical conditions
- Damage to civil structures
- Damage to other principal SSCs.

These explosion/overpressurization events are postulated to occur inside the MOX Fuel Fabrication Building from process operations, outside the MOX Fuel Fabrication Building from nearby support facilities and the storage of chemicals on the MFFF site, and from laboratory operations.

5.5.2.4.2 Causes

Causes identified for explosion/overpressurization events include the following:

- Loss of scavenging air in units where radiolysis is credible, and subsequent ignition of the hydrogen after reaching its explosive conditions
- Loss of offgas exhaust flow in units where radiolysis is credible, and subsequent ignition of the hydrogen after reaching its explosive conditions
- Pressurizing reactions in vessels or tanks
- Increase in temperature beyond the safety limit in tanks and vessels

- Incorrect chemical addition/reagent preparation
- Excessive introduction of hydrogen into the sintering furnace
- Excessive introduction of liquids into high-temperature process equipment
- Hydrogen accumulation, and its subsequent ignition after reaching explosive conditions
- Plutonium (in valence state VI) oxalate addition to calcining furnace
- Dry-out of azides
- Organic liquid vapor exceeding flammability limits and subsequent ignition
- Excessive heating of solution.

5.5.2.4.3 Specific Locations

Explosive events are postulated to occur in the process and reagent preparation areas of the MOX Fuel Fabrication Building. Outside of the MOX Fuel Fabrication Building, explosions are postulated to occur in support facilities such as the Reagent Processing Building, Gas Storage Area, and the Emergency and Standby Generator Buildings. Specific event locations are provided in Section 5.5.1.

5.5.2.4.4 Unmitigated Event Consequences

Unmitigated event radiological consequences have been established for explosive events identified in the hazard assessment. These consequences are used to establish the need for the application of principal SSCs.

5.5.2.4.5 Unmitigated Event Likelihood

The likelihood of occurrence of unmitigated explosive events was qualitatively and conservatively assessed: all unmitigated event likelihoods are assumed to be Not Unlikely. Consequently, no postulated explosive events are screened due to likelihood considerations.

5.5.2.4.6 Safety Evaluation

This section presents information on event grouping, safety strategies, principal SSCs, and safety function. The selection of the explosion groups is based on the chemicals identified in the MFFF that have the potential to create explosive conditions. Specific explosion/overpressurization event groups that could occur within the MOX Fuel Fabrication Building from process operations are as follows:

- Hydrogen Explosion
- Steam Over-Pressurization Explosion
- Radiolysis Induced Explosion
- HAN Explosion
- Hydrogen Peroxide Explosion
- Solvent Explosion
- TBP-Nitrate (Red Oils) Explosion

- AP Vessel Over-Pressurization Explosion
- Pressure Vessel Over-Pressurization Explosion
- Hydrazoic Acid Explosion
- Metal Azide Explosion
- Pu (VI) Oxalate Explosion
- Electrolysis Related Explosion.

Additional explosion groups include the following:

- Laboratory Explosion
- Outside Explosion (outside the MFFF Building, but on the MFFF site)

Table 5.5-18 presents a mapping of hazard assessment explosion events to their respective event groups.

The following sections describe the safety evaluation for the respective explosion groups. Table 5.5-19 summarizes the explosion event groupings, principal SSCs, and associated safety functions for all receptors.

In addition to the principal SSCs listed in Table 5.5-19, defense-in-depth protection is provided to minimize the risks presented by the explosions postulated to occur inside the MOX Fuel Fabrication Building. The MOX Fuel Fabrication Building final filters and the C2 confinement system passive boundary provide this defense-in-depth protection.

5.5.2.4.6.1 Hydrogen Explosion

A mixture of hydrogen-argon gas is used within the sintering furnaces associated with the sintering process. The use of hydrogen gas introduces the hazards associated with explosions. General explosion events considered include the following: events involving the sintering furnace itself, events involving leaks of the hydrogen-argon gas mixture into a room, events involving the furnace airlocks and associated gloveboxes, events involving the furnace offgas, and events involving startup, shutdown, and earthquake conditions.

Hydrogen also poses an explosion hazard at the hydrogen storage unit and hydrogen-argon mixing station. These units are located outside of the MFFF Building and events involving these units are discussed in Section 5.5.2.4.6.15. Additionally, hydrogen produced from radiolysis is discussed in Section 5.5.2.4.6.3 and hydrogen produced from electrolysis is discussed in Section 5.5.2.4.6.13.

To reduce the risk to the public, site worker, facility worker, and the environment associated with this postulated explosion group, a safety strategy utilizing prevention features is adopted. The principal SSC identified to implement this safety strategy is the process safety control subsystem. The safety function of the process safety control subsystem is to prevent the formation of an explosive mixture of hydrogen within the MFFF associated with the use of the hydrogen-argon gas. Within the MFFF facility includes all locations within the facility including the furnace, process rooms, airlocks, and associated gloveboxes.

DCS is performing detailed analyses of the hydrogen-argon system and associated furnace design and operations as part of the final design (and ISA) to determine specific scenarios that could lead to the formation of an explosive mixture of hydrogen. As necessary, specific controls (such as limiting the hydrogen content in the hydrogen-argon mixture, monitoring for oxygen within the furnace, monitoring for hydrogen outside of the furnace, crediting dilution flow associated with the HDE or VHD systems) to prevent the formation of an explosive mixture of hydrogen will be identified as IROFS and described in the ISA.

5.5.2.4.6.2 Steam Explosion

Steam explosions may be associated with the use of humidifier water in the inlet gas stream to the sintering furnace. Water carryover from the humidifier can lead to the rapid generation of steam within the sintering furnace and potentially result in an explosion.

To reduce the risk to the public, site worker, facility worker, and the environment associated with this postulated explosion group, a safety strategy utilizing prevention features is adopted. The principal SSC identified to implement this safety strategy is the process safety control subsystem. The safety function of the process safety control subsystem is to ensure isolation of sintering furnace humidifier water flow on high water level.

5.5.2.4.6.3 Radiolysis Induced Explosion

Within the MFFF processes, hydrogen is generated as a result of radiolysis of water or other hydrogenous materials. Radiolysis occurs mainly within the AP process where materials in process equipment are exposed to radiation fields and hydrogen is released. Radiolysis may also occur in other locations where waste and byproducts (e.g., contaminated organic waste or organic-additive-bearing scraps) are contained in closed containers. If not removed, the hydrogen can accumulate and present an explosion hazard.

To reduce the risk to the public, site worker, facility worker, and the environment associated with this postulated explosion group, a safety strategy utilizing prevention features is adopted. The principal SSCs identified to implement this safety strategy are the offgas treatment system and dilution air provided by the instrument air system. In addition, waste containers (utilized to transfer contaminated organic waste, organic-additive-bearing scraps in closed containers, and other liquid waste) are designated as principal SSCs for protection of the site worker, facility worker, and the environment. The safety function of the instrument air system is to provide sufficient scavenging air to dilute the hydrogen generated during radiolysis such that explosive concentrations of hydrogen do not occur. See Section 11.9 for additional details. The safety function of the offgas treatment system is to provide an exhaust path for the removal of this diluted hydrogen gas in process vessels. The safety function of the waste containers is to ensure that hydrogen buildup in excess of explosive limits does not occur while providing appropriate confinement of radioactive material.

5.5.2.4.6.4 HAN Explosion

Hydroxylamine nitrate (HAN) and nitric acid are used in the AP process to strip plutonium from the solvent after removal of americium, gallium, and other impurities at the extraction step. Hydrazine nitrate is used in conjunction with HAN to impede the HAN reaction with nitrous acid and consequently increase the HAN availability for the plutonium (IV) reduction. Within the AP process, the HAN/hydrazine nitrate and hydrazoic acid (a byproduct of the nitrous acid reaction with hydrazine nitrate) are destroyed in the purification cycle oxidation column, CLMN 6000, and recycling tanks, to prevent the propagation of these reactants, via the aqueous phase, to downstream process units and to the front end of the purification cycle (PULS2000). In addition to the HAN/hydrazine nitrate solution utilized in the AP process, HAN is present within the AP area in a storage tank containing 1.9 M hydroxylamine solution with 0.1 N nitric acid. This tank is used to feed HAN to the AP process.

The HAN interaction with nitrous acid can, under specific conditions discussed below, create an autocatalytic reaction that could result in an explosion and/or over-pressurization event. Control of systems containing both HAN and nitrous acid (i.e., such that nitrous acid concentration does not increase) may be performed either by:

- utilizing a reducing agent (e.g., hydrazine nitrate) that consumes nitrous acid at a rate faster than the rate at which it is being produced by HAN and metal catalyzed reactions, or
- maintaining the temperature, metal impurities, nitric acid concentration, and the HAN concentration within a specified regime for systems not containing hydrazine nitrate.

Another means of contending with HAN-nitrous acid reactions is to ensure that the system is designed for the conditions resulting from the non-autocatalytic reaction between HAN and nitrous acid.

HAN explosions that potentially occur within the MFFF may be characterized by one of the following three cases:

1. Process Vessels containing HAN and hydrazine nitrate without NO_x addition
2. Vessels containing HAN and no hydrazine nitrate
3. Process Vessels containing HAN and hydrazine nitrate with NO_x addition

The safety strategies for these three distinct process applications are presented below.

1. Process Vessels Containing HAN and Hydrazine Nitrate Without NO_x Addition

In AP process vessels where HAN has been introduced to reduce the plutonium valence state from IV to III (e.g., pulse column PULS3000 of the purification cycle), a preventative safety strategy is adopted to reduce the risk to the facility worker, site worker, public, and environment. The principal SSCs to implement this safety strategy are the process safety control subsystem and chemical safety control. The safety function of the process safety control subsystem is to ensure that the temperature of the solution containing HAN is limited to temperatures that are within safety limits. The safety function of the chemical safety control is to ensure that the concentration of nitric acid, metal impurities, and HAN introduced in the process are within safety limits.

It should be noted that the presence of hydrazine nitrate is effective in limiting the quantity of nitrous acid in the system due to the fact that its reaction rate with nitrous acid is approximately a factor of 12,000 greater than the autocatalytic reaction of HAN with nitrous acid. Consequently, the presence of hydrazine nitrate also effectively ensures that an autocatalytic reaction does not occur in process vessels with HAN.

2. Vessels Containing HAN and No Hydrazine Nitrate

For vessels in the AP Building (used to feed the AP process) that contain HAN and no hydrazine nitrate (e.g., the 1.9M HAN buffer tank in the Hydroxylamine Nitrate System), a preventative safety strategy is adopted to reduce the risk to the facility worker, site worker, public, and environment from an explosion or over-pressurization event that could impact process vessels containing radiological material. The principal SSCs identified to implement this safety strategy are the process safety control subsystem and chemical safety control. The safety function of the process safety control subsystem is to ensure that the temperature of the solution containing HAN is limited to temperatures that are within safety limits. The safety function of the chemical safety control is to ensure that the concentration of nitric acid, metal impurities, and HAN introduced in the process are maintained below their respective safety limits.

An additional concern in systems comprised of HAN and nitric acid, in which there is no hydrazine, is the possible concentration of the HAN and nitrous acid due to evaporation. To reduce the risk to the facility worker, site worker, public and the environment, a preventative safety strategy is adopted. The principal SSC utilized to implement this safety strategy is the chemical safety controls. The safety function of the chemical safety controls is to ensure that the concentration of HAN and nitric acid are maintained below their respective safety limits.

3. Process Vessels containing HAN and Hydrazine nitrate with NO_x Addition

In the AP purification cycle, vessels designed to receive NO_x gases for reaction with hydrazine nitrate, HAN, and hydrazoic acid include: the oxidation column CLMN6000 and recycling tanks. Unlike other AP process vessels, these vessels are designed to destroy hydrazine nitrate, HAN, and hydrazoic acid via reaction with excess nitrous acid produced from the introduction of NO_x. The temperature and pressure rise in these vessels as a result of these reactions are dependent on the concentrations of the reagents introduced into these vessels and the vent size of these vessels.

To reduce the risk to the facility worker, site worker, public, and the environment, a preventative safety strategy is adopted. The principal SSCs utilized to implement this safety strategy are chemical safety control, offgas treatment system, and the process safety control subsystem. The safety function of chemical safety control is to limit the concentration of the HAN, hydrazine nitrate, and hydrazoic acid in the system. The safety function of the offgas treatment system is to provide an exhaust path for the removal of off-gases generated during the decomposition of these chemicals, which provides a means for heat transfer/pressure relief for affected process vessels. The safety function of the process safety control subsystem is to control the liquid flowrate into the oxidation column, thereby regulating the quantity of HAN, hydrazine nitrate and hydrazoic acid added to the column ensuring the potential heat evolution and pressure increase do not exceed the design capabilities of the process vessel.

5.5.2.4.6.5 Hydrogen Peroxide Explosion

A solution of 10 wt % hydrogen peroxide is used in the dissolution units. Explosive vapors can be produced from concentrated solutions higher than 75 wt %.

To reduce the risk to the facility worker, site worker, public, and the environment associated with this postulated explosion group, a safety strategy utilizing prevention features is adopted. The principal SSC identified to implement this safety strategy is chemical safety control. The safety function of chemical safety control is to ensure that explosive concentrations of hydrogen peroxide do not occur. Details of this event are presented in Section 8.5.

5.5.2.4.6.6 Solvent Explosion

Some units within the AP process are fed with solvent. The potential for explosions exists due to high process temperatures and the possible attainment of a flammable/explosive mixture in the gaseous phase due to excessive heating. Solvent explosions resulting from chemical interactions with strong oxidizers are discussed in the following section. Section 8.5 presents more details related to this event.

To reduce the risk to the facility worker, site worker, and the environment associated with this postulated event, a safety strategy utilizing prevention features is adopted. The principal SSCs identified to implement this safety strategy are the process safety control subsystem, process cell fire prevention features, and the offgas treatment system. The safety function of the process safety control subsystem is to ensure the temperature of the solutions containing solvents do not exceed the temperature at which the resulting gaseous phase becomes flammable. The safety function of the process cell fire prevention features is to ensure that fires in process cells are highly unlikely. The safety function of the offgas treatment system is to provide an exhaust path for the removal of gases in process vessels thereby ensuring that an explosive buildup of vapors does not occur.

5.5.2.4.6.7 TBP – Nitrate (Red Oils) Explosion

The acid-catalyzed hydrolysis of TBP and subsequent oxidation of the associated by-products introduces the risk of a runaway reaction and associated over-pressurization event. This risk exists in AP process units that may contain these by-products and reach high temperatures (e.g., acid recovery unit, oxalic mother liquors recovery unit, purification cycle and solvent recovery unit). These energetic reactions may involve TBP, nitric acid, plutonium nitrate TBP adduct, and TBP degradation products due to chemical reactions (nitration/oxidation/hydrolysis) and radiolysis. Runaway reactions involving TBP and nitric acid are referred to as "red-oil reactions."

To reduce the risk to the facility worker, site worker, public, and the environment, a preventative safety strategy is adopted. To implement this preventative safety strategy, principal SSCs are established to control the rate of energy production from the exothermic chemical reactions and the amount of energy liberated from the system (e.g., heat transfer). By ensuring that the rate of energy generation does not exceed the rate of heat removal, such runaway reactions are prevented. The principal SSCs established to implement this safety strategy are the offgas treatment system, the process safety control subsystem, and chemical safety control. These controls ensure that a system initially composed of TBP and nitric acid will not runaway and result in over-pressurization of the process vessel.

An additional consideration is the accumulation of organic by-products formed through hydrolysis reactions of TBP. Most notably, butanol and butyl nitrate have been identified as potential by-products that could liberate significant energy when undergoing oxidation. Thus, controls -are established to ensure that significant quantities of butanol and/or butyl nitrate do not build up in the process (i.e., in process vessels containing oxidizing agents and potentially exposed to high temperatures). Furthermore, energetic byproducts formed from TBP degradation may also be generated via radiolysis. Consequently, the exposure time of TBP to radiological materials is limited to ensure that unacceptable quantities of butanol and butyl-nitrate do not accumulate in the system from radiolysis.

Additional details pertaining to the identified principal SSCs are presented below. Additional information on the mechanism and safety evaluation for this event is presented in Section 8.5.

Offgas Treatment System

A prerequisite for a runaway reaction is for the energy generation to exceed the heat removal from the system. Venting provides a mechanism by which energy may be effectively transferred from the system and also serves to limit the extent of the energy generation, by allowing for the evacuation of the reactants via evaporation. The heat transfer mechanism afforded by venting is given by providing an exhaust path for evaporated water and nitric acid, which carry off heat from the system. In addition, venting limits the degree of completion of the hydrolysis reactions by allowing the reactants, nitric acid, and by-products (butanol and butyl nitrate) formed through TBP hydrolysis to evaporate from the system. Furthermore, an open system will not lead to higher temperatures prior to the boiling of water and nitric acid and hence, result in diminished reaction rates and energy generation rates compared to a closed system. Thus, the safety function of the offgas treatment system is to provide an exhaust path for the removal of gases in process vessels thereby providing a mechanism for heat removal by these evacuated gases and limiting the degree of completion of the hydrolysis reaction due to the removal of reactants from the vessel.

Process Safety Control Subsystem

The process safety control subsystem ensures temperatures in process vessels, which may contain organics, are limited to ensure that the rate of energy generation given by the hydrolysis of TBP and associated oxidation reactions is limited. Control of the energy generation in a system initially containing TBP and nitric acid is effectively given by the rate of hydrolysis of TBP. In addition to the control of temperature, the residence time of organics in the presence of oxidizers, such as nitric acid, and radiation fields is also controlled to limit the quantity of degraded organics that may buildup in the system either through hydrolysis and/or radiolysis.

Chemical Safety Control

The offgas treatment system provides an exhaust path for the removal of gases in process vessels;, it may also be necessary to limit the quantities of organics in these vessels. Thus, the safety function of chemical safety control is to limit the quantity of organics entering vessels with oxidizing agents and high temperatures.

Certain diluents could undergo nitration or radiolysis, introducing more reactive byproducts that could facilitate a runaway reaction. The properties of the diluent have been recognized as contributing a role in the early "red oil" runaway reactions and may have also contributed to the Tomsk event (Section 8.5 provides more details of these events). The diluent may provide both an energy source and a mechanism by which the heat transfer characteristics are degraded (e.g., during heating above a threshold temperature, diluents have been shown to exhibit foaming). Consequently, to provide reasonable assurance that these phenomena do not occur, an additional safety function for chemical safety control is to ensure that a diluent is utilized which is less susceptible to either nitration or radiolysis.

5.5.2.4.6.8 AP Vessel Over-Pressurization Explosion

Over-pressurization of AP tanks, vessels, and piping are postulated as the result of increases in the temperature or exothermic chemical reactions of solutions in, or entering into, tanks or vessels, or as a result of excessive addition of fluids into high temperature environments (e.g., calcining furnace).

To reduce the risk to the public, site worker, facility worker, and the environment associated with this postulated explosion group, a safety strategy utilizing prevention features is adopted. The principal SSCs identified to implement this safety strategy include the fluid transport systems, offgas treatment system, and chemical safety controls. The safety function of the fluid transport systems is to ensure that process vessels, tanks, and piping are designed to prevent process deviations from creating over-pressurization events that result in the release of radioactive material. The safety function of the offgas treatment system is to provide an exhaust path for the removal of gases in process vessels thereby preventing over-pressurization conditions. The safety function of the chemical safety controls is to ensure control of the chemical makeup of the reagents and ensure segregation/separation of vessels/components from incompatible chemicals.

5.5.2.4.6.9 Pressure Vessel Over-Pressurization Explosion

This group involves vessels that are identified as pressure vessels. Explosion events related to pressure vessels arise from the MFFF support systems due to the presence of pressurized gas bottles, tanks, or receivers (pressure vessels) within these systems. These pressure vessels could over-pressurize and explode, impacting primary confinements and resulting in a release of radioactive material.

To reduce the risk to the public, site worker, facility worker, and the environment associated with this postulated explosion group, a safety strategy utilizing prevention features is adopted. The principal SSCs identified to implement this safety strategy are the pressure vessel controls. The safety function of the pressure vessel controls is to ensure that primary confinements are protected from the impact of pressure vessel failures.

5.5.2.4.6.10 Hydrazoic Acid Explosion

In the AP process, interactions between hydrazine nitrate and nitrous acid result in the formation of hydrazoic acid (hydrogen azide), HN_3), in the process solution. Hydrazoic acid is a relatively weak acid with a low boiling point, making it volatile at room temperature. Under specific conditions, as described in Section 8.5, hydrazoic acid could be explosive and could also lead to the formation of metal azides. A chemical assessment has revealed that three types of hazards might be created by the presence of this material in process solutions:

- An explosion related to a mixture of HN_3 and air
- An explosion related to the distillation and condensation of HN_3 solutions
- An explosion related to the precipitation of metallic azides under dry conditions.

To reduce the risk to the facility worker, site worker, public, and the environment for the first two types of hazards above (involving HN_3), a preventative safety strategy is adopted. The principal SSCs to implement this safety strategy are chemical safety control and the process safety control subsystem. The safety function of chemical safety control is: (1) to assure the proper concentration of hydrazine nitrate is introduced into the system, thereby limiting the quantity of hydrazoic acid produced, and (2) to ensure that hydrazoic acid is not accumulated in the process or propagated into the acid recovery and oxalic mother liquors recovery units by either taking representative samples in upstream units or by crediting the neutralization process within the solvent recovery unit. The safety function of the process safety control subsystem is to limit the temperature of the solution, thereby limiting the evaporation rate and resulting vapor pressure of hydrazoic acid and providing reasonable assurance that an explosive concentration of hydrazoic acid does not occur. If the neutralization process is credited, then the process safety control subsystem may have additional safety functions that include assuring control of the flow and concentration of sodium carbonate to the process unit and assuring mixing occurs within the process unit. These functions, if required, will be identified in the ISA.

The third hazard related to metallic azides is addressed in the following section.

5.5.2.4.6.11 Metal Azide Explosions

As noted in Section 5.5.2.4.6.10, hydrazoic acid is generated from the reaction between nitrous acid and hydrazine nitrate and is restricted to the purification cycle and the solvent recovery unit by principal SSCs. The hydrazoic acid may subsequently interact with metal cations leading to the formation of metal azides within these units. In the solvent recovery unit, sodium carbonate and sodium hydroxide in the process of washing the solvent form a sodium azide. Further details of the potential azide reactions in the AP process are discussed in Section 8.5.

To reduce the risk to the facility worker, site worker, public, and the environment associated with possible metal azide explosions, a preventative safety strategy is adopted. The principal SSCs to implement this safety strategy are chemical safety control and the process safety control subsystem. The safety functions of chemical safety control are to: (1) ensure that metal azides are not added to high temperature process equipment (e.g., calcining furnace) and (2) ensure that the sodium azide has been destroyed prior to transfer of the alkaline waste to the waste recovery unit. The safety function of the process safety control subsystem is to ensure that metal azides are not exposed to temperatures that would supply sufficient energy to overcome the activation energy needed to initiate the energetic azide decomposition and limit and control conditions under which dry-out can occur.

5.5.2.4.6.12 Pu(VI) Oxalate Explosion

Formation of plutonium (VI) oxalate is discussed in Section 8.5. If this plutonium (VI) oxalate were to be introduced into the calcining furnace in the oxalic precipitation and oxidation unit, then an energetic release attributed to the rapid decomposition of the oxalate via the oxidation by plutonium (VI) oxalate may occur.

To reduce the risk to the facility worker, site worker, public, and the environment, a preventative safety strategy is utilized. The principal SSC identified to implement this safety strategy is chemical safety control. The safety function of the chemical safety control is to perform a measurement of the valency of the plutonium prior to adding oxalic acid to the oxalic precipitation and oxidation unit. Determination of the plutonium valency and subsequent termination of feed to the precipators where oxalic acid is added ensures that plutonium (VI) oxalate cannot be produced and therefore cannot enter the calcining furnace.

5.5.2.4.6.13 Electrolysis Related Explosion

The dissolution unit and the dechlorination and dissolution unit utilize a catholyte loop in which nitric acid is used to dissolve plutonium oxide. This electrolytic dissolution process introduces the risk of generating appreciable amounts of hydrogen, which poses an explosion hazard. To reduce the risk to the facility worker, site worker, public, and the environment, a preventative safety strategy is adopted. This safety strategy ensures that an explosive mixture of hydrogen is not produced. This safety strategy is implemented with the process safety control subsystem, which will limit the generation of hydrogen. More specifically, the process safety control subsystem ensures that the normality of the acid is sufficiently high to ensure that the off-gas is not flammable.

5.5.2.4.6.14 Laboratory Explosion

Explosions within the MFFF laboratory are postulated to occur as a result of operator error or equipment failure within the laboratory.

To reduce the risk to the facility worker, a safety strategy utilizing both prevention and mitigation features is adopted. The principal SSCs identified to implement this safety strategy include chemical safety control, controls on radiological/chemical material quantities contained in the laboratory, and facility worker actions. Chemical safety control minimizes the likelihood of explosions by ensuring the chemical makeup of laboratory reagents is correct and that incompatible chemicals are segregated. Laboratory material controls will minimize the quantity of hazardous material available for dispersion following an explosion and also minimize the extent of any potential explosion. Facility worker actions to don respiratory protection and evacuate the laboratory mitigate the effects of a potential laboratory explosion. These features will ensure that the performance requirements of 10 CFR §70.61 are satisfied.

To reduce the risk to the site worker, public, and the environment, a safety strategy utilizing mitigation features is adopted. The principal SSC identified to implement this safety strategy is the C3 confinement system. The safety function of the C3 confinement system is to mitigate dispersions into the C3 areas. Calculations will be performed as part of the ISA to demonstrate that laboratory explosions and the resulting pressure waves will not impact process operations and to demonstrate the effectiveness of the ventilation system following a laboratory explosion.

The C2 confinement system passive boundary provides defense-in-depth protection for the public, site worker, and the environment.

5.5.2.4.6.15 Outside Explosion

Outside explosion events occurring within the MFFF site that could potentially impact MFFF operations or required support systems are postulated in the following specific areas:

- Reagent Processing Building
- Gas Storage Area
- Emergency Generator Building
- Standby Generator Building
- Access Control Building (Armory).

The explosion events evaluated include those involving both the onsite storage and delivery of flammable gases and liquids to the MFFF site. The effects of explosion-generated missiles are also evaluated. Explosions external to the restricted area are discussed in Section 5.5.2.7.

To reduce the risk to the facility worker, site worker, public, and the environment associated with this explosion group, a safety strategy utilizing mitigation features is adopted. The principal SSCs identified to implement this safety strategy are the MOX Fuel Fabrication Building structure, Emergency Generator Building structure, the waste transfer line, and administrative controls on the delivery of hazardous materials to the MFFF. The safety function of the structures of the MOX Fuel Fabrication Building and Emergency Generator Building is to maintain structural integrity and prevent damage to internal SSCs. The safety function of the waste transfer line is to prevent damage to the line from outside explosions. The safety function of the hazardous material delivery controls is to ensure the quantity of delivered hazardous material and its proximity to the MOX Fuel Fabrication Building structure, Emergency Generator Building structure, and the waste transfer line are controlled to within the bounds of the values used to demonstrate that the consequences of these outside explosions are acceptable. Calculations involving energies, pressures, distances, building structures, etc. will be performed as part of the ISA to demonstrate the effectiveness of the principal SSCs specified for this event.

5.5.2.4.7 Mitigated Event Consequences

Mitigated consequences for the bounding explosion event are addressed in Section 5.5.3.

5.5.2.4.8 Mitigated Event Likelihoods

The likelihood of mitigated events is discussed in Section 5.5.4.

5.5.2.4.9 Comparison to 10 CFR §70.61 Requirements

The SA evaluates a comprehensive list of potential explosion events. Based on the results of the bounding consequence analysis and the effective application of the principal SSCs identified in Section 5.5.2.4.6, the risks from explosion events satisfy the performance requirements of 10 CFR §70.61.

5.5.2.5 Criticality Events

5.5.2.5.1 General Description

Criticality is a physical phenomenon characterized by the attainment of a self-sustaining fission chain reaction. Criticality accidents can potentially release a large amount of energy over a short period of time as a result of accidental production of a self-sustaining divergent neutron chain reaction. A criticality hazard arises whenever fissionable materials, such as ^{235}U or ^{239}Pu, are present in sufficient quantities to attain a self-sustaining fission chain reaction under optimal conditions. Criticality depends not only on the quantity of fissionable material present, but also on the size, shape, moderation, and materials present adjacent to the fissionable material that may possibly reflect neutrons back into the fissionable material.

The immediate consequence of a criticality accident is a rapid increase in system thermal power and radiation as a "fission spike" that is generally terminated by heating and thermal expansion of the system. Subsequent spikes of less intensity may occur. Direct radiation produced as a consequence of criticality accidents occurs rapidly and initially over a short duration, with little or no time for personnel to evacuate during its occurrence. Direct radiation is primarily a concern for the facility worker, since radiation shielding afforded by facility structural features and distance will inherently mitigate consequences to site workers and the public. Potential consequences of airborne exposure to radioactive material are assessed for the facility worker, site worker, and public as well.

Chapter 6 provides a detailed discussion of criticality safety at the MFFF.

5.5.2.5.2 Causes

Causes identified for criticality events at the MFFF include the violation of several safety limits, where applicable, established by the following parameter controls:

- Geometry control
- Mass control
- Density control
- Isotopics control
- Reflection control
- Moderation control
- Concentration control
- Interaction control
- Neutron absorber control
- Volume control

- Heterogeneity control
- Process variable control.

5.5.2.5.3 Specific Locations

Criticality is applicable to operations within the MFFF where fissionable materials, such as ^{235}U or ^{239}Pu, are present in quantities sufficient to attain a self-sustaining fission chain reaction under optimal conditions.

5.5.2.5.4 Unmitigated Event Consequences

Unmitigated event radiological consequences have been established utilizing the guidance for the evaluation of potential radiological consequences of accidental nuclear criticality in a plutonium processing and fuel fabrication plant provided in Regulatory Guide 3.35. The unmitigated consequences (considering airborne and direct exposure) have been evaluated to be low to the public and site worker. The unmitigated consequences to the environment have been evaluated to be in the intermediate category based on 10 CFR §70.61.

5.5.2.5.5 Unmitigated Event Likelihood

This section is not applicable (see Chapter 6).

5.5.2.5.6 Safety Evaluation

As required by 10 CFR §70.61(d), preventive controls and measures are the primary means of protection against criticality events provided at the MFFF. Adherence to the double contingency principle, as required by the baseline design criteria specified by 10 CFR §70.64(a) must be demonstrated. The double contingency principle stipulated in ANSI/ANS-8.1 requires that "process designs shall incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident can occur." In all cases, no single credible event or failure results in the potential for a criticality accident.

A single event group is utilized to characterize nuclear criticality events within the MFFF. As discussed above, a safety strategy utilizing prevention features is adopted. These prevention features are implemented to ensure adherence to the double contingency principle. Information regarding the development of principal SSCs and their safety function for criticality events is provided in Chapter 6.

In addition to preventive measures, a criticality accident alarm system (CAAS) is provided with detection capability in areas of the MFFF containing process units with criticality accident potential as required by 10 CFR §70.24 (see Chapter 6).

Nuclear criticality safety evaluations will be performed during the ISA process to identify features to preclude nuclear criticality events. The features identified as being required to ensure that the design bases are fulfilled will be designated as principal SSCs and subsequently IROFS. The features listed above are applicable to the following criticality events identified in the hazard assessment and shown in Appendix 5A: AP-25, RC-10, PW-4, PT-9, RD-8, AS-6, MA-8, and WH-7.

5.5.2.5.7 Mitigated Event Consequences

Although criticality events at the MFFF are prevented, a generic hypothetical criticality event is evaluated in Section 5.5.3. The resulting consequences demonstrate that the site worker and the public do not receive significant radiological consequences as a result of this event.

5.5.2.5.8 Mitigated Event Likelihood

The likelihood of mitigated criticality events will meet the double contingency principle. This will be demonstrated in the ISA.

5.5.2.5.9 Comparison to 10 CFR §70.61 Requirements

Application of the double contingency principle will ensure that the requirements of 10 CFR §70.61 are satisfied (see Chapter 6 for additional information regarding the criticality evaluation).

5.5.2.6 Natural Phenomena

5.5.2.6.1 General Discussion

This section summarizes the evaluation of credible natural phenomena that have the potential to affect the MFFF during the period of facility operation. Credible natural phenomena that could have an impact on MFFF operations are listed in Table 5.5-6 and include the following:

- Extreme wind
- Earthquake (including liquefaction)
- Tornado (including tornado missiles)
- External fire
- Rain, snow, and ice
- Lightning
- Temperature extreme.

Natural phenomena could result in either the dispersion of radioactive material and hazardous chemicals or a loss of subcritical conditions. Criticality events and chemical events are discussed in Sections 5.5.2.5 and 5.5.2.10, respectively. Natural phenomena are also considered as initiators of other events such as explosions or leaks.

The SA addresses NPHs up to and including design basis accidents. The design bases for applicable NPHs are based on the information presented in Chapter 1. The magnitudes of the design basis NPHs have been selected considering the most severe documented historical event for the MFFF site. The design bases for each NPH are summarized in Table 5.5-20. The selection of annual exceedance probabilities for natural phenomena events is based on the criteria for reactors licensed under 10 CFR 50. The applicable regulatory guides specify recurrence intervals for each design basis event. Demonstration that the MFFF structures satisfy these requirements (i.e., structural evaluations to demonstrate the building capability during these events) will be provided as part of the ISA summary.

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The impacts of earthquakes and the principal SSCs and associated safety functions to mitigate these impacts are as follows:

- Damage to the structures of the MOX Fuel Fabrication Building and Emergency Generator Building resulting in damage to SSCs within the structures.

  The principal SSCs are the structures of the MOX Fuel Fabrication Building and Emergency Generator Building. The safety function of these structures is to withstand the effects of the DBE.

- Direct damage to principal SSCs within the MOX Fuel Fabrication Building and Emergency Generator Building.

  The principal SSC is the qualification of internal principal SSCs and support systems as necessary to withstand the effects of the DBE. The safety function is to withstand the effects of the DBE and perform their required safety function(s). The system descriptions provided in this CAR summarize the seismic qualifications at a system level. SSCs will be evaluated at a component level as part of the ISA and detailed design to determine appropriate seismic requirements in accordance with the information provided in Section 11.12.

- Damage to other SSCs (non-principal SSCs) within the MOX Fuel Fabrication Building and Emergency Generator Building causing them to fail in a manner that prevents principal SSCs from performing their safety functions.

  The principal SSC is the qualification of these SSCs as necessary to withstand the effects of the DBE. The safety function is to withstand the effects of the DBE such that their failure, physical or otherwise, will not prevent primary SSCs from performing their intended safety functions. As part of the ISA and detailed design, SSCs will be evaluated to determine appropriate seismic requirements in accordance with the information provided in Section 11.12.

- Damage to the waste transfer line leading to a release.

  The safety function of the waste transfer line is to withstand the effects of the DBE.

- Damage to primary confinements (e.g., glovebox or vessel/pipe) within the MFFF process units leading to multiple breaches and subsequent releases.

  The principal SSC is the qualification of the fluid transport systems as necessary to withstand the effects of the DBE. The safety function is to withstand the effects of the DBE such that confinement of radionuclides is maintained. As part of the ISA and detailed design, SSCs will be evaluated to determine appropriate seismic requirements in accordance with the information provided in Section 11.12.

- Damage to fluid systems conveying hazardous materials and water within the MFFF.

  The principal SSCs are the seismic monitoring system and associated seismic isolation valves. The safety function is to prevent fire and criticality as a result of an uncontrolled release of chemicals and water within the MFFF Building in the event of an earthquake.

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5.5.2.6.5.4 External Fire

External fires are those fires associated with nearby forests or vegetation. The design basis external fire assumes a forest fire occurs in the forest nearby the MFFF site. Heat and smoke are the risks associated with these fires. To address these risks, a safety strategy utilizing principal SSCs to prevent damage from this event is adopted.

The principal SSCs are the structures of the MOX Fuel Fabrication Building and Emergency Generator Building, the Emergency Control Room Air-Conditioning System, and the waste transfer line. The safety functions of the building structures are to withstand the effects of the design basis external fire and to provide protection for internal SSCs from the effects of heat, fire, and smoke. The safety function of the air-conditioning system is to ensure habitable conditions for operators as necessary. The safety function of the waste transfer line is to withstand the effects of external fires.

5.5.2.6.5.5 Rain, Snow, and Ice

Rain, snow, and ice are postulated to occur at the MFFF site during operation of the facility. The design basis rainfall has an annual exceedance probability of 1×10^{-5}, which corresponds to a peak rainfall of 7.4 in (18.8 cm) in one hour, or 3.9 in (9.9 cm) in 15 minutes. As noted in Chapter 1, the MFFF site is above the flood level associated with the design basis flood and the maximum probable flood for the MFFF site.

The design basis snow and ice events have an annual exceedance probability of 1×10^{-2}, similar to the requirements for reactors licensed in accordance with 10 CFR 50. Building codes are typically used to define the snow and ice design loads. The loads associated with these events are less than 10 psf (50 kg/m^2). The MFFF incorporates a 10-psf load for combined snow and ice (approximately 2 in [5 cm] of ice) into the design to account for these loads. As discussed in Section 1.3.3.3, it is also possible to estimate the magnitude of snow and ice loads for greater return intervals. The ice and snow accumulation values can both be extrapolated to higher recurrence intervals. With this method, it is estimated that the design basis snow or ice load for a recurrence period of 10,000 years would be approximately twice that for 100 years. Even if the design basis snow and ice loading were increased by this factor to represent a highly unlikely (extreme) snow and ice loading, its magnitude would still be bounded by the allowance (50 psf) for general live loadings and would not control the design of MFFF SSCs. Such highly unlikely snow and ice roof loads are not combined with roof live loads from other sources in the structural evaluations described in Section 11.1. The effects of snow and ice loads associated with events that have a lower annual exceedance probability are bounded by the design for other live loads. To address these risks, a safety strategy utilizing principal SSCs to prevent damage from this event is adopted.

The principal SSCs are the structures of the MOX Fuel Fabrication Building and Emergency Generator Building and the waste transfer line. The safety functions of the building structures are to withstand the effects of the design basis rain, snow, and ice loads and to provide protection for internal SSCs. The safety function of the waste transfer line is to withstand the effects of design basis rain, snow, and ice loads.

5.5.2.6.5.6 Lightning

Lightning occurs during extreme weather (e.g., thunderstorms) and is postulated to occur on or near the MFFF site several times per year. Lightning could cause fires or failures of electrical equipment. As a general practice, the MFFF will have lightning protection in accordance with NFPA 780-1997.

5.5.2.6.5.7 Temperature Extreme

Observed temperature extremes for SRS over the period 1961 to 1996 ranged from 107°F (42°C) to -3°F (-20°C). Temperature extremes for SRS are postulated to occur on or near the MFFF occasionally. The MFFF ventilation systems are designed to account for these temperatures. Due to the low risk, no principal SSCs are required for this event.

5.5.2.6.6 Mitigated Event Consequence

Consequences due to natural phenomena events are prevented by the specified principal SSCs.

5.5.2.6.7 Mitigated Event Likelihoods

The likelihood of natural phenomena events is provided in the previous discussion of the individual natural phenomena events.

5.5.2.6.8 Comparison to 10 CFR §70.61 Requirements

The SA evaluates a comprehensive list of natural phenomena events. The effective application of the principal SSCs identified in Section 5.5.2.6.5 ensures that the risks from natural phenomena events satisfy the performance requirements of 10 CFR §70.61.

5.5.2.7 External Man-Made Events

5.5.2.7.1 General Description

External man-made events are those events generated by EMMHs. EMMHs are those hazards that arise outside of the MFFF site from the operation of nearby public, private, government, industrial, chemical, nuclear, and military facilities and transportation routes that could impact MFFF operations. Chapter 1 identifies and describes the location of the facilities and transportation corridors near the MFFF. SRS information (including SRS facility Safety Analysis Reports), along with a comprehensive set of NRC and DOE documents, is used to develop the initial list of EMMHs. The events listed with an "NS" in one of the columns in Table 5.5-8 are further evaluated in this section.

5.5.2.7.2 Causes

External man-made events are caused by EMMHs. EMMHs are described in Section 5.5.1.1.3.

5.5.2.7.3 Locations

External man-made events are initiated external to the MFFF Area and could impact the MFFF or the MFFF operations. Thus, the impact of external man-made events is evaluated for the MFFF and the MFFF Area.

5.5.2.7.4 Unmitigated Event Consequences

The impact of unmitigated external man-made events on the MFFF is discussed in Section 5.5.2.7.6.

5.5.2.7.5 Unmitigated Event Likelihoods

The likelihood of unmitigated external man-made events is based on the specific external man-made event. Credible external man-made events are further evaluated. Those external man-made events determined to be not credible are identified in Section 5.5.1.1.3.

5.5.2.7.6 Safety Evaluation

The major events that result from EMMHs and the potential effects they could have on MFFF operations are as follows:

- A release of radioactive material or hazardous chemicals resulting in exposures to MFFF personnel
- Explosions that could directly damage principal SSCs
- Events that result in a loss of offsite power
- Events that results in a fire (and/or resulting smoke) that spreads to the MFFF.

These events are discussed in the following sections.

5.5.2.7.6.1 Release of Radioactive Material or Hazardous Chemicals

A release of radioactive material or hazardous chemicals from a nearby SRS facility or transportation route was evaluated to determined if protection from these events is necessary for MFFF operations personnel who may be required to perform a safety function.

SRS has numerous documented safety evaluations demonstrating that the various SRS facilities operate safely and within the guidelines established by DOE. DOE's guidelines are based on 10 CFR Part 100, 29 CFR §1910.110, and Emergency Response Planning Guideline (ERPG) values.

For credible accidents, the SRS documentation provides estimates of radiological/chemical consequences as a result of postulated accidents. On the basis of a review of SRS analyses, the applicability of these guidelines and the proximity of the MFFF to these SRS areas, it is judged that there are no radiological or chemical hazards from SRS facilities that could significantly impact MFFF operations personnel.

In addition, SRS documentation evaluates the radiological/chemical consequences as a result of postulated transportation accidents. Due to the location and potential consequences associated with these events, the consequences will not significantly impact MFFF operations personnel.

One nearby SRS facility, the Pit Disassembly and Conversion Facility (PDCF), is in the early design stage. Thus, the risks presented by this facility have not been fully evaluated. Based on DOE requirements and preliminary evaluations, it is expected that this facility will not present a significant hazard for the MFFF facility.

Even though the SRS evaluations indicate that postulated events at these facilities will not have a significant impact on MFFF operations, the MFFF has principal SSCs in place to reduce the impact on the MFFF from radioactive material or hazardous chemical releases from EMMHs. As described in Section 5.5.2.10, the Emergency Control Room Air-Conditioning System ensures that the emergency control rooms remain habitable during and after events by effectively filtering radioactive material and hazardous chemicals as necessary. Thus, no new principal SSCs are required for protection from this group of external man-made events.

5.5.2.7.6.2 Direct Damage to Principal SSCs

Direct damage to principal SSCs could occur as result of an external explosion originating outside of the MFFF Area at a SRS facility or along a SRS transportation route. For all hypothetical explosions external to the MFFF Area, a preliminary analysis demonstrates that a hypothetical explosion originating along a transportation route in F Area will bound all external explosion events outside of the MFFF Area.

This conclusion is based on a review of SRS inventory reports, shipment reports, purchase data, emergency preparedness information, and safety analysis documentation. From these documents, the maximum hazardous material transported, stored, or processed, and the distance between the hazardous material and the MFFF Area were determined. In addition, distances were determined between the MFFF Area and SRS transportation routes. From this information, hypothetical bounding explosion scenarios were postulated to determine the bounding explosion overpressure for explosions external to the MFFF Area. These explosions were assumed to occur at the nearest SRS processing facilities, the nearest SRS roadways, and the nearest SRS railway to determine the resulting overpressures and possible impact on the MFFF Area facilities.

For each hypothetical explosion, the maximum bounding inventory is assumed released and assumed to form a vapor cloud. The entire content of the cloud is assumed to be within the flammability limits, and the cloud is assumed to explode from an undefined ignition source. The resulting overpressure from the explosion is calculated based on the bounding minimum distances and maximum inventories. Of all hypothetical explosions originating outside of the MFFF area, the bounding reflected pressure is between the BEG and the F-Area Road.

Final peak pressure calculations and the ability of the MFFF and BEG to withstand overpressures will be demonstrated during final design calculations. These will be described in the ISA summary. Thus, no new principal SSCs are required for this event.

5.5.2.7.6.3 Loss of Offsite Power

Loss of offsite power caused by EMMHs is similar to the loss of offsite power caused by NPHs or for any other reason. Loss of offsite power is expected to occur during the life of the MFFF and is accounted for in the design of the MFFF. Principal SSCs requiring power are supplied with emergency power upon loss of offsite power as shown in Section 5.5.2.9. No additional principal SSCs are required for protection from this group of external man-made events.

5.5.2.7.6.4 External Man-Made Fire

External man-made fires are those fires resulting from a vehicle crash, train crash/derailment, barge/shipping accident, or SRS facility fire that engulfs neighboring grasslands or forests. This event has the same consequences and risks as the design basis external fire discussed in Section 5.5.2.6, which assumes a forest fire occurs in the forest nearby the MFFF site. The effects of these events are direct damage from the fire and smoke from the fire. No new principal SSCs are required for this group of events beyond those established for the external fire event (see Section 5.5.2.6 for the applicable principal SSCs).

5.5.2.7.7 Mitigated Event Consequences

There are no significant consequences at the MFFF as a result of external man-made events.

5.5.2.7.8 Mitigated Event Likelihoods

The likelihood of mitigated events is discussed in Section 5.5.4.

5.5.2.7.9 Comparison to 10 CFR §70.61 Requirements

The SA evaluates a comprehensive list of external man-made events. Based on the results of the bounding consequence analysis and the effective application of the principal SSCs identified in Section 5.5.2.7.6, the risks from external man-made events satisfy the performance requirements of 10 CFR §70.61.

5.5.2.8 External Exposure

5.5.2.8.1 General Description

A direct radiation hazard arises from the presence of radioactive material. Direct radiation exposure events include those events that result in an unexpected radiation dose from an exposure to a radiation source(s) external to the body. The scope of this section does not include the consequences of radioactive material uptake and the associated internal exposure. The consequences of internal exposure are included in the analysis of other event types. Planned and expected exposures associated with normal operations are addressed in Chapter 9.

5.5.2.8.2 Causes

Potential causes resulting in an inadvertent exposure to personnel include the following:

- Unplanned access to radiation areas
- Human error or equipment failures resulting in accumulation of radioactive material and subsequent over-exposure of personnel.

5.5.2.8.3 Specific Locations

The impact of external exposures has been evaluated throughout the MFFF facilities. Additional information related to the expected dose throughout the facility is contained in Chapter 9.

5.5.2.8.4 Unmitigated Event Consequences

Due to the nature of the radioactive material present in the MFFF and the distance to the site boundary, there is no direct radiation exposure hazard to the public or site worker from MFFF operations. The direct radiation exposure hazard to the facility worker is low, also due to the nature of the radioactive material.

5.5.2.8.5 Unmitigated Event Likelihood

The likelihood of occurrence of unmitigated direct radiation events was qualitatively and conservatively assessed: all unmitigated event frequencies were assumed to be Not Unlikely. Consequently, no postulated direct radiation events were screened due to likelihood considerations.

5.5.2.8.6 Safety Evaluation

Due to the low consequences of the external exposure event, no principal SSCs are required. However, the following MFFF features are utilized to ensure that external exposures are as low as reasonably achievable (ALARA):

- Radiation shielding
- Radiological Protection Program
- Restricted access to potential exposure locations.

Additional information describing radiological protection is contained in Chapter 9. The features listed above are applicable to the following external exposure events identified in the hazard assessment and shown in Appendix 5A: MA-7, AP-24, RC-9, PW-3, PT-8, RD-7, AS-5, and WH-6.

5.5.2.8.7 Mitigated Event Consequences

As stated for the unmitigated event consequences, there is no direct radiation exposure hazard to the public or site worker from MFFF operations due to the nature of the radioactive material present in the MFFF and the distance to the receptors. The MFFF Radiological Protection Program, radiation shielding, and radiation area access restrictions ensure that the risk associated with a direct exposure event satisfies the performance requirements of 10 CFR Part 70.

5.5.2.8.8 Mitigated Event Likelihoods

This section is not applicable for direct exposure events.

5.5.2.8.9 Comparison to 10 CFR §70.61 Requirements

As described in Section 5.5.2.8.6, the risk of unmitigated direct exposure events satisfies the performance requirements of 10 CFR §70.61.

5.5.2.9 Support System Evaluation

This section identifies the systems and structures that are required to support the principal SSCs and the specific safety functions of these support systems. Based on the safety functions of each principal SSC, the support systems required to ensure the implementation of these safety functions are identified. These support systems are subsequently categorized as principal SSCs. The methodology for identifying required support systems is provided in Section 5.4.

Once established as principal SSCs, the safety functions of these support systems are established by considering how they support the safety function of the principal SSC. Table 5.5-22 summarizes the required support systems and their associated safety functions. Specific components that support the performance of the required safety functions for these SSCs will be identified in the ISA.

5.5.2.10 Chemicals

5.5.2.10.1 General Description

Chemical hazards at the MFFF exist as a result of the delivery, storage and use of hazardous chemicals. Chemical-related events could involve a release of only chemicals or a release of chemicals with radioactive material or a release of a chemical from processing radioactive material. The radiological risks associated with chemical-related events are provided in other sections of this chapter. Chapter 8 describes the chemicals used at the MFFF and the MFFF Chemical Process Safety Program. Chapter 8 also describes the analysis performed to determine chemical consequences resulting from the release of hazardous chemicals. Sections 11.3 and 11.9 describe the MFFF chemical processes.

5.5.2.10.2 Causes

Causes considered for events postulated to result in chemical release at the MFFF include the following:

- Mechanical failure of a vessel, tank, or pipe containing chemicals
- Corrosion failure of a vessel, tank, or pipe containing chemicals
- Failure of a ventilation system that scavenges potentially hazardous chemicals from vessels
- Incorrect chemical addition resulting in a chemical reaction

- Drop of a container containing a hazardous chemical
- Impact of NPHs on the Reagent Processing Building.

5.5.2.10.3 Specific Locations

Accident sequences that may result in the release of a hazardous chemical are postulated to occur in the areas where chemicals are stored or used and in areas where these chemicals may be in transit (e.g., from the Reagent Processing Building to the MOX Fuel Fabrication Building, unloading areas). Table 8-2 lists the inventory of the hazardous chemicals used at the MFFF.

5.5.2.10.4 Unmitigated Event Consequences

Chemical consequences are discussed in Section 5.5.2.10.6.

5.5.2.10.5 Unmitigated Event Likelihood

The unmitigated event likelihood of occurrence of chemical events was qualitatively and conservatively assessed: all unmitigated event likelihoods were assumed to be Not Unlikely. Consequently, no chemical events were screened due to likelihood considerations.

5.5.2.10.6 Safety Evaluation

This section presents information on the event grouping, safety strategies, principal SSCs, and safety function. The grouping of chemical events is based on whether or not the release occurs with a release of radioactive material. The grouping is as follows:

- Events involving a release of hazardous chemicals only from inside or outside the MFFF
- Events involving a release of hazardous chemicals only, produced from licensed material
- Events involving a release of hazardous chemicals and radioactive material.

As described in 10 CFR 70, the term hazardous chemicals produced from licensed material means substances having licensed material as precursor compounds or substances that physically or chemically interact with licensed material, and that are toxic, explosive, flammable, corrosive, or reactive to the extent that they can endanger life or health if not adequately controlled. These include substances commingled with licensed material, but do not include substances prior to process addition to licensed material or after process separation from licensed material.

Table 5.5-23 presents a mapping of hazard assessment chemical events to these three groups.

5.5.2.10.6.1 Events Involving a Release of Hazardous Chemicals Only, from Inside or Outside the MFFF

Events involving a release of hazardous chemicals not produced from licensed material can occur both inside and outside of the MOX Fuel Fabrication Building. Events involving a release of hazardous chemicals result in the following two risks:

- Direct chemical consequences to the public, site worker, and facility worker with no impact on radiological safety
- Chemical consequences that impact radiological safety or MFFF operations and may result in a radioactive material release.

Risks posed by the first case are not regulated by 10 CFR Part 70 since they do not impact or directly involve radioactive material. These risks are not discussed further in this section.

In the second case, a release of chemicals has the potential to impact a facility worker and prevent the worker from performing a required safety function and is therefore evaluated. As discussed in Chapter 12, facility workers mainly perform a monitoring role during emergency conditions. To ensure that workers can perform this function, the Emergency Control Room Air-Conditioning System is designated as a principal SSC. Its safety function is to ensure that habitable conditions for workers in the emergency control room are maintained. The HVAC intake for the Emergency Control Room will be monitored to ensure continued habitability for operators in the control room. No facility worker or operator actions outside the control room are required to mitigate the consequences to meet the requirements of 10 CFR §70.61 for a chemical release.

5.5.2.10.6.2 Events Involving a Release of Hazardous Chemicals Only, Produced from Licensed Material

Events involving a release of hazardous chemicals directly produced from the processing of licensed materials, but not released with radiological materials, are regulated by 10 CFR Part 70. These events may result in chemical consequences that directly impact the public, site worker, or facility worker. The results of the bounding chemical consequence analysis described in Chapter 8 indicate that the unmitigated consequences to the site worker and public are low from these events. Thus, no principal SSCs are required to protect the public or site worker from a release of hazardous chemicals produced from licensed material. However, the consequences to the facility worker have the potential to exceed the performance requirements of 10 CFR 70, thus PSSCs are identified.

Releases of these hazardous chemicals could occur from pipes and process vessels in one of three areas: gloveboxes (e.g., the Dechlorination and Dissolution Unit electrolyzer), process cells, and C3 ventilated areas (e.g., the Dechlorination and Dissolution Unit chlorine offgas scrubbing column). To reduce the risk to the facility worker associated with a release of hazardous chemicals produced from the processing of licensed materials in these three areas, a safety strategy utilizing mitigation features is adopted. The principal SSCs identified to implement this safety strategy are process cell entry controls for leaks occurring in a process cell, the C4 confinement system for leaks occurring in a glovebox, and facility worker action for leaks occurring in C3 ventilated areas.

The safety function of the process cell entry controls is to prevent the entry of personnel into process cells during normal operations and to ensure that workers do not receive a chemical consequence in excess of limits while performing maintenance in the AP process cells. Similarly, the safety function of the principal SSC facility worker action is to ensure that facility workers take proper actions to limit chemical consequences for leaks occurring in C3 ventilated areas. The safety function of the C4 confinement system is to contain a chemical release within a glovebox and provide an exhaust path for removal of the chemical vapors

5.5.2.10.6.3 Events Involving the Release of Hazardous Chemicals and Radioactive Material

Events involving the release of hazardous chemicals and radioactive material are regulated by 10 CFR Part 70. These events are postulated to occur inside the MOX Fuel Fabrication Building and consist of the event types previously addressed in Section 5.5.2. These events may result in chemical consequences that directly impact the public, site worker, or facility worker. The results of the bounding chemical consequence analysis described in Chapter 8 indicate that the unmitigated consequences to the public are low from these events. Thus, no principal SSCs are required to protect the public from a release of hazardous chemicals. With the potential exception of releases of nitrogen dioxide/dinitrogen teroxide, consequences to the site worker have also been calculated to be low, thus no principal SSCs are required except as noted below.

The Chapter 8 chemical consequence analysis includes releases of nitric acid at elevated temperatures from the AP process. Since these chemical releases are accompanied by a release of radioactive material, the previously discussed principal SSCs that protect the facility worker from radioactive material releases also provide protection for chemical releases. Thus, no additional principal SSCs are required for these events.

Dinitrogen tetroxide is stored in the Reagents Processing Building in liquefied form and passes through a vaporizer, also located in the Reagents Processing Building, where it is converted to gaseous nitrogen dioxide and other NOx gases prior to entry into the aqueous polishing area. Under normal operations, these gases are reacted with the hydrazine, HAN, and hydrazoic acid that are present with plutonium nitrate in the oxidation column of the Purification Cycle of the Aqueous Polishing process. If these gases or the unreacted nitrogen dioxide/dinitrogen tetroxide gases are released from the stack the consequences to all potential receptors are acceptable (no offgas treatment assumed).

However, if the process fails (e.g., the flow of plutonium nitrate with hydrazine, HAN, and hydrazoic acid is abnormally terminated to the oxidation column) and/or the nitrogen dioxide/dinitrogen tetroxide supplied to the oxidation column flows at an abnormally high rate, then there is the potential for chemical consequences associated with the release of these gases that may have come into contact with licensed materials to be unacceptable to the site worker. To reduce the risk to the site worker, a safety strategy utilizing mitigation features is adopted. The principal SSC identified to implement this safety strategy is the process safety control subsystem. The safety function of the process safety control subsystem is to ensure the flow of nitrogen dioxide/dinitrogen tetroxide is limited (e.g., by active flow controls) to the oxidation column such that chemical consequences to the site worker are acceptable.

Any additional chemical impacts created by this event group are similar to those discussed in Sections 5.5.2.10.6.1 and 5.5.2.10.6.2. Table 5.5-24 summarizes the chemical event groupings, principal SSCs, and associated safety functions.

Although not required to limit the chemical consequences of a leak to satisfy the requirements of 10 CFR §70.61, leak detection is provided for the process cells.

5.5.2.10.7 Mitigated Event Consequences

The mitigated event consequences for these events are low (see Chapter 8 for a discussion of chemical consequences).

5.5.2.10.8 Mitigated Event Likelihoods

The likelihood of mitigated events is discussed in Section 5.5.4.

5.5.2.10.9 Comparison to 10 CFR §70.61 Requirements

The SA evaluates chemical-related events. Based on the results of the bounding consequence analysis and the effective application of the principal SSCs identified in Section 5.5.2.10.6, the risks from chemical-related events satisfy the performance requirements of 10 CFR §70.61.

5.5.2.11 Low Consequence Events

This section presents the events that have been screened from further evaluation due to the unmitigated radiological consequences satisfying the low dose limits (less than intermediate) established by 10 CFR §70.61.

Conservative unmitigated radiological consequences have been established for each of the events included in this screened category utilizing the methodology of Section 5.4.4. The unmitigated event consequences have been evaluated to be low to the public, site worker, facility worker, and the environment for each of the events considered in this section. Table 5.5-25 lists the events that have been screened based on low consequences.

Unmitigated quantitative consequences to the site worker and the public as a result of these events have been conservatively analyzed to fall clearly into the low category.

The unmitigated dose consequences to the facility worker have been qualitatively determined to be low. The basis for this qualitative assessment is that many of these events involve one of the following:

- Small quantities of material at risk
- Material with a low specific activity (e.g., depleted UO_2)
- Material not easily converted into respirable airborne particulate (i.e., small release fractions)
- Liquid–liquid interfaces where mass transfer rates are small
- Decay heat insufficient to result in radiological consequences.

Evaluations of events and consequences are limited to the time that the radwaste is under the responsibility of DCS. The scope of the analysis is terminated once DOE takes responsibility for waste shipments. For example, in the loss of confinement event involving the waste container (i.e., the carboy) containing the excess solvent waste from the aqueous polishing process (event GH-14), radiological consequences are established to all receptors for leaks within the MFFF restricted area boundary and are found to be low to all receptors. However, since the DOE will take possession of the waste container within the MFFF restricted area boundary, radiological consequences due to leaks that occur at and outside of the restricted area boundary are not DCS' responsibility. Nevertheless, consequences to the site worker and the public from these events are established to be low.

5.5.3 Bounding Consequences Assessment

This section presents the results of the bounding consequence analysis for each event type. It demonstrates that the bounding events result in low consequences as defined by 10 CFR §70.61 for the public and site worker. The events described are derived from the hazard assessment and preliminary accident analysis and represent the events with the largest airborne and respirable source terms.

The potential consequences associated with mitigated events range from no consequences to the bounding consequences presented in this section. The bounding consequences have been established using the methodology presented in Section 5.4.4. Specific values for the factors used to calculate the source term are presented, as appropriate. Constants needed to calculate the total effective dose equivalent (TEDE) and the effluent concentration (EC), such as the dose conversion factors, half-lives, limiting ECs, and atomic masses, are established in the references noted in Section 5.4. Atmospheric dispersion factors, breathing rates, and isotopic fractions for radionuclides contained in polished and unpolished plutonium (the materials that produce the bounding consequences) used to establish the TEDE are established in Section 5.4.4.

Two sets of events are presented: bounding events and bounding low consequence events.

Bounding events are those events with the potential to produce the highest unmitigated consequences for each event type. They are presented to demonstrate that their mitigated consequences satisfy the performance requirements of 10 CFR §70.61 (i.e., low consequence). Criticality and explosion events are prevented by design, thereby satisfying 10 CFR §70.61 requirements. Nonetheless, they are hypothetically assumed to occur, and their mitigated consequences are discussed for completeness.

Bounding low consequence events are those events with the potential to produce the largest unmitigated low consequence for each event type (i.e., unmitigated consequences are low and therefore satisfy 10 CFR §70.61 performance requirements without principal SSCs). They are presented for completeness.

Table 5.5-26 summarizes the radiological consequences and EC ratio for the bounding events and bounding low consequence events, respectively. Radiological consequence limits are presented in Table 5.4-1. To satisfy the environmental consequences established in Table 5.4-1, the EC ratio must be less than one (see Section 5.4.4.3).

For conservatism, these consequence analyses do not credit the performance of all applicable principal SSCs, defense in depth features, additional protection features, or MFFF operations to mitigate the event. Additionally, the analyses use conservative values as described in CAR Section 5.4. Therefore, the results of these analyses indicate that even under conservative estimates of SSC performance and physical laws, the consequences associated with potential accidents at the MFFF are low.

5.5.3.1 Loss of Confinement

Within the MFFF, radioactive material is confined within confinement boundaries. Primary confinement boundaries include gloveboxes and the associated ventilation systems; welded vessels, tanks, and piping; plutonium storage (inner can) containers; fuel rod cladding; ventilation system ducts and filters; and some process equipment. Secondary confinement boundaries include plutonium storage containers (outer can) and process rooms and the associated ventilation systems. Tertiary confinement systems include process cells and the associated ventilation systems and the MOX Fuel Fabrication Building and associated ventilation systems. This event type considers the loss of one or more of these confinement boundaries.

The bounding loss of confinement event is an event caused by a load handling accident involving the Jar Storage and Handling Unit (see Section 5.5.3.3 for a description of this event). The bounding radiological consequences associated with this event are provided in Table 5.5-26.

The bounding low consequence loss of confinement event is a spill involving the dissolution unit's (KDB) tank 7000 (see Section 5.5.3.3 for a description of this event). The bounding radiological consequences associated with this event are provided in Table 5.5-27.

As shown in Tables 5.5-26 and 5.5-27, the radiological consequences at the site boundary and to the nearest site worker are low. Consequences to the facility worker are also acceptable since the worker is trained and is either not in the area of the event, or evacuates the area prior to a significant release of radioactive material. Additionally, the EC ratio is less than one and thus satisfies the performance requirements of 10 CFR §70.61.

The MFFF utilizes many features to reduce the likelihood and consequences of these events, as well as other loss-of-confinement events. Key features include reliable and redundant confinement systems; process temperature, pressure, and flow controls; and redundant control systems.

5.5.3.2 Internal Fire

Fires are postulated to occur and are evaluated for each fire area within the MFFF. Fire areas account for the entire combustible loading within the fire area and are designed to contain the fire within the fire area. No unlikely or likely event has been identified that would cause fires to occur simultaneously in multiple fire areas, thus the evaluation is based on a fire impacting one fire area.

The bounding fire event is a fire in the fire area containing the Final Dosing Unit. This unit contains polished plutonium powder for the purpose of down blending the mixed oxide powder to the desired blend for fuel rod fabrication. This fire area is postulated to contain the largest source term for this event type and consequently produces the largest consequences. The evaluation conservatively assumes that a fire occurs in this fire area and impacts the powder

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5.5.3.7 Chemical Releases

Chemical consequences as a result of events are established in Chapter 8 and discussed in Section 5.5.2.10. The results of the preliminary chemical evaluation indicate that the chemical consequences to the public and site worker are low. These results and the application of principal SSCs ensure that the performance requirements of 10 CFR §70.61 will be satisfied.

5.5.4 Likelihood Assessment

This section provides additional information on the likelihood evaluation associated with the SA. The likelihood evaluation methodology and associated likelihood definitions are provided in Section 5.4.3.

5.5.4.1 Likelihood Assessment Results

An assessment is performed to determine those NPHs and EMMHs that present a credible hazard to the MFFF. The results of this assessment are presented in Section 5.5.1. All credible NPHs and EMMHs are further evaluated in the accident analysis to determine their potential impact on the MFFF. For those NPHs and EMMHs that could impact the MFFF, principal SSCs are specified to satisfy the performance requirements of 10 CFR §70.61.

For events generated by internal hazards, a qualitative likelihood assessment is made in the hazard evaluation. In that evaluation, all unmitigated events are conservatively assumed to be Not Unlikely. Thus, no internally generated unmitigated events are screened out on the basis of likelihood and they are further evaluated to determine potential consequences. As necessary, principal SSCs are specified to satisfy the performance requirements of 10 CFR §70.61.

Unmitigated events are either prevented and/or mitigated through the application of principal SSCs as identified in Section 5.5.2. For events that are prevented, demonstration that the specified principal SSCs reduce the likelihood of occurrence of the event to a level consistent with the performance requirements of 10 CFR §70.61 will be provided in the ISA utilizing the likelihood definitions given in Section 5.4.3. For events that are mitigated, a demonstration that the mitigation features are sufficiently effective and available to satisfy the performance requirements of 10 CFR §70.61 will also be provided in the ISA Summary.

The MFFF general design philosophy, design bases, system design, and commitments to applicable management measures are based on standard nuclear industry practices. Past precedent regarding the conservative nature of traditional engineering practices provides reasonable assurance that the likelihood requirements of 10 CFR §70.61 will be satisfied by the final design. Principal SSCs either are IROFS or presumed to be IROFS (pending results of the ISA), and are controlled as Quality Level 1 in accordance with the management measures described in Chapter 15. These management measures include design, procurement, installation, testing, and maintenance (as appropriate) in accordance with the MOX Project Quality Assurance Plan to ensure adequate availability and reliability, based on the results of the ISA. These elements ensure that applicable industry codes and standards are utilized, adequate safety margins are provided, engineering features are utilized to the extent practicable, the defense-in-depth philosophy is incorporated into the design, and principal SSCs will be appropriately maintained. The MFFF general design philosophy is discussed in Section 5.5.5. Specific implementation of this philosophy, along with the specific design bases and system description of principal SSCs, is provided in Chapters 6, 7, 8, and 11. Management measures are described in Chapter 15.

5.5.4.2 Likelihood Evaluation Methods to Be Used in the ISA

Likelihood evaluation methods to be used in the ISA are described in Sections 5.4.3 and 5.4.5.

5.5.5 MFFF General Design Philosophy and Defense-in-Depth Practices

This section describes the MFFF general design philosophy and the defense-in-depth practices applied at the MFFF. This information, along with the specific design bases and design descriptions provided in Chapters 6, 7, 8, 9, and 11, provides reasonable assurance that the likelihood requirements of 10 CFR §70.61 will be satisfied by the final design. Additionally, this information, along with the specific defense-in-depth practices cited in Section 5.5.2, provides assurance that the defense-in-depth requirements of 10 CFR §70.64(b) will be satisfied by the final design.

5.5.5.1 Hierarchy of Controls

To ensure that engineering controls are utilized, to the extent practicable, in implementing preventive and mitigative principal SSCs, a hierarchy of controls has been established as follows:

1. Protection by a single passive safety device, functionally tested on a pre-determined basis
2. Independent and redundant active engineered features, functionally tested on a pre-determined basis
3. Single hardware system/engineered feature, functionally tested on a pre-determined basis
4. Enhanced administrative controls
5. Simple administrative controls or normal process equipment.

This hierarchy of controls will be utilized to assist in evaluating the adequacy of the risk evaluation performed in the ISA. Additional detail on this methodology is provided in Section 5.4.3.

5.5.5.2 Defense-in-Depth

The MFFF incorporates defense-in-depth practices throughout MFFF facilities and processes. These practices are incorporated through the following principles:

- **Double contingency** – for protection against criticality events. In general, double contingency requires the design to incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality is possible. Protection is provided by either (1) the control of two independent process parameters (which is the preferred approach, when practical, to prevent common-mode failure), or (2) a system of multiple controls on a single process parameter. The number of controls required upon a single controlled process parameter is based upon control reliability and any features that mitigate the consequences of control failure. In all cases, no single credible event or failure results in a criticality accident.

- **Single failure criterion** – for the MFFF, principal SSCs are required to be capable of carrying out their functions given the failure of any single active component (see clarification below) within the system or in an associated system that supports its operation.

A single failure means an occurrence that results in the loss of capability of a component to perform its intended safety functions. Multiple failures resulting from a single occurrence are considered to be a single failure (also called common mode or common cause failures). Electric and fluid systems are considered to be designed against an assumed single failure if neither (1) a single failure of any active component (assuming passive components function properly) nor (2) a single failure of a passive component (assuming active components function properly) results in a loss of the capability of the system to perform its safety functions.

Single failures of passive components in electric components is assumed in designing against a single failure. No distinction is made between electrical active and passive failures when applying the single failure criterion.

An active failure in a fluid system means (1) the failure of a component that relies on mechanical movement for its operation to complete its intended function on demand, or (2) an unintended movement of the component. A passive failure in a fluid system means a breach in the fluid pressure boundary or a mechanical failure that adversely affects a flow path. In the study of passive failures, it is appropriate to assume valve seat failures, fluid leakage from gross failure of pump or valve seals during long term operations, but not pipe breaks.

Components and systems not qualified for seismic events or accident environments and non-principal SSCs are assumed to fail/operate if such failure/operation adversely affects protection system performance. SSCs will be evaluated for seismic interactions and qualified as necessary.

Implementation of the single failure criterion dictates application of the principles of redundancy, independence, physical separation, and fail-safe operation for principal SSCs as appropriate, consistent with a risk-informed, performance-based approach. Implementation of these principles is as follows:

- **Redundant equipment or systems** – A piece of equipment or a system is redundant if it duplicates the operation of another piece of equipment or system to the extent that either may perform the required function (either identically or similarly), regardless of the state of operation or failure of the other.
- **Independence** – Principal SSCs are designed to ensure that the effects of natural phenomena and of normal operating, maintenance, testing, and postulated accident conditions on redundant equipment of systems do not result in loss of their safety function, or are demonstrated to be acceptable on some other defined basis.

- **Separation** – Principal SSCs are separated to the extent that failure of a single system component, or failure or removal from service of any principal SSC that is common to the other systems and the principal SSC, leaves intact a principal SSC satisfying applicable reliability, redundancy, and independence requirements.
- **Fail safe** – Principal SSCs are designed to fail into a safe state or into some other non-threatening defined basis if conditions such as disconnection of the system, loss of energy, or loss of pressure occur.

In addition, certain SSCs that are not credited directly in the SA for prevention or mitigation of design basis events are nonetheless designated principal SSCs for additional defense in depth. Examples include fire detection and suppression SSCs.

5.5.5.3 Additional Protection Features

The MFFF design incorporates additional protection features based on standard engineering practices or features that are required for process operations. While not credited in the SA, in many cases these features prevent or mitigate events prior to a principal SSC being challenged.

5.5.5.4 Implementation of the Baseline Design Criteria

The baseline design criteria specified in 10 CFR §70.64(a) are incorporated into the design and operation of the MFFF. Information demonstrating compliance with these criteria is provided in the applicable chapters of this CAR.

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Tables

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Table 5.5-1. MFFF Workshops and Process Units

Process	Workshop	Unit ID	Process Unit Description
Aqueous Polishing	Aqueous Polishing	KDA	PuO_2 Decanning
		KDB	Dissolution
		KPA	Purification Cycle
		KDM	Pre-polishing Milling
		KDD	Dissolution of Chlorinated Feed
		KDR	Recanning
		KDC	Uranium Dissolution
		KPB	Solvent Recovery
		KPC	Acid Recovery
		KPG	Sampling
		KCA	Precipitation - Filtration - Oxidation
		KCB	Homogenization - Sampling
		KCC	PuO_2 Canning
		KCD	Oxalic Mother Liquors Recovery
		KWD	Liquid Waste Reception
		KWG	Off Gas Treatment
		LLI	Reagents
MOX Processing	Receiving	DRS	UO_2 Receiving & Storage
		DDP	UO_2 Drum Emptying
		DCP	PuO_2 Receiving
		DCM	PuO_2 3013 Storage
		DCE	PuO_2 Buffer Storage
	Powder	NDD	PuO_2 Can Receiving and Emptying
		NDP	Primary Dosing
		NBX/NBY	Ball Milling Units
		NDS	Final Dosing
		NXR	Powder Auxiliary
		NCR	Scrap Processing

Table 5.5-1. MFFF Workshops and Process Units (continued)

Process	Workshop	Unit ID	Process Unit Description
MOX Processing (cont.)	Powder (cont.)	NTM	Jar Storage and Handling
		NPE/NPF	Homogenization and Pelletizing Units
	Pellets	PFE/PFF	Sintering Furnaces
		PRE/PRF	Grinding Units
		PTE/PTF	Pellet Inspection and Sorting Units
		PQE	Quality Control and Manual Sorting
		PAD	Pellet Repackaging
		PAR	Scrap Box Loading
		PSE	Green Pellet Storage
		PSF	Sintered Pellet Storage
		PSI	Scrap Pellet Storage
		PSJ	Ground and Sorted Pellet Storage
		PML	Pellet Handling
	Cladding and Rod Control	GME	Rod Cladding and Decontamination
		GMK	Rod Tray Loading
		GDE	Rod Decladding
		SXE/SXF	X Ray Inspection
		SEK	Helium Leak Test
		SDK	Rod Inspection and Sorting
		SCE	Rod Scanning
		STK	Rod Storage
		SMK	Rod Tray Handling
	Assembly	TGM	Assembly Mockup Loading
		TGV	Assembly Mounting
		TAS	Assembly Handling and Storage
		TCK	Assembly Dry Cleaning
		TCP	Assembly Dimensional Inspection
		TCL	Assembly Final Inspection
		TXE	Assembly Packaging
	Wastes	VDQ	Waste Storage
		VDT	Waste Nuclear Counting
		VDR	Filter Dismantling
		VDU	Maintenance and Mechanical Dismantling

Table 5.5-2. MFFF Process Support Units

Support Group	Support Subgroup	Support Units
Auxiliaries and Utilities	Miscellaneous	Offices and Personnel Access Areas
		Control Areas/Computer Areas
		Air Locks, Corridors, Stairways and Safe Areas
		Storage Areas (non-waste)
		Laboratories (MOX & AP)
		Additives Preparation
		Electrical Support Utilities
		Mechanical Support Utilities
	Outside Support Facilities	Gas Storage Area
		Secured Warehouse Building
		Small Rod Components Cleaning (in warehouse)
		Reagents Processing Building
		Administration Building
		Emergency Generator Building
		Standby Generator Building
		Technical Support Building
Confinement	HVAC (Dynamic Confinement)	HVAC Units and General Areas
	Gloveboxes (Static Confinement)	Gloveboxes

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Table 5.5-4. Summary Hazard Identification Table by Workshop/Process Support Group

		AP	MOX Processing						Auxiliaries and Utilities		Confinement	
		Aqueous Polishing	Receiving	Powder	Pellets	Cladding and Rod Control	Assembly	Wastes	Miscellaneous Areas	Outside Support Facilities	HVAC (Dynamic Confinement)	Gloveboxes (Static Confinement)
Hazardous Materials												
	Corrosive Chemicals	X							X	X		X
	Toxic Chemicals	X							X	X		X
	Other Oxidizers	X								X		
	Alkali Metals	X										
	Nitric Acid	X							X			
	Hydroxylamine Nitrate	X										
	Hydrazine	X								X		
	Other Hazardous Materials	X										
Ionizing Radiation Sources												
	Fissile Material	X	X	X	X	X	X	X	X		X	X
	Radioactive Material	X	X	X	X	X	X	X	X	X	X	X
	Radiography Equipment					X						
	Radioactive Sources					X		X				
	Other Ionizing Radiation Sources					X						
Explosive Materials												
	Explosive Gases	X			X	X			X	X	X	
	Explosive Chemicals	X										
	Incompatible Chemicals - Explosive Incompatibility	X								X		X
	Radioactive/Hydrogenous (Radiolysis)	X						X			X	X
	Other Explosive Materials											
Flammable / Combustibles												
	Flammable Gases	X			X				X	X		
	Flammable Liquids	X	X	X		X			X	X		
	Propane											
	Hydrogen/Argon	X			X				X	X		
	Methane/Argon		X	X	X	X	X	X	X			
	Oxygen	X							X	X		
	Solvents	X							X	X		X
	Other Combustibles	X	X	X	X	X	X	X	X	X	X	X
	Pyrophoric Materials					X	X					
	Other Flammable/ Combustibles	X										

Table 5.5-4. Summary Hazard Identification Table by Workshop / Process Support Group (continued)

		AP	MOX Processing						Auxiliaries and Utilities		Confinement	
		Aqueous Polishing	Receiving	Powder	Pellets	Cladding and Rod Control	Assembly	Wastes	Miscellaneous Areas	Outside Support Facilities	HVAC (Dynamic Confine-ment)	Gloveboxes (Static Confine-ment)
Thermal Sources												
	Furnaces	X			X				X			X
	Evaporators/Boilers	X										
	Electrical Equipment	X	X	X	X	X	X	X	X	X	X	X
	Electrolyzers	X										X
	Grinders			X	X	X						X
	Lasers				X							X
	Heating Plates								X			X
	Other Process Equipment	X	X	X								X
	Welding Equipment	X				X						X
	Bunsen burners								X			
	Radioactive Decay Heat		X	X	X	X	X					X
	Solar											
	Cryogenic											
	Microwave											
	Electric Arc	X										
	Electrical Heating Resistor	X										
	Heater	X								X		
	Incompatible Chemicals - Thermal Release	X								X		
	Other Thermal Sources			X								
Pressure Sources												
	Autoclaves								X			
	Gas Receivers								X	X		
	Pressure Vessels	X			X	X			X	X		
	Steam Header and Steam Lines	X										
	Gas Bottles								X	X		
	Other Pressure Sources											

Table 5.5-4. Summary Hazard Identification Table by Workshop / Process Support Group (continued)

		AP	MOX Processing						Auxiliaries and Utilities		Confinement	
		Aqueous Polishing	Receiving	Powder	Pellets	Cladding and Rod Control	Assembly	Wastes	Miscellaneous Areas	Outside Support Facilities	HVAC (Dynamic Confinement)	Gloveboxes (Static Confinement)
Gravitational Sources												
	Cranes/Hoists	X	X	X	X	X	X	X		X	X	X
	Elevators	X		X	X	X	X	X				X
	Human efforts	X							X			
	Lifts		X	X	X	X	X	X				X
	Suspended objects	X		X			X					
	Other Gravitational											
Kinetic Energy Sources												
	Crane Loads in Motion	X	X	X	X	X	X	X		X	X	X
	Carts	X		X		X	X		X	X		
	Conveyors	X	X	X	X	X	X	X				X
	Dollies											
	Fork Lifts		X									
	Air Ejector/Air Lift/Air Jet	X					X					
	Steam Ejector	X										
	Power-driving Tools											
	Impacter	X		X						X		
	Presses	X		X								X
	Shears					X		X				
	Other Kinetic Energy Sources	X										
Rotational / Friction												
	Belts	X	X	X	X	X	X	X		X	X	X
	Centrifuges	X		X								
	Fans	X		X	X						X	X
	Exhausters	X		X			X				X	
	Gears	X	X	X	X	X	X	X		X	X	X
	Power Rotating Tools	X		X		X						
	Bearings	X	X	X	X	X	X	X		X	X	X
	Motors	X	X	X	X	X	X	X		X	X	X
	Other Rotational / Friction	X	X			X						

Table 5.5-4. Summary Hazard Identification Table by Workshop / Process Support Group (continued)

	AP	MOX Processing						Auxiliaries and Utilities		Confinement	
	Aqueous Polishing	Receiving	Powder	Pellets	Cladding and Rod Control	Assembly	Wastes	Miscellaneous Areas	Outside Support Facilities	HVAC (Dynamic Confinement)	Gloveboxes (Static Confinement)
Confinement Type											
AP vessels, tanks and piping	X							X			
Glove Box	X	X	X	X	X		X	X			X
Containers inside Gloveboxes	X	X	X	X	X		X	X			
Containers outside Gloveboxes	X	X	X	X		X	X	X			
Rods/ Assemblies					X	X					
HEPA Filters	X	X	X	X	X		X	X		X	X
HVAC	X	X	X	X	X		X	X	X	X	X
Pneumatic transfer tubes	X	X	X	X				X			
Off-gas Process Confinement	X										
Other Confinement Type	X	X	X	X				X			
Utilities											
Process Water Supply	X			X				X	X		
Compressed Air	X	X	X	X	X	X	X	X	X		X
Process Gas Lines	X	X	X	X	X		X	X	X		X
Pneumatic Pipe Vacuum Transfer System	X	X	X	X				X			X
Radiation Air Monitoring System	X	X	X	X	X	X	X	X			X
Reagents Supply Lines	X								X		
Steam/Condensate Lines	X								X		
Contaminated Drains	X							X			
Other Utilities	X										

Table 5.5-5. Comprehensive List of NPH Initially Evaluated and Applicable NPH

Event	Definition	Required Condition	Conclusion
Avalanche	A large mass of snow, ice, soil, or rock, or mixture of these materials, falling, sliding, or flowing very rapidly under force of gravity.	Steeply sloped terrain found in high mountain ranges.	This event is not applicable. This event is eliminated from consideration as an initiating event based on the lack of significant quantities of snow, ice, or rock in the surrounding area, which supports the argument that this event is not credible. In addition, the surrounding topography renders this event non-credible.
Coastal Erosion	The wearing away of soil and rock by waves and tidal action.	Coastline.	This event is not applicable. This event is eliminated from consideration as an initiating event based on the lack of a coastline. SRS lies approximately 161 km (100 mi) from the coast.
Dam Failure	Failure of a large man-made barrier, which creates and restrains a large body of water.	Existing dam.	This event is not applicable. The only significant dams or impoundment structures that could possibly affect the safety of SRS are large dams on the Savannah River and its tributaries upstream of Augusta, Georgia. A domino failure of the dams on the Savannah River and its tributaries upstream of Vogtle Electric Generating Plant (VEGP) was analyzed because VEGP resides at the lowest mean sea level (msl) of all the surrounding SRS facilities. The worst possible case resulted from Jocassee Dam failing during a combined standard project flood and earthquake, with the resulting chain reaction. Using conservative assumptions, this worst dam failure yielded a peak flow of 2,400,000 cubic feet per second (cfs) at Strom Thurmond Dam. This rate, undiminished in magnitude, was transferred to below Augusta, Georgia. However, because of the great width of the floodplain, routing of the dam failure surge to the VEGP site (Savannah River Mile 151) resulted in a peak discharge of 980,000 cfs, with a corresponding stage of 43 m (141 ft) above msl. This event will not result in adverse consequences to the facility due to the surface elevation of the MFFF, 81 m (265 ft) above msl. Therefore, it is concluded that a dam failure will not adversely affect the facility and consequently this event is eliminated from consideration as an initiating event.

Table 5.5-5. Comprehensive List of NPH Initially Evaluated and Applicable NPH (continued)

Event	Definition	Required Condition	Conclusion
Debris Avalanching	The sudden and rapid movement of soil and weathered rock down steep slopes resulting from intensive rainfall.	Steep slopes and debris.	This event is not applicable. This event is eliminated from consideration as an initiating event based on the lack of significant quantities of soil or rock in the surrounding area. In addition, the surrounding topography renders this event non-credible.
Denudation (See Erosion)	The sum of the processes that result in the wearing away or the progressive lowering of the earth's surfaces by weathering, mass wasting, and transportation.	Weather, soil, and rock.	This event is not applicable. Denudation is a process that occurs over geologic time much greater than the operational time of the facility. Therefore, this event is too slow to have an appreciable effect on the facility.
Dissolution	A process of chemical weathering by which mineral and rock material passes into solution.	Minerals, rocks, and fluids.	This event is not applicable. Dissolution is a process that occurs over time-scales much greater than the operational time of the facility. Therefore, this event is too slow to have an appreciable effect on the facility.
Drought	Extreme lack of precipitation.	Weather.	This event is not applicable. This event is of concern to facilities where water is needed for safety purposes.
Epeirongenic Displacement	Movements of uplift and subsidence that have produced the broader features of the continents and oceans.	Continents or oceans.	This event is not applicable. Epeirongenic displacement is a process that occurs over time-scales much greater than the operational time of the facility. Therefore, the event is too slow to have an appreciable effect on the facility.

Table 5.5-5. Comprehensive List of NPH Initially Evaluated and Applicable NPH (continued)

Event	Definition	Required Condition	Conclusion
Erosion	The wearing away of soil and rock by weathering, mass wasting, and the action of streams, glaciers, waves, wind, and underground water.	Soil, rock, and weather.	This event is not applicable. The relatively level land and a cover growth effectively control surface erosion at the SRS.
Extreme Wind	Wind is a meteorological term for that component of air that moves parallel to the earth's surface.	Meteorological conditions conducive to wind generation.	This event is potentially applicable. See Chapter 1 for details.
Fire (Range)	The event of combustion external to the facility manifested in light, flames, and heat.	Natural materials.	This event is potentially applicable. The Savannah River Forest Station considers SRS to have an average to moderately high fire hazard potential due to the forested areas close to the production area.
Flooding (Storm, River, Diversion)	The covering or causing to be covered with water.	Source of water and topography that does not allow drainage.	This event is not applicable. Since Strom Thurmond Dam was constructed, no major flood has occurred at Augusta, Georgia. Probable Maximum Flood (PMF) levels were previously calculated for the Savannah River, Upper Three Runs, a small unnamed tributary of Upper Three Runs (located about 0.6 km [0.4 mi] northwest of F Canyon), and McQueen Branch, using NRC Regulatory Guide 1.59 (NRC 1977). None of these calculations indicated a PMF above the elevation of the MFFF, 81 m (265 ft) above mean sea level (msl). The largest PMF was obtained from the small unnamed tributary with a peak stage of 69 m (225 ft) above msl. Therefore, flooding is not a credible hazard for the MFFF.
Fog	Low-lying Clouds.	Low clouds/weather conditions and topological siting.	This event is not applicable. Heavy fog (reducing visibility to less than 0.4 km [0.25 mi]) occurred at the Augusta National Weather Service office on an average of about 30 days per year between 1951 and 1995. Fog is observed less frequently at SRS because the site is at a higher elevation and a greater distance from the river than Augusta. Despite the observance of fog at SRS, it should not affect the MFFF and therefore, is eliminated from further consideration.

Table 5.5-5. Comprehensive List of NPH Initially Evaluated and Applicable NPH (continued)

Event	Definition	Required Condition	Conclusion
Glacial Erosion	Reduction of the earth's surface as a result of grinding and scouring by glacier ice armed with rock fragments.	Glaciers.	This event is not applicable. This process requires the presence of glaciation. (See Glaciation.)
Glaciation	The formation, movement, and recession of glaciers or ice sheets.	Climate change.	This event is not applicable.
High Tide	Tides are the rhythmic, alternate rise and fall of the surface of the ocean, and bodies of water connected to the ocean.	Ocean or coastal area.	This event is not applicable. This event is eliminated from consideration as an initiating event based on the lack of a coastline and the height the MFFF is above msl. SRS lies approximately 161 km (100 mi) from the coast and 81 m (265 ft) above msl.
Hurricane	An intense cyclone that forms over the tropical oceans and ranges from 100 to 1,000 km (62 to 621 mi) in diameter.	Tropical Weather	This event is potentially applicable. See Chapter 1 for details.
Ice/Hail Storm/Frost	Frozen precipitation or a state of coldness sufficient to freeze water.	Weather Conditions.	This event is potentially applicable. See Chapter 1 for details.
Ice Flooding	Flooding attributed to the melting of ice.	Significant quantities of ice.	This event is not applicable. This event is eliminated from consideration as an initiating event based on the lack of significant amounts of ice on streams and rivers. Because the site is so much higher than the nearest streams and rivers, it is not considered credible that the site could be affected by ice flooding, even if the climatic conditions were conducive to ice formation.

Table 5.5-5. Comprehensive List of NPH Initially Evaluated and Applicable NPH (continued)

Event	Definition	Required Condition	Conclusion
Landslides (See Debris Avalanching)	A general term covering a wide variety of mass-movement land forms and processes involving the downslope transport, under gravitational influence, of soil and rock material en masse.	Soil, rocks, and downslopes.	This event is not applicable. The siting of the facility renders this event non-credible (i.e., the site is relatively flat).
Lightning	Atmospheric discharge of accumulated electrical charge between clouds and ground.	Clouds and the earth's surface.	This event is potentially applicable. See Chapter 1 for details.
Liquefaction	Liquefaction is a event in which the strength and stiffness of a soil is reduced by earthquake shaking or other rapid loading.	Loosely packed ground soil and earthquake or rapid loadings.	This event is potentially applicable. See Chapter 1 for details.
Low Lake Level	Any inland body of standing water occupying a depression in the earth's surface, generally of appreciable size and too deep to permit surface vegetation to take root completely across the expanse of water.	Lake and facility reliance on the lake for water for safety systems.	This event is not applicable. This event is of concern to facilities where water is needed for safety purposes. The MFFF has neither the need nor the required conditions.

Table 5.5-5. Comprehensive List of NPH Initially Evaluated and Applicable NPH (continued)

Event	Definition	Required Condition	Conclusion
Low River Level	A river is a natural freshwater surface stream of considerable volume and a permanent or seasonal flow.	River and facility reliance on the river for water for safety systems.	This event is not applicable. This event is of concern to facilities where water is needed for safety purposes. The facility has neither the need nor the required conditions.
Meteorite Impact	The impact of any meteorite that has reached the earth's surface without being completely vaporized.	Geosphere.	This event is not applicable. This event could occur anywhere on earth. However, the probability is calculated to be less than 1.0×10^{-6} per year within the SRS.
Orogenic Diastrophism	Movement of the earth's crust produced by tectonic processes in which structures within fold-belt mountainous areas were formed, including thrusting, folding, and faulting.	Large-scale mountain ranges.	This event is not applicable. The region is geomorphically stable and the rate of geomorphic processes is likely to remain low.
Rainstorm	A storm accompanied with rain.	Rain.	This event is potentially applicable. See Chapter 1 for details.
Sedimentation	The process of forming or accumulating sediment (solid fragmental material that originates from weathering of rocks) in layers.	Weathered rocks.	This event is not applicable. This process occurs slowly over many years and is too slow to have an appreciable effect.

Table 5.5-5. Comprehensive List of NPH Initially Evaluated and Applicable NPH (continued)

Event	Definition	Required Condition	Conclusion
Seiche	A free or standing wave oscillation of the surface of water in an enclosed or semi-enclosed basin (as a lake, bay, or harbor).	Large body of water.	For the Savannah River and Upper Three Runs, the extent of flooding is far removed from site facilities in both distance and elevation. Thus, it is inconceivable that wind-induced waves would affect safety-related facilities on the site. Therefore, this event will have no effect on the facility and is therefore dispositioned.
Seismic Activity (Earthquake)	Pertaining to earthquake or earth vibrations, including those that are artificially induced.	Natural seismic activity.	This event is potentially applicable. See Chapter 1 for details.
Snow	Accumulation of snow to produce a loading.	Weather.	This event is potentially applicable. See Chapter 1 for details.
Static Fracturing	Any break in a rock due to mechanical failure by stress (includes cracks, joints, and faults).	Faulting, the presence of capable faults.	This event is not applicable. There are no known faults in the surrounding area capable of producing this event.
Stream Erosion	The progressive removal by a stream, of bedrock, overburdén, soil, or other exposed matter, from the surface of its channel.	Intermittent or continuous flowing stream.	This event in not applicable. This is a long-term event that cycles between erosion and deposition.
Subsidence	The sudden sinking or gradual downward settling of the earth's surface with little or no horizontal motion.	Natural geologic processes or man-induced activity that results in a large consolidated subsurface void space.	See earthquake.

Table 5.5-5. Comprehensive List of NPH Initially Evaluated and Applicable NPH (continued)

Event	Definition	Required Condition	Conclusion
Temperature Extreme (High/Low)	Departures from the expected temperatures.	Weather.	This event is potentially applicable. See Chapter 1 for details.
Tornado	A small-scale cyclone generally less than 500 m (1,640 ft) in diameter and with very strong winds. Intense thunderstorms are generally present.	Tornadoes.	This event is potentially applicable. See Chapter 1 for details.
Tornado Missiles	The projection of objects onto the facility due to the presence of a tornado.	Tornado.	This event is potentially applicable. See Chapter 1 for details.
Tsunami	A gravitational sea wave produced by a large-scale, short-duration disturbance on the ocean floor. Wave heights of up to 30 m (98 ft) may impact coastal regions.	Coastal region.	This event is eliminated from consideration as an initiating event based on the lack of a coastline and the height the MFFF is above msl. The SRS lies approximately 161 km (100 mi) from the coast and 81 m (265 ft) above msl.
Volcanic Eruption	The process by which magma and its associated gases rise into the crust and are extruded onto the earth's surface and into the atmosphere.	Volcanic Center.	This event is eliminated from consideration as an initiating event since MFFF does not reside in an area that is subject to volcanic eruptions.

Table 5.5-5. Comprehensive List of NPH Initially Evaluated and Applicable NPH (continued)

Event	Definition	Required Condition	Conclusion
Volcanism, Magmatic Activity (Extrusive and Intrusive)	The development and movement of magma (mobile rock material) and its solidification to igneous rock.	Volcanism potential.	This event is eliminated from consideration as an initiating event since MFFF does not reside in an area that is subject to volcanic eruptions.
Volcanism (Ash Flow)	A highly heated mixture of volcanic gases and ash traveling down the flank of a volcano or along the surface of the ground.	Silicic volcanism potential.	This event is eliminated from consideration as an initiating event since MFFF does not reside in an area that is subject to volcanic eruptions.
Volcanism (Ash Fall)	A rain of airborne volcanic ash falling from an eruption cloud.	Basaltic volcanism potential.	This event is eliminated from consideration as an initiating event since MFFF does not reside in an area that is subject to volcanic eruptions.
Waves (Aquatic)	An oscillatory movement of water manifested by an alternate rise and fall of the surface in or on the water.	Body of water.	This event is eliminated from consideration as an initiating event based on the lack of a large body of water. SRS lies approximately 161 km (100 mi) from the coast.

Table 5.5-6. List of Applicable NPHs

NPH	Definition
Extreme Wind	Wind is a meteorological term for that component of air that moves parallel to the earth's surface.
Fire (Range)	The event of combustion external to the facility manifested in light, flames, and heat.
Hurricane (4)	An intense cyclone that forms over the tropical oceans and ranges from 100 to 1,000 km (62 to 621 mi) in diameter.
Ice/Hail Storm/Frost (1)	Frozen precipitation or a state of coldness sufficient to freeze water.
Lightning	Atmospheric discharge of accumulated electrical charge between clouds and ground.
Liquefaction (2)	Liquefaction is an event in which the strength and stiffness of a soil is reduced by earthquake shaking or other rapid loading.
Rainstorm (1)	A storm accompanied with rain.
Seismic Activity (Earthquake) (2)	Pertaining to earthquake or earth vibrations, including those that are artificially induced.
Snow (1)	Accumulation of snow to produce a loading.
Temperature Extreme (High/Low)	Departures from the expected temperatures.
Tornado (3)	A small-scale cyclone generally less than 500 m (1,640 ft) in diameter and with very strong winds. Intense thunderstorms are generally present.
Tornado Missiles (3)	The projection of objects onto the facility due to the presence of a tornado.

Note: Identified NPHs are further evaluated and accounted for as necessary in the MFFF design and operation as described in Section 5.5.2.6. NPHs not requiring future evaluation have been screened as not applicable to the MFFF (i.e., not credible) and not further evaluated and are not considered in the MFFF design or operations.

(1) These events are combined in Section 5.5.2.6 under the Rain, Snow, and Ice NPH.

(2) These events are combined in Section 5.5.2.6 under the Earthquake NPH.

(3) These events are combined in Section 5.5.2.6 under the Tornado NPH.

(4) The consequences associated with this event are covered by the Tornado and Extreme Wind NPHs in Section 5.5.2.6 and potential flooding associated with this event dispositioned in the same manner as the Flood event in Table 5.5-5.

Table 5.5-7. EMMH Screening Criteria

Screening Criteria	Reference
1. No radiological or chemical hazards are present.	N/A
2. Not applicable to the MFFF site	N/A
3. An external event is excluded if the event is of equal or lesser damage potential than the events for which the plant has been designed.	NUREG/ CR-4839
4. An external event is excluded if the event has a significantly lower mean frequency of occurrence than other events with similar uncertainties and could not result in worse consequences than those events.	NUREG/ CR-4839
5. An external event is excluded if the event cannot occur close enough to the facility to affect it. This criterion is also a function of the magnitude of the event.	NUREG/ CR-4839
6. An explosion (caused by a transportation event) that produces a peak overpressure no greater than the wind pressure caused by the design basis tornado should not cause an accident or prevent the safe shutdown of the plant. When carriers that transport explosives can approach vital structures of a nuclear facility no closer than the distances indicated in Reg. Guide 1.91, no further consideration need be given to the effects of external dynamic overpressure in plant design.	Reg. Guide 1.91
7. The effects of potential accidents in industrial and military facilities in the vicinity of a nuclear power plant include explosion-created overpressure, missiles and thermal effects, and chemical releases that may cause the control room to become uninhabitable. If the facility is located farther than the safe distance defined in RG 1.91, no further analysis of the explosion effects is necessary.	Reg. Guide 1.91
8. The probability of aircraft accidents resulting in unacceptable radiological consequences is less than 1E-07/yr if all of the following requirements are met: • The plant-to-airport distance *D* is between 5 and 10 statute miles and the projected annual number of operations is less than 500 * D^2, or the plant-to-airport distance *D* is greater than 10 statute miles and the project annual number of operations is less than 1,000 * D^2. • The plant is at least 5 statute miles from the edge of military training routes, including low-level training routes, except for those associated with a usage greater than 100 flights per year, or where activities (i.e., bombing) may create an unusual stress situation. • The plant is at least 2 statute miles beyond the nearest edge of a federal airway, holding pattern, or approach pattern.	NUREG-0800 § 3.5.1.6
9. The distance from nearby railroad lines is checked to determine if the plant is within the range of a "rocketing tank" car, which is 350 m (1,148 ft), with the range for smaller pieces extending to 500 m (1,640 ft).	NUREG-0800 §2.2.1-2.2.2
10. If the source of the chemical release is situated at a distance greater than 8.0 km (5 mi), its potential impact on control room habitability does not need to be assessed. If hazardous chemicals are known or projected to be frequently shipped by rail, water, or road routes within an 8.0-km (5-mi) radius of the facility, these shipments should be considered in the evaluation of control room habitability. Shipments are defined as being frequent if there are 10 per year for truck traffic, 30 per year for rail traffic, or 50 per year for barge traffic.	Reg. Guide 1.78

Table 5.5-8. EMMH Screening Evaluation Summary

Event	Applicable Screening Criteria[2]				
	Release of radiological material	Release of hazardous chemical	Damage to principal SSCs	Loss of offsite power	External man-made fire
SRS Roadways	NS[1]	NS[1]	5, 6	NS[1]	NS[1]
SRS Rail	NS[1]	NS[1]	6, 9	NS[1]	NS[1]
SRS Helicopters[3]	8, 4	8, 4	8, 4	8, 4	8, 4
SRS Facilities					
K Reactor Area	NS[1]	10	5, 7	NS[1]	NS[1]
P Reactor Area	NS[1]	10	5, 7	NS[1]	NS[1]
C Reactor Area	NS[1]	1	5, 7	NS[1]	NS[1]
L Reactor Area	NS[1]	10	5, 7	NS[1]	NS[1]
R Reactor Area	NS[1]	10	5, 7	NS[1]	NS[1]
F Area	NS[1]	NS[1]	NS[1]	NS[1]	NS[1]
H Area	NS[1]	NS[1]	5, 7	NS[1]	NS[1]
S Area	NS[1]	NS[1]	5, 7	NS[1]	NS[1]
E Area	NS[1]	NS[1]	5, 7	NS[1]	NS[1]
M Area	NS[1]	NS[1]	5, 7	NS[1]	NS[1]
Z Area	NS[1]	NS[1]	5, 7	NS[1]	NS[1]
D Area	NS[1]	10	5, 7	NS[1]	NS[1]
N Area	NS[1]	NS[1]	5, 7	NS[1]	NS[1]
A Area	NS[1]	10	5, 7	NS[1]	NS[1]
New SRS Facilities					
Plutonium Conversion	NS[1]	NS[1]	NS[1]	NS[1]	NS[1]
Plutonium Immobilization	NS[1]	NS[1]	NS[1]	NS[1]	NS[1]
Pipeline accident	2	2	2	2	2
Retaining structure failure	2	2	2	2	2
Public Highway (Surface vehicle impact/explosion)	NS[1]	NS[1]	5, 6	NS[1]	NS[1]
Public Railroad	5	10	6, 9	NS[1]	NS[1]

Table 5.5-8. EMMH Screening Evaluation Summary (continued)

Event	Applicable Screening Criteria[2]				
	Release of radiological material	**Release of hazardous chemical**	**Damage to principal SSCs**	**Loss of offsite power**	**External man-made fire**
Aircraft Accidents (Does not include SRS helicopters)[3]					
Commercial/Military Aircraft[3]	8	8	8	8	8
Private Aircraft[3]	8, 4	8, 4	8, 4	8, 4	8, 4
Barge/Shipping traffic	5	5, 10	5, 6	5	NS[1]
Industrial Facilities (Non-SRS)					
Chem Nuclear Systems, Inc	5	5, 10	7	7	5
Transnuclear, Inc.	5	5, 10	7	7	5
Carolina Metals, Inc.	5	5, 10	7	7	5
Vogtle Electric Generating Plant	5	5, 10	7	7	5
Urquhart Station	5	5, 10	7	7	5
Military Facilities	5	5, 10	7	7	7

1. NS – Not Screened, further evaluated as described in Section 5.5.2.7.
2. Applicable Screening Criteria values are defined in Table 5.5-7.
3. The Aircraft screening evaluation summary includes both current flight information and projected flight information over the operational life of the MFFF.

Table 5.5-9. Mapping of Hazard Assessment Events to Loss of Confinement Event Groups

Event Group	Description	Hazard Assessment Events
Over-Temperature	This event is an over temperature in a process cell or glovebox, which leads to primary confinement failure from excessive temperature and melting of vessels or seals. High temperature process equipment includes the sintering furnaces, the calcining furnace, the AP evaporators, and other various heat sources within gloveboxes.	AP-11 * GB-6 AP-10 PT-7
Corrosion	This event involves the corrosion of a primary confinement barrier. Barriers included are AP gloveboxes containing corrosive chemicals, AP related confinement ducting, pneumatic transfer sample lines, and laboratory gloveboxes.	HV-12 FW-11* MA-6 AP-12 FW-5
Small Breaches in a Glovebox Confinement Boundary or Backflow from a Glovebox through Utility Lines	This event involves small breaches in a glovebox confinement boundary or backflow from a glovebox through utility lines.	GB-5 * AP-13 GB-4 AP-22
Leaks of AP process Vessels or Pipes within Process Cells	This event involves leaks of nuclear material from welded vessels into process cells.	AP-16 * AP-42
Backflow From a Process Vessel Through Utility Lines	This event involves the backflow of material from a process vessel through utility lines to an interfacing system.	AP-14 * AP-17 AP-18
Rod Handling Operations	This event involves a breach of a fuel rod while being handled in a C2 area.	RD-11* AS-10
Breaches in Containers Outside Gloveboxes Due to Handling Operations	This event involves a breach of containers while being handled outside the gloveboxes.	MA-5 * WH-4 GB-7 GB-11
Over/Under-Pressurization of Glovebox	This event is an over/under pressurization of AP or MP gloveboxes. This includes all C4 confinements within the MFFF, including over-pressurization of pneumatic tubing.	GB-3 * FW-9
Excess Temperature due to Decay Heat from Radioactive Materials	This event is an over temperature in the storage areas due to decay heat following a loss of cooling.	RC-5 *
Glovebox Dynamic Exhaust Failure	This event is a complete loss of the C4 confinement system leading to a global loss of negative pressure within all AP and MP gloveboxes.	HV-5 *
Process Fluid Line Leak In a C3 Area Outside a Glovebox	This event involves a leak from a line carrying a process fluid in a C3 area outside of a glovebox.	AP-50 *
Sintering Furnace Confinement Boundary Failure	This event involves a leak from the sintering furnace in a C3 area outside of a glovebox.	PT-6 * PT-13

* Hazard assessment event with bounding consequences for this event group.

Table 5.5-10a. Summary of Principal SSCs for Facility Worker Protection From Loss of Confinement Events

Event Group	Principal SSC	Safety Function
Over-temperature	Process Safety Control Subsystem	Shut down process equipment prior to exceeding temperature safety limits
Corrosion	Material Maintenance and Surveillance Programs	Detect and limit the damage resulting from corrosion.
Small breaches in a glovebox confinement boundary or backflow from a glovebox through utility lines	C4 Confinement System	Maintain a negative glovebox pressure differential between the glovebox and the interfacing systems. Maintain minimum inward flow through small glovebox breaches.
Leaks of AP process vessels or pipes within process cells	Process Cells	Contain fluid leaks within process cells.
	Process Cell Entry Controls	Prevent the entry of personnel into process cells during normal operations. Ensure that workers do not receive a radiological exposure in excess of limits while performing maintenance in the AP process cells.
Backflow From a Process Vessel Through Utility Lines	Backflow Prevention Features	Prevent process fluids from back-flowing into interfacing systems
Rod handling operations	Facility Worker Action	Ensure that facility workers take proper actions to limit radiological exposure.
	Material Handling Controls	Ensure proper handling of primary confinement types outside of gloveboxes.
	Material Handling Equipment	Limit damage to fuel rods/assemblies during handling operations.

Table 5.5-10a. Summary of Principal SSCs for Facility Worker Protection From Loss of Confinement Events (continued)

Event Group	Principal SSC	Safety Function
Breaches in containers outside gloveboxes due to handling operations in C2 and C3 areas	Material Handling Controls	Ensure proper handling of primary confinement types outside of gloveboxes.
	3013 Canister	Withstand the effects of design basis drops without breaching.
	Transfer Container	Withstand the effects of design basis drops without breaching.
	Facility Worker Controls (for events in C3 areas only)	Ensure that facility workers take proper actions prior to bag-out operations to limit radiological exposure.
Over/Under-pressurization of glovebox	Facility Worker Action	Ensure that facility workers take proper actions to limit radiological exposure.
	Process Safety Control Subsystem	Warn operators of glovebox pressure discrepancies prior to exceeding differential pressure limits.
	Glovebox pressure controls	Maintain glovebox pressure within design limits.
Excess temperature due to decay heat from radioactive materials	C3 Confinement System	Provide exhaust to ensure that temperatures in the 3013 canister storage structure are maintained within design limits.
Glovebox Dynamic Exhaust Failure	C4 Confinement System	Operate to ensure that a negative pressure differential exists between the C4 glovebox and the C3 area Effectively filter C4 exhaust.
Process Fluid Line Leak In a C3 Area Outside of a Glovebox	Double-Walled Pipe	Prevent leaks from pipes containing process fluids from leaking into C3 areas
Sintering Furnace Leak	Sintering Furnace	Provide a primary confinement boundary against leaks into C3 areas Minimize consequences of leak from seal failure
	Sintering Furnace Pressure Controls	Maintain sintering furnace pressure within design limits

Table 5.5-10b. Summary of Principal SSCs for Environmental Protection From Loss of Confinement Events

Event Group	Principal SSC	Safety Function
Over-temperature	Process Safety Control Subsystem	Shut down process equipment prior to exceeding temperature safety limits
Corrosion	Material Maintenance and Surveillance Programs	Detect and limit the damage resulting from corrosion.
Small breaches in a glovebox confinement boundary or backflow from a glovebox through utility lines	C4 Confinement System	Maintain a negative glovebox pressure differential between the glovebox and the interfacing systems. Maintain minimum inward flow through small glovebox breaches.
Leaks of AP process vessels or pipes within process cells	None Required	N/A
Backflow From a Process Vessel Through Utility Lines	Backflow Prevention Features	Prevent process fluids from back-flowing into interfacing systems
Rod handling operations	None Required	N/A
Breaches in containers outside gloveboxes due to handling operations in C2 and C3 areas	Material Handling Controls (for events in C2 areas)	Ensure proper handling of primary confinement types outside of gloveboxes.
	3013 Canister (for events in C2 areas)	Withstand the effects of design basis drops without breaching.
	Transfer Container (for events in C2 areas)	Withstand the effects of design basis drops without breaching.
	C3 Confinement System (for events in C3 areas)	Provide filtration to mitigate dispersions from the C3 areas.
Over/Under-pressurization of glovebox	C3/C4 Confinement System	Provide filtration to mitigate dispersion from C3/C4 areas.
Excess temperature due to decay heat from radioactive materials	C3 Confinement System	Provide exhaust to ensure that temperatures in the 3013 canister storage structure are maintained within design limits.
Glovebox Dynamic Exhaust Failure	C4 Confinement System	Operate to ensure that a negative pressure differential exists between the C4 glovebox and the C3 area Effectively filter C4 exhaust

Table 5.5-10b. Summary of Principal SSCs for Environmental Protection From Loss of Confinement Events (continued)

Event Group	Principal SSC	Safety Function
Process Fluid Line Leak In a C3 Area Outside of a Glovebox	Double-Walled Pipe	Prevent leaks from pipes containing process fluids from leaking into C3 areas
Sintering Furnace Leak	Sintering Furnace	Provide a primary confinement boundary against leaks into C3 areas
	Sintering Furnace Pressure Controls	Maintain sintering furnace pressure within design limits

Table 5.5-11. Summary of Principal SSCs for Public and Site Worker Protection from Loss of Confinement Events

Event Group	Principal SSC	Safety Function
Over-temperature	C3 Confinement System	Provide filtration to mitigate dispersions from the C3 areas.
Corrosion	None Required	N/A
Small breaches in a glovebox confinement boundary or backflow from a glovebox through utility lines	None Required	N/A
Leaks of AP process vessels or pipes within process cells	None Required	N/A
Backflow From a Process Vessel Through Utility Lines	Backflow Prevention Features[a]	Prevent process fluids from backflowing into interfacing systems
Rod handling operations	None Required	N/A
Breaches in containers outside gloveboxes due to handling operations in C2 and C3 areas	Material Handling Controls (for events in C2 areas)	Ensure proper handling of primary confinement types outside of gloveboxes.
	Transfer Container (for events in C2 areas)	Withstand the effects of design basis drops without breaching.
	3013 Canister (for events in C2 areas)	Withstand the effects of design basis drops without breaching.
	C3 Confinement System (for events in C3 areas)	Provide filtration to mitigate dispersions from the C3 areas.
Over/under-pressurization of glovebox	None Required	N/A
Excess temperature due to decay heat from radioactive materials	C3 Confinement System	Provide exhaust to ensure that temperatures in the 3013 canister storage structure are maintained within design limits.
Glovebox Dynamic Exhaust Failure	C4 Confinement System[a]	Operate to ensure that a negative pressure differential exists between the C4 glovebox and the C3 area Effectively filter C4 exhaust.

Table 5.5-11. Summary of Principal SSCs for Public and Site Worker Protection from Loss of Confinement Events (continued)

Event Group	Principal SSC	Safety Function
Process Fluid Line Leak In a C3 Area Outside of a Glovebox	None Required	N/A
Sintering Furnace Leak	None Required	N/A

[a] Required for site worker only

Table 5.5-12. Mapping of Hazard Assessment Events to Fire Event Groups

Event Group	General Event Description	Hazard Assessment Events
AP Process Cells	Fires in fire areas within the AP process cells	AP-4*, AP-3, AP-40, HV-17
AP/MP C3 Glovebox Areas	Fires in fire areas in the AP or MP Areas.	GB-1*,RC-4, PW-1, PT-1, PT-2, AP-5, RD-2, RD-3, AP-2, MA-1, AP-1, WH-2, PT-3, GB-2, WH-1
C1 and/or C2 Areas - 3013 Canister	Fire involving 3013 canisters	RC-1*
C1 and/or C2 Areas – Fuel Rod	Fire involving fuel rods or assemblies	AS-1* AS-2, RD-1
C1 and/or C2 Areas - 3013 Transport Cask	Fire involving 3013 transport casks	RC-3*
C1 and/or C2 Areas - MOX Fuel Transport Cask	Fire involving MOX fuel transport cask	AS-11*
C1 and/or C2 Areas - Transfer Container	Transfer containers involved in a fire outside of a C3 area	MA-2*
C1 and/or C2 Areas - Waste Container	Waste Containers involved in a fire	AS-13*, MA-12, RC-16
C1 and/or C2 Areas - Final C4 HEPA filter	Fires involving the areas containing the final C4 HEPA filters	HV-1*
Outside MOX Fuel Fabrication Building	Fires originating outside of the MOX Fuel Fabrication Building	SF-1*, GH-13
Facilitywide Systems	Fires involving systems that cross fire areas	FW-2*, HV-2
Facility	Fire involving more than one fire area	FW-1*

* Hazard assessment event with bounding consequences for this event group.

Table 5.5-13a. Fire Event - Summary of Principal SSCs - Facility Worker

Event Group	Principal SSC	Safety Function
AP Process Cells	Process Cell Fire Prevention Features	Ensure that fires in the process cells are highly unlikely
AP/MP C3 Glovebox Areas	Facility Worker Action	Ensure that facility workers take proper actions to limit radiological exposure.
	Facility Worker Controls	Ensure that facility workers take proper actions prior to maintenance activities to limit radiological exposure.
C1 and/or C2 Areas - 3013 Canister	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing 3013 canisters to ensure that the canisters are not adversely impacted by a fire.
C1 and/or C2 Areas - 3013 Transport Cask	3013 Transport Cask	Withstand the design basis fire without breaching.
	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing 3013 transport casks to ensure that the cask design basis fire is not exceeded.
C1 and/or C2 Areas - Fuel Rod	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing fuel rods to ensure that the fuel rods are not adversely impacted by a fire.
C1 and/or C2 Areas - MOX Fuel Transport Cask	MOX Fuel Transport Cask	Withstand the design basis fire without breaching.
	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing MOX fuel transport casks to ensure that the cask design basis fire is not exceeded.
C1 and/or C2 Areas - Waste Container	Facility Worker Action	Ensure that facility workers take proper actions to limit radiological exposure.
C1 and/or C2 Areas - Transfer Container	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing transfer containers to ensure that the containers are not adversely impacted by a fire.

Table 5.5-13a. Fire Event - Summary of Principal SSCs - Facility Worker (continued)

Event Group	Principal SSC	Safety Function
C1 and/or C2 Areas - Final C4 HEPA Filter	Combustible Loading Controls	Limit the quantity of combustibles in the filter area to ensure that the final C4 HEPA filters are not adversely impacted by a fire in the filter room.
Outside MOX Fuel Fabrication Building	MOX Fuel Fabrication Building Structure	Maintain structural integrity and prevent damage to internal SSCs from external fires.
	Emergency Generator Building Structure	Maintain structural integrity and prevent damage to internal SSCs from fires external to the structure.
	Emergency Control Room Air Conditioning System	Ensure habitable conditions for operators
	Waste Transfer Line	Prevent damage to line from external fires.
Facilitywide Systems	Facility Worker Action	Ensure that facility workers take proper actions to limit radiological exposure.
	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing a pneumatic system to ensure that this system is not adversely impacted by a fire.
Facility	Fire Barriers	Contain fires within a single fire area
	Facility Worker Action	Ensure that facility workers take proper actions to limit radiological exposure.

Table 5.5-13b. Summary of Principal SSCs for Environmental Protection From Fire Events

Event Group	Principal SSC	Safety Function
AP Process Cells	Process Cell Fire Prevention Features	Ensure that fires in the process cells are unlikely.
AP/MP C3 Glovebox Areas	C3 Confinement System	Remain operable during design basis fire and effectively filter any release.
	Fire Barriers	Contain/limit fires to a single fire area
	Combustible Loading Controls [For Storage Gloveboxes ONLY]	Limit the quantity of combustibles in fire areas containing a storage glovebox such that any fire that may occur will not encompass a large fraction of the stored radiological material.
C1 and/or C2 Areas - 3013 Canister	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing 3013 canisters to ensure that the canisters are not adversely impacted by a fire.
C1 and/or C2 Areas - 3013 Transport Cask	3013 Transport Cask	Withstand the design basis fire without breaching.
	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing 3013 transport casks to ensure that the cask design basis fire is not exceeded.
C1 and/or C2 Areas - Fuel Rod	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing fuel rods to ensure that the fuel rods are not adversely impacted by a fire.
C1 and/or C2 Areas - MOX Fuel Transport Cask	MOX Fuel Transport Cask	Withstand the design basis fire without breaching.
	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing MOX fuel transport casks to ensure that the cask design basis fire is not exceeded.
C1 and/or C2 Areas - Waste Container	None Required	N/A
C1 and/or C2 Areas - Transfer Container	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing transfer containers to ensure that the containers are not adversely impacted by a fire.

Table 5.5-13b. Summary of Principal SSCs for Environmental Protection From Fire Events (continued)

Event Group	Principal SSC	Safety Function
C1 and/or C2 Areas - Final C4 HEPA Filter	Combustible Loading Controls	Limit the quantity of combustibles in the filter area to ensure that the C4 final HEPA filters are not impacted by a filter room fire.
Outside MOX Fuel Fabrication Building	MOX Fuel Fabrication Building Structure	Maintain structural integrity and prevent damage to internal SSCs from external fires.
	Emergency Generator Building Structure	Maintain structural integrity and prevent damage to internal SSCs from fires external to the structure.
	Emergency Control Room Air Conditioning System	Ensure habitable conditions for operators
	Waste Transfer Line	Prevent damage to line from external fires.
Facility Wide Systems	Combustible Loading Controls	Limit the quantity of combustibles in areas containing the pneumatic transfer system to ensure this system is not adversely impacted
Facility	Fire Barriers	Contain fires within a single fire area

Table 5.5-14. Fire Event - Summary of Principal SSCs - Public and Site Worker

Event Group	Principal SSC	Safety Function
AP Process Cells	Process Cell Fire Prevention Features	Ensure that fires in the process cells are highly unlikely
AP/MP C3 Glovebox Areas	C3 Confinement System	Remain operable during design basis fire and effectively filter any release.
	Fire Barriers	Contain/limit fires to a single fire area
	Combustible Loading Controls [For Storage Gloveboxes ONLY]	Limit the quantity of combustibles in fire areas containing a storage glovebox such that any fire that may occur will not encompass a large fraction of the stored radiological material.
C1 and/or C2 Areas - 3013 Canister	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing 3013 canisters to ensure that the canisters are not adversely impacted by a fire.
C1 and/or C2 Areas - 3013 Transport Cask	3013 Transport Cask	Withstand the design basis fire without breaching.
	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing 3013 transport casks to ensure that the cask design basis fire is not exceeded.
C1 and/or C2 Areas - Fuel Rod	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing fuel rods to ensure that the fuel rods are not adversely impacted by a fire.
C1 and/or C2 Areas - MOX Fuel Transport Cask	MOX Fuel Transport Cask[a]	Withstand the design basis fire without breaching.
	Combustible Loading Controls[a]	Limit the quantity of combustibles in a fire area containing MOX fuel transport casks to ensure that the cask design basis fire is not exceeded.
C1 and/or C2 Areas - Waste Container	None Required	N/A
C1 and/or C2 Areas - Transfer Container	None Required	N/A

Table 5.5-14. Fire Event - Summary of Principal SSCs - Public and Site Worker (continued)

Event Group	Principal SSC	Safety Function
C1 and/or C2 Areas - Final C4 HEPA Filter	Combustible Loading Controls[a]	Limit the quantities of combustibles in the filter area to ensure that the C4 final HEPA filters are not impacted by a filter room fire.
Outside MOX Fuel Fabrication Building	Waste Transfer Line	Prevent damage to line from external fires.
	Emergency Control Room Air Conditioning System	Ensure habitable conditions for operators
	MOX Fuel Fabrication Building Structure	Maintain structural integrity and prevent damage to internal SSCs from external fires.
	Emergency Generator Building Structure	Maintain structural integrity and prevent damage to internal SSCs from fires external to the structure.
Facilitywide Systems	None Required	N/A
Facility	Fire Barriers	Contain fires within a single fire area

[a] Required for site worker only

Table 5.5-15. Mapping of Hazard Assessment Events to Load Handling Event Groups

Event Group	Event Description	Hazard Assessment Event
AP Process Cells	Load Handling Events within an AP Process Cell	AP-27*, AP-43
AP/MP C3 Glovebox Areas	Load Handling Events in C3b/glovebox areas	PT-10, GB-8, GB-9*
C1 and/or C2 Areas – 3013 Canister	Load Handling Events within the C2 areas involving 3013 canisters	RC-12*
C1 and/or C2 Areas - 3013 Transport Cask	Load Handling Events involving 3013 Transport Cask	RC-17*
C1 and/or C2 Areas – Fuel Rod	Load Handling Events in the C2 areas involving fuel rods.	AS-7*, AS-9, RD-10
C1 and/or C2 Areas - MOX Fuel Transport Cask	Load Handling Event involving MOX Fuel Cask	AS-14*
C1 and/or C2 Areas - Waste Container	Loading Handling events in the C2 areas involving Waste Containers	AS-12*, MA-11, RC-15, WH-8
C1 and/or C2 Areas – Transfer Containers	Load Handling Events in the C2 areas involving Transfer Containers	FW-20*
C1 and/or C2 Areas - Final C4 HEPA Filter	Load Handling Events involving the final C4 HEPA filters	HV-15*
C4 Confinement	Leaks or spills within a glovebox	AP-36, GB-10*, RC-7
Outside MOX Fuel Fabrication Building	Load handling events occurring outside the AP/MP Buildings	SF-14*
Facilitywide	Load Handling Events that impact and damage the internal or external MFFF structure	FW-15*, FW-21, RC-13, HV-14, AS-8, RD-9, FW-17

* Hazard assessment event with bounding consequences for this event group.

Table 5.5-16a. Summary of Principal SSCs for the Facility Worker Protection from Load Handling Events

Event Group	Principal SSC	Safety Function
AP Process Cells	Process Cells	Contain fluid leaks within process cells.
	Process Cell Entry Controls	Prevent the entry of personnel into process cells during normal operations. Ensure that workers do not receive a radiological exposure in excess of limits while performing maintenance in the AP process cells.
AP/MP C3 Glovebox Areas	Material Handling Controls	Prevent impacts to the glovebox during normal operations from loads outside or inside the glovebox that could exceed the glovebox design basis.
	Material Handling Equipment	Prevent impacts to the glovebox through the use of engineered equipment.
	Glovebox	Maintain confinement integrity for design basis impacts
	Facility Worker Controls	Ensure that facility workers take proper actions prior to maintenance activities to limit radiological exposure.
C1 and/or C2 Areas - 3013 Canister	3013 Canister	Withstand the effects of design basis drops without breaching
	Material Handling Controls	Ensure that the design basis lift height of the 3013 canisters is not exceeded.
C1 and/or C2 Areas - 3013 Transport Cask	3013 Transport Cask	Withstand the effects of design basis drops without release of radioactive material
	Material Handling Controls	Ensure that the design basis lift height of the 3013 transport cask is not exceeded.
C1 and/or C2 Areas - Fuel Rod	Facility Worker Action	Ensure that facility workers take proper actions to limit radiological exposure.

Table 5.5-16a. Summary of Principal SSCs for the Facility Worker Protection from Load Handling Events (continued)

Event Group	Principal SSC	Safety Function
C1 and/or C2 Areas - MOX Fuel Transport Cask	MOX Fuel Transport Cask	Withstand the effects of design basis drops without release of radioactive material
	Material Handling Controls	Ensure that the design basis lift height of the MOX fuel transport cask is not exceeded.
C1 and/or C2 Areas - Waste Container	Facility Worker Action	Ensure that facility workers take proper actions to limit radiological exposure.
C1 and/or C2 Areas - Transfer Container	Transfer Container	Withstand the effects of design basis drops without breaching
	Material Handling Controls	Ensure that the design basis lift height of the transfer container is not exceeded.
C1 and/or C2 Areas - Final C4 HEPA Filter	Material Handling Controls	Prevent load handling activities that could potentially lead to a breach in the final C4 HEPA filters.
C4 Confinement	C4 Confinement System	Maintain a negative glovebox pressure differential between the glovebox and the interfacing systems. Ensure C4 exhaust is effectively filtered.
Outside MOX Fuel Fabrication Building	Waste Transfer Line	Ensure that waste transfer line is protected from activities taking place outside the MOX Fuel Fabrication Building.
Facilitywide	MOX Fuel Fabrication Building Structure	Withstand the effects of load drops that could potentially impact radiological material.
	Material Handling Controls	Prevent load handling events that could breach primary confinements.

Table 5.5-16b. Summary of Principal SSCs for Environmental Protection from Load Handling Events

Event Group	Principal SSC	Safety Function
AP Process Cells	None Required	N/A
AP/MP C3 Glovebox Areas	Material Handling Controls	Prevent impacts to the glovebox during normal operations from loads outside or inside the glovebox that could exceed the glovebox design basis.
	Material Handling Equipment	Prevent impacts to the glovebox through the use of engineered equipment.
	Glovebox	Maintain confinement integrity for design basis impacts
C1 and/or C2 Areas - 3013 Canister	3013 Canister	Withstand the effects of design basis drops without breaching
	Material Handling Controls	Ensure that the design basis lift height of the 3013 canisters is not exceeded.
C1 and/or C2 Areas - 3013 Transport Cask	3013 Transport Cask	Withstand the effects of design basis drops without release of radioactive material
	Material Handling Controls	Ensure that the design basis lift height of the 3013 transport cask is not exceeded.
C1 and/or C2 Areas - Fuel Rod	None Required	N/A
C1 and/or C2 Areas - MOX Fuel Transport Cask	MOX Fuel Transport Cask	Withstand the effects of design basis drops without release of radioactive material
	Material Handling Controls	Ensure that the design basis lift height of the MOX fuel transport cask is not exceeded.
C1 and/or C2 Areas - Waste Container	None Required	N/A
C1 and/or C2 Areas - Transfer Container	Transfer Container	Withstand the effects of design basis drops without breaching
	Material Handling Controls	Ensure that the design basis lift height of the transfer container is not exceeded.

Table 5.5-16b. Summary of Principal SSCs for Environmental Protection from Load Handling Events (continued)

C1 and/or C2 Areas - Final C4 HEPA Filter	Material Handling Controls	Prevent load handling activities that could potentially lead to a breach in the final C4 HEPA filters.
C4 Confinement	C4 Confinement System	Ensure C4 exhaust is effectively filtered. Maintain a negative glovebox pressure differential between the glovebox and the interfacing systems.
Outside MOX Fuel Fabrication Building	Waste Transfer Line	Ensure that waste transfer line is protected from activities taking place outside the MOX Fuel Fabrication Building.
Facilitywide	MOX Fuel Fabrication Building Structure	Withstand the effects of load drops that could potentially impact radiological material.
	Material Handling Controls	Prevent load handling events that could breach primary confinements.

Table 5.5-17. Summary of Principal SSCs for Public and Site Worker Protection from Load Handling Events

Event Group	Principal SSC	Safety Function
AP Process Cells	None Required	N/A
AP/MP C3 Glovebox Areas	C3 Confinement System	Provide filtration to mitigate dispersions from the C3 areas
C1 and/or C2 Areas - 3013 Canister	3013 Canister[a]	Withstand the effects of design basis drops without breaching
	Material Handling Controls[a]	Ensure that the design basis lift height of the 3013 canisters is not exceeded.
C1 and/or C2 Areas - 3013 Transport Cask	3013 Transport Cask[a]	Withstand the effects of design basis drops without release of radioactive material
	Material Handling Controls[a]	Ensure that the design basis lift height of the 3013 transport cask is not exceeded.
C1 and/or C2 Areas - Fuel Rod	None Required	N/A
C1 and/or C2 Areas - MOX Fuel Transport Cask	None Required	N/A
C1 and/or C2 Areas - Waste Container	None Required	N/A
C1 and/or C2 Areas - Transfer Container	Transfer Container[a]	Withstand the effects of design basis drops without breaching
	Material Handling Controls[a]	Ensure that the design basis lift height of the transfer container is not exceeded.
C1 and/or C2 Areas - Final C4 HEPA Filter	Material Handling Controls[a]	Prevent load handling activities that could potentially lead to a breach in the final C4 HEPA filters.
C4 Confinement	C4 Confinement System[a]	Maintain a negative glovebox pressure differential between the glovebox and the interfacing systems. Ensure C4 exhaust is effectively filtered.

Table 5.5-17. Summary of Principal SSCs for Public and Site Worker Protection from Load Handling Events (continued)

Event Group	Principal SSC	Safety Function
Outside MOX Fuel Fabrication Building	Waste Transfer Line	Ensure that waste transfer line is protected from activities taking place outside the MOX Fuel Fabrication Building.
Facilitywide	MOX Fuel Fabrication Building Structure	Withstand the effects of load drops that could potentially impact radiological material.
	Material Handling Controls	Prevent load handling events that could breach primary confinements.

[a] Required for site worker only

Table 5.5-18. Explosion Groups and Associated Hazard Assessment Events

Explosion Event Group	Hazard Assessment Event(s)
Hydrogen Explosion	PT-4
Steam Explosion	PT-12
Radiolysis Induced Explosion	AP-6, AP-41, WH-3
HAN Explosion	AP-8
Hydrogen Peroxide Explosion	AP-37
Solvent Explosion	AP-38
TBP – Nitrate (Red Oils) Explosion	AP-39
AP Vessel Over-Pressurization Explosion	AP-7, AP-20, AP-49, FW-4, FW-6
Pressure Vessel Over-Pressurization Explosion	FW-3
Hydrazoic Acid Explosion	AP-9
Metal Azide Explosion	AP-44
Pu(VI) Oxalate Explosion	AP-48
Electrolysis Related Explosion	AP-47
Laboratory Explosion	MA-4
Outside Explosion	SF-3, GH-2, GH-3

Table 5.5-19. Principal SSCs and Associated Safety Functions for all Receptors for the Explosion Event Type

Explosion Group	Principal SSC	Safety Function
Hydrogen Explosion	Process Safety Control Subsystem	Prevent the formation of an explosive mixture of hydrogen within the MFFF facility associated with the use of the hydrogen-argon gas
Steam Explosion	Process Safety Control Subsystem	Ensure isolation of sintering furnace humidifier water flow on high water level.
Radiolysis Induced Explosion	Offgas Treatment System	Provide an exhaust path for the removal of gases in process vessels
	Instrument Air System (Scavenging Air)	Provide sufficient scavenging air-flow to dilute the hydrogen produced by radiolysis such that an explosive condition does not occur
	Waste Containers[a]	Ensure that hydrogen buildup in excess of limits does not occur while providing appropriate confinement of radioactive materials
HAN Explosion [Process vessels containing HAN and hydrazine nitrate without NOx addition]	Process Safety Control Subsystem	Ensure the temperature of solutions containing HAN is limited to temperatures within safety limits
	Chemical Safety Control	Ensure that nitric acid, metal impurities, and HAN concentrations are controlled and maintained to within safety limits
HAN Explosion [Vessels containing HAN and no hydrazine nitrate]	Process Safety Control Subsystem	Ensure the temperature of solutions containing HAN is limited to temperatures within safety limits
	Chemical Safety Control	Ensure that nitric acid, metal impurities, and HAN concentrations are controlled and maintained to within safety limits

Table 5.5-19. Principal SSCs and Associated Safety Functions for all Receptors for the Explosion Event Type (continued)

Explosion Group	Principal SSC	Safety Function
HAN Explosion [Process vessels containing HAN and hydrazine nitrate with NO_x addition]	Chemical Safety Control	Ensure concentrations of HAN, hydrazine nitrate, and hydrazoic acid are controlled to within safety limits
	Offgas Treatment System	Provide an exhaust path for the removal of gases in process vessels
	Process Safety Control Subsystem	Control the flow rate into the oxidation column
Hydrogen Peroxide	Chemical Safety Control	Ensure that explosive concentrations of hydrogen peroxide do not occur
Solvent Explosion	Process Safety Control Subsystem[a]	Ensure the temperature of solutions containing solvents is limited to temperatures within safety limits
	Process Cell Fire Prevention Features[a]	Ensure that fires in process cells are highly unlikely
	Offgas Treatment System[a]	Provide an exhaust path for the removal of gases in process vessels
TBP - Nitrate (Red Oil) Explosion	Offgas Treatment System	Provide an exhaust path for the removal of gases in process vessels
	Process Safety Control Subsystem	Ensure the temperature of solutions containing organic is limited to temperatures within safety limits Limit the residence time of organics in process vessels containing oxidizing agents and potentially exposed to high temperatures and in radiation fields

Table 5.5-19. Principal SSCs and Associated Safety Functions for all Receptors for the Explosion Event Type (continued)

Explosion Group	Principal SSC	Safety Function
TBP - Nitrate (Red Oil) Explosion (continued)	Chemical Safety Control	Ensure that quantities of organics are limited from entering process vessels containing oxidizing agents and at potentially high temperatures Ensure a diluent is used that is not very susceptible to either nitration or radiolysis
AP Vessel Over-Pressurization	Fluid Transport Systems	Ensure that vessels, tanks, and piping are designed to prevent process deviations from creating over-pressurization events
	Offgas Treatment System	Provide an exhaust path for the removal of gases in process vessels
	Chemical Safety Control	Ensure control of the chemical makeup of the reagents and ensure segregation/ separation of vessels/components from incompatible chemicals
Pressure Vessel Over-Pressurization	Pressure Vessel Controls	Ensure primary confinements are protected from the impact of pressure vessel failures (bulk gas, breathing air, service air and instrument air systems)
Hydrazoic Acid Explosion	Chemical Safety Control	Ensure the proper concentration of hydrazine nitrate is introduced into the system Ensure that hydrazoic acid is not accumulated in the process or propagated to units that might lead to explosive conditions
	Process Safety Control Subsystem	Ensure the temperature of solutions potentially containing hydrazoic acid is limited to prevent an explosive concentration of hydrazoic acid from developing

Table 5.5-19. Principal SSCs and Associated Safety Functions for all Receptors for the Explosion Event Type (continued)

Explosion Group	Principal SSC	Safety Function
Metal Azide Explosion	Chemical Safety Control	Ensure metal azides are not introduced into high temperature process equipment Ensure the sodium azide has been destroyed prior to the transfer of the alkaline waste to the waste recovery unit
	Process Safety Control Subsystem	Ensure the temperature of solutions potentially containing metal azides is insufficient to overcome the activation energy needed to initiate the energetic decomposition of the azide Limit and control conditions under which dry-out can occur
Pu(VI) Oxalate Explosion	Chemical Safety Control	Ensure the valance of the plutonium prior to oxalic acid addition is not VI
Electrolysis-Related Explosion	Process Safety Control Subsystem	Ensure the normality of the nitric acid is sufficiently high to ensure that the offgas is not flammable and to limit excessive hydrogen production
Laboratory Explosions	Chemical Safety Control[c]	Ensure control of the chemical makeup of the reagents and ensure segregation/ separation of vessels/components from incompatible chemicals
	Laboratory Material Controls[c]	Minimize quantities of hazardous chemicals in the laboratory Minimize quantities of radioactive materials in the laboratory
	Facility Worker Action[c]	Ensure that facility workers take proper actions to limit radiological exposure

Table 5.5-19. Principal SSCs and Associated Safety Functions for all Receptors for the Explosion Event Type (continued)

Explosion Group	Principal SSC	Safety Function
Laboratory Explosions (continued)	C3 Confinement System[d]	Provide filtration to mitigate dispersions from the C3 areas
Outside Explosions	Waste Transfer Line	Prevent damage to line from explosions
	MOX Fuel Fabrication Building Structure	Maintain structural integrity and prevent damage to internal SSCs from explosions external to the structure
	Emergency Generator Building Structure	Maintain structural integrity and prevent damage to internal SSCs from explosions external to the structure
	Hazardous Material Delivery Controls	Ensure that the quantity of delivered hazardous material and its proximity to the MOX Fuel Fabrication Building structure, Emergency Generator Building structure, and the waste transfer line are controlled to within the bounds of the values used to demonstrate that the consequences of outside explosions are acceptable.

[a] Required for facility worker, site worker, and environment only
[b] Required for facility worker and site worker only
[c] Required for facility worker only
[d] Required for site worker, environment, and the public only

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Table 5.5-21. List of Principal SSCs for NPH and their Associated Safety Functions

Event	Principal SSC	Safety Function
Extreme Wind	Waste Transfer Line	Withstand the effects of the wind loads Withstand the effects of wind driven missiles
	Emergency Generator Building Structure	Withstand the effects of the wind loads Withstand the effects of wind driven missiles Prevent damage to internal SSCs from wind loads and missiles
	Missile Barriers	Withstand the effects of the wind loads Withstand the effects of wind driven missiles Prevent damage to internal SSCs
	MOX Fuel Fabrication Building Structure	Withstand the effects of the wind loads Withstand the effects of wind driven missiles Prevent damage to internal SSCs from wind loads and missiles
Earthquake	Waste Transfer Line	Withstand the effects of the design basis earthquake (DBE)
	MOX Fuel Fabrication Building Structure	Withstand the effects of the DBE
	Emergency Generator Building Structure	Withstand the effects of the DBE
	Fluid Transport Systems	Withstand as necessary the effects of the DBE
	Seismic Monitoring System and Associated Seismic Isolation Valves	Prevent fire and criticality as a result of an uncontrolled release of hazardous material and water within the MFFF Building in the event of an earthquake
Tornado	Emergency Generator Building Structure	Withstand the effects of the tornado wind loads Withstand the effects of tornado driven missiles Prevent damage to internal SSCs from tornado wind loads and missiles
	Missile Barriers	Withstand the effects of the tornado wind loads Withstand the effects of tornado driven missiles Protect internal SSCs from damage caused by tornado generated missiles
	MOX Fuel Fabrication Building Structure	Withstand the effects of the tornado wind loads Withstand the effects of tornado driven missiles Prevent damage to internal SSCs from wind loads and missiles

Table 5.5-21. List of Principal SSCs for NPH and their Associated Safety Functions (continued)

Event	Principal SSC	Safety Function
Tornado (continued)	MFFF Tornado Dampers	Protect MFFF ventilation systems from differential pressure effects of the tornado
	Waste Transfer Line	Withstand the effects of the tornado wind loads Withstand the effects of tornado driven missiles
External Fires	Emergency Generator Building Structure	Withstand the effects of design basis external fire and protect internal SSCs from the effects of heat, fire and smoke
	MOX Fuel Fabrication Building Structure	Withstand the effects of design basis external fire and protect internal SSCs from the effects of heat, fire and smoke
	Emergency Control Room Air Conditioning System	Ensure habitable conditions for operators
	Waste Transfer Line	Withstand the effects of external fires
Rain, Snow, and Ice	MOX Fuel Fabrication Building Structure	Withstand the effects of rain, snow, or ice loads Protect internal SSCs from the effects of rain, snow, and ice loads
	Emergency Generator Building Structure	Withstand the effects of rain, snow, or ice loads Protect internal SSCs from the effects of rain, snow, and ice loads
	Waste Transfer Line	Withstand the effects of rain, snow, or ice loads
Lightning	None Required	N/A
Temperature Extremes	None Required	N/A

Table 5.5-22. Support System Functions for Principal SSCs

Principal SSC	Required Support System Principal SSCs	Support System Function
3013 Canister	No Support Systems Required	N/A
3013 Transport Cask	No Support Systems Required	N/A
C2 Confinement System Passive Boundary	No Support Systems Required	N/A
C3 Confinement System	Emergency AC Power System	Provide AC power to High Depressurization Exhaust System
	Emergency Control System	Provide controls for High Depressurization Exhaust System
	Emergency DC Power System	Provide DC power for High Depressurization Exhaust System
	Emergency Diesel Generator Fuel Oil System	Provide emergency diesel generator fuel oil for the emergency diesel generators
	Emergency Generator Ventilation System	Provide emergency diesel generator ventilation
	Supply air system	Provide unconditioned emergency cooling air to the storage vault and designated electrical rooms
C3 Confinement System Passive Boundary	No Support Systems Required	N/A
C4 Confinement System	Emergency AC Power System	Provide AC power to C4 confinement system
	Emergency Control System	Provide controls for C4 confinement system
	Emergency DC Power System	Provide DC power for C4 confinement system
	Emergency Diesel Generator Fuel Oil System	Provide emergency diesel generator fuel oil for the emergency diesel generators
	Emergency Generator Ventilation System	Provide emergency diesel generator ventilation
Backflow Prevention Features	No Support Systems Required	N/A
Chemical Safety Controls	No Support Systems Required	N/A
Combustible Loading Controls	No Support Systems Required	N/A
Criticality Control	(See Chapter 6)	N/A
Double-Walled Pipe	No Support Systems Required	N/A
Emergency AC Power System	Emergency Control System	Provide controls for Emergency AC System
	Emergency DC Power System	Provide DC power for Emergency AC Power System controls
	Emergency Diesel Generator Fuel Oil System	Provide emergency diesel generator fuel oil for the emergency diesel generators
	Emergency Generator Ventilation System	Provide emergency diesel generator ventilation

Table 5.5-22. Support System Functions for Principal SSCs (continued)

Principal SSC	Required Support System Principal SSCs	Support System Function
Emergency Control Room Air Conditioning System	Emergency AC Power System	Provide AC power to emergency control room air conditioning system
	Emergency Control System	Provide controls for emergency control room air conditioning system
	Emergency DC Power System	Provide DC power for emergency control room air conditioning system
	Emergency Generator Ventilation System	Provide emergency diesel generator ventilation
Emergency Control System	Emergency AC Power System	Provide AC power to Emergency Control System
	Emergency DC Power System	Provide DC power for the Emergency Control System
	Emergency Diesel Generator Fuel Oil System	Provide emergency diesel generator fuel oil for the emergency diesel generators
	Emergency Generator Ventilation System	Provide emergency diesel generator ventilation
	C3 Confinement System	Provide cooling air exhaust from designated electrical rooms
	Emergency Control Room Air Conditioning System	Provide cooling to maintain appropriate temperature limits for emergency electrical equipment
Emergency DC Power System	Emergency AC Power System	Provide AC power to Emergency DC Power System Battery Chargers
	Emergency Control System	Provide controls for Emergency DC Power System
	Emergency Diesel Generator Fuel Oil System	Provide emergency diesel generator fuel oil for the emergency diesel generators
	Emergency Generator Ventilation System	Provide emergency generator ventilation
Emergency Diesel Generator Fuel Oil Systems	Emergency AC Power System	Provide AC power to Emergency Diesel Generator Fuel Oil System
	Emergency Control System	Provide controls for Emergency Diesel Generator Fuel Oil System
Emergency Generator Building Structure	No Support Systems Required	N/A

Table 5.5-22. Support System Functions for Principal SSCs (continued)

Principal SSC	Required Support System Principal SSCs	Support System Function
Emergency Generator Ventilation System	Emergency AC Power System	Provide AC power to Emergency Generator Ventilation System
	Emergency Control System	Provide controls for Emergency Generator Ventilation System
	Emergency DC Power System	Provide DC power for System to Emergency Generator Ventilation System
Facility Worker Action	No Support Systems Required	N/A
Facility Worker Controls	No Support Systems Required	N/A
Fire Barriers, Detection, and Suppression	(See Chapter 7)	N/A
Fluid Transport Systems	No Support Systems Required	N/A
Glovebox	No Support Systems Required	N/A
Glovebox pressure controls	No Support Systems Required	N/A
Hazardous Material Delivery Controls	No Support Systems Required	N/A
Instrument Air System (Scavenging Air)	No Support Systems Required	N/A
Laboratory Material Controls	No Support Systems Required	N/A
Material Handling Controls	No Support Systems Required	N/A
Material Handling Equipment	No Support Systems Required	N/A
Material Maintenance and Surveillance Programs	No Support Systems Required	N/A
MFFF Tornado Dampers	No Support Systems Required	N/A
Missile Barriers	No Support Systems Required	N/A
MOX Fuel Fabrication Building Structure	No Support Systems Required	N/A
MOX Fuel Transport Cask	No Support Systems Required	N/A
Offgas Treatment System	No Support Systems Required	N/A
Pressure Vessel Controls	No Support Systems Required	N/A
Process Cells	No Support Systems Required	N/A
Process Cell Entry Controls	No Support Systems Required	N/A
Process Cell Fire Prevention Features	No Support Systems Required	N/A
Process Cell Ventilation System Passive Boundary	No Support Systems Required	N/A
Process Safety Control Subsystem	Emergency Control System	Shutdown process on loss of power Shutdown and isolate process and systems, as necessary, in response to an earthquake
Seismic Monitoring System and Associated Seismic Isolation Valves	Emergency AC Power System	Provide AC power to Seismic Monitoring System and Seismic Isolation Valves
Sintering Furnace	No Support Systems Required	N/A
Sintering Furnace Pressure Controls	No Support Systems Required	N/A
Supply Air System	No Support Systems Required	N/A

Table 5.5-22. Support System Functions for Principal SSCs (continued)

Principal SSC	Required Support System Principal SSCs	Support System Function
Transfer Containers	No Support Systems Required	N/A
Waste Containers	No Support Systems Required	N/A
Waste Transfer Line	No Support Systems Required	N/A

Table 5.5-23. Mapping of Hazard Assessment Events to Chemical Event Groups

Event Group	General Event Description	Hazard Assessment Events
Events involving only hazardous chemicals not produced from licensed material - Inside Chemical Events	Hazardous chemical (not produced from licensed material)releases from vessels, tanks, pipes, or transport containers internal to the MOX Fuel Fabrication Building	AP-28, AP-30, AP-31, AP-32, AP-33, HV-16, MA-9, MA-10, FW-18 SF-4
Events involving only hazardous chemicals produced from licensed material – Inside Chemical Events	Hazardous chemical (produced from licensed material) releases from pipes and process vessels internal to the MOX Fuel Fabrication Building	AP-45
Events involving only hazardous chemicals - Outside Chemical Events	Hazardous chemical releases from vessels, tanks, pipes, or transport containers external to the MOX Fuel Fabrication Building, primarily from the BRP	SF-6, SF-7, SF-8, SF-11, SF-12
Events involving hazardous chemicals and radioactive material	Releases from the AP Process	No mapping required, see other event types

Table 5.5-24. Principal SSCs and their Safety Functions for the Chemical Event Type

Event Group	Principal SSCs	Safety Function
Events involving only hazardous chemicals not produced from licensed material	Emergency Control Room Air Conditioning System	Ensure habitable conditions for operators
Events involving only hazardous chemicals produced from licensed material	Process Cell Entry Controls	Prevent the entry of personnel into process cells during normal operations
		Ensure that workers do not receive a chemical consequence in excess of limits while performing maintenance in the AP process cells
	Facility Worker Action	Ensure that facility workers take proper actions to limit chemical consequences for leaks occurring in C3 ventilated areas
	C4 Confinement System	Contain a chemical release within a glovebox and provide an exhaust path for removal of the chemical vapors
Events involving hazardous chemicals and radioactive material	See SSCs proposed for other event types	N/A
	Process Safety Control Subsystem	Ensure the flow rate of nitrogen dioxide/ dinitrogen tetroxide is limited to the oxidation column of the purification cycle

Table 5.5-25. Low Consequence Screened Hazard Assessment Events

Loss of Confinement Events	Fire Events	Load Handling Events
AP-21	MA-3	FW-16
AP-46	RC-2	RC-11
AS-3	SF-2	SF-13
AS-4		
FW-7		
FW-8		
FW-12		
GH-14		
HV-3		
HV-4		
HV-6		
HV-10		
HV-11		
RC-6		
RD-4		
RD-5		

Table 5.5-26. Summary of Bounding Mitigated MFFF Event Consequences

Bounding Accident[ba]	Maximum Impact to Site Worker (mrem)	Maximum Impact to Person at Controlled Area Boundary (mrem)	Effluent Concentration Ratio
Internal Fire	<100	<0.5	<4.0E-2
Load Handling	<150	<1.0	<1.1E-2
Hypothetical Explosion Event	<500	<3.0	4.5E-2
Hypothetical Criticality Event	<2200	<12	<7.5E-3

[a] The bounding loss of confinement event is bounded by the load handling event provided above.

Table 5.5-27. Summary of Bounding Unmitigated Low Consequence Events

Bounding Accident	Maximum Impact to Site Worker (mrem)	Maximum Impact to Person at Controlled Area Boundary (mrem)	Effluent Concentration Ratio
Loss of Confinement	<2	<1E-2	<3.06E-3
Internal Fire	<500	<4	<3.2E-3
Load Handling	<2	<1E-2	<1.2E-3
Hypothetical Explosion Event	N/A	N/A	N/A
Hypothetical Criticality Event	N/A	N/A	N/A