DUKE COGEMA
STONE & WEBSTER

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U.S. Nuclear Regulatory Commission
Washington, DC 20555

18 February 2003
DCS-NRC-000129

Subject: Docket Number 070-03098
Duke Cogema Stone & Webster
Mixed Oxide (MOX) Fuel Fabrication Facility
Construction Authorization Request Change Pages

Reference: 1) P. S. Hastings (DCS) to Document Control Desk (NRC), *Docket Number 070-03098 Duke Cogema Stone & Webster Mixed Oxide (MOX) Fuel Fabrication Facility Construction Authorization Request*, DCS-NRC-000123, 20 December 2002

Enclosed are change pages for Duke Cogema Stone & Webster's (DCS) request for authorization of construction of the Mixed Oxide (MOX) Fuel Fabrication Facility. The enclosed change pages replace pages in the Construction Authorization Request as updated per Reference 1.

The enclosed change pages do not contain information which is considered to be proprietary to DCS. Enclosure 1 provides twenty-five copies of the change pages, which may be disclosed to the public. Enclosure 2 provides replacement instructions.

Each of these changes has been discussed previously with the NRC staff. The main purpose of these changes is to update information based to discussions at recent NRC public meetings.

If I can provide any additional information, please feel free to contact me at (704) 373-7820.

Sincerely,

For/ Peter S. Hastings, P.E.
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1/25

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NMSS01

Enclosures: 1) Change Pages to the Mixed Oxide Fuel Fabrication Facility Construction Authorization Request (non-proprietary)
2) Construction Authorization Request 02/18/03 Update Instructions

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Enclosure 1

Change Pages for Mixed Oxide Fuel Fabrication Facility Construction Authorization Request (non-proprietary)

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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 (1) the lid of a reusable plutonium oxide can, (2) a lifting device, or (3) 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.

3013 Canister

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.

3013 Transport Cask

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.

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 into the high alpha waste of 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.

- 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.

Any adverse impacts to an operator occurring during a release of unregulated material (i.e., material that does not constitute "licensed material or chemicals produced from licensed material") will not result in exceeding the performance requirements of 10 CFR §70.61. The controls that could be impacted by a release of unregulated material are effectively "permissive" (i.e., positive result required before additional processing can continue) and are not required following such a release. These include: chemical safety controls that are administrative and laboratory material controls (i.e., permissive sampling and analysis, etc.); and material handling controls that are either permissive or that fail in a safe state. There are, therefore, no PSSCs required to mitigate an unregulated 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 depleted uranium dioxide and 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.

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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.

Fires in the secured warehouse could result in unacceptable chemical consequence to the facility worker and the site worker. To reduce the risk to these receptors, a safety strategy utilizing mitigation features is adopted. The principal SSCs identified to implement this safety strategy are combustible loading controls and facility worker action. The safety function of the facility worker action principal SSC is to ensue that facility workers take proper actions to limit chemical consequences as the results of a fire. The safety function of combustible loading controls is to limit the quantity of combustibles in the secured warehouse to ensure that any fire that may occur will not encompass a large fraction of the stored depleted uranium dioxide.

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

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 into the high alpha waste of 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

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
	Combustible Loading Controls	Limit the quantify of combustibles in the secured warehouse to ensure that any fire that may occur will not encompass a large fraction of the stored depleted uranium dioxide
	Facility Worker Action	Ensure that facility workers take proper actions to limit chemical consequences in the secured warehouse

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		

5.6 DESCRIPTION OF PRINCIPAL STRUCTURES, SYSTEMS, AND COMPONENTS

This section provides a general description of the principal SSCs and their required support systems identified in Section 5.5.2. The identification of principal SSCs and their support systems is based on the analysis presented in Sections 5.4 and 5.5.

5.6.1 Description of Principal SSCs and Required Support Systems

Table 5.6-1 lists the principal SSCs, required support systems, and associated safety functions required to satisfy the performance requirements of 10 CFR §70.61.[1] These support systems are also designated as principal SSCs. The receptors associated with each principal SSC are provided in Section 5.5.2. Principal SSCs are described in the following chapters:

- Chapter 5, Integrated Safety Analysis
- Chapter 6, Nuclear Criticality Safety
- Chapter 7, Fire Protection
- Chapter 8, Chemical Process Safety
- Chapter 10, Environmental Protection
- Chapter 11, Plant Systems
- Chapter 15, 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.

A reference to the applicable SA section describing the design basis for the principal SSC is provided in Table 5.6-1. The level of detail is consistent with the SA purpose of identifying principal SSCs and required safety functions. Management measures required to ensure the availability and reliability of the listed principal SSCs are described in Chapter 15. More detailed descriptions will be provided in the ISA Summary to satisfy the purpose of demonstrating that IROFS are capable of performing their intended safety functions.

5.6.2 MFFF Administrative Controls

The designation of principal SSCs also includes required administrative controls. Administrative controls are those provisions associated with personnel actions necessary to ensure the safe operation of the MFFF. The MFFF design has placed an emphasis on engineered controls over administrative controls to ensure a high degree of system reliability such that a limited number of administrative controls have been identified as principal SSCs. Required administrative controls are listed in Table 5.6-1 and are identified with an asterisk. A description of each administrative control is provided below.

[1] Table 5.6-1 also lists defense-in-depth SSCs that are not required or credited in the analysis to meet the performance criteria of 10 CFR §70.61.

5.6.2.1 Chemical Safety Controls

Chemical safety controls minimize the likelihood of explosions by ensuring the chemical makeup of the reagents and/or chemical species produced in the AP process are acceptable and that incompatible chemicals are segregated. This program includes both administrative controls and engineering features.

The reagent system chemical safety controls in the reagents building include the following:

1. Use of certified chemicals that have been independently certified prior to delivery to the reagents building for storage and use
2. Preparation of the reagents by utilizing measured quantities of chemicals and solvents
3. Transfer to AP Building (BAP) by the Control Room Operator only if the test results meet reagent chemical composition requirements
4. Chemical preparation conducted by trained personnel in accordance with approved procedures
5. Limiting quantities of materials stored and maintained

These measures ensure that the proper chemicals are delivered to the AP process from the reagents building.

Low usage reagent chemicals, such as manganese nitrate, are prepared in the BAP from aqueous-based reagent grade chemicals with known compositions that are mixed with measured quantities of chemical additives and the aqueous solvent. Before use, however, these prepared reagents undergo redundant testing procedures to ensure chemical composition. Transfer to head tanks or supply tanks by the Control Room Operator occurs only if the test results meet chemical composition requirements.

To ensure that incompatible chemical species do not propagate through the process, the AP process employs sampling measures to detect for incompatible chemical species. The principal SSC chemical safety controls is used to implement this sampling process (which serves as a permissive control for other processes, not as a control unto itself) and it utilizes the following engineering and administrative measures:

1. Isolation of process vessels, as necessary, to ensure a representative sample is obtained and to prevent inadvertent additions after sample is taken and prior to processing of sampled process fluid
2. Acquisition of sufficient number of samples to obtain a representative measurement
3. Redundant testing of samples to ensure chemical composition
4. A means to ensure results of tests performed on samples are correctly conveyed from the laboratory to process unit controller

In addition, chemical safety controls will ensure the chemicals used in the MFFF laboratories are properly controlled; assuring incompatible chemicals are separated/segregated. To establish these incompatibilities for the laboratory and reagents in general, a complete chemical interaction evaluation will be provided as part of the ISA.

As an additional protection feature, the chemicals in the reagents building are physically separated by type (for example, to ensure that oxidizers are not mixed with reducing compounds). Similarly, the nitric oxide (NOx), solvent (diluent with tributylphosphate), and hydroxylamine nitrate (HAN) are prepared in separate rooms to ensure segregation from incompatible chemicals. These measures, in addition to providing control of the chemical makeup of the reagents prior to piping into the BAP, also provide non-safety protection against chemical events in the BRP. Chapter 8 provides more details related to the chemical safety of the MFFF.

5.6.2.2 Combustible Loading Controls

The principal SSC, combustible loading controls, is used to describe the control of combustible and transient combustible loads by design and the control of transient combustible loads during operations. The design limits the combustible loads inherent in the fixtures and equipment within a fire area. The safety function of these administrative controls is to limit the amount of transient combustible material within a fire area to allowable quantities during operations to ensure that the design basis fire is not exceeded. The administrative controls are enhanced by training, posting, routine house-keeping and periodic surveillance. Fire models will be performed as part of the ISA to demonstrate that combustible loading controls are effective. Refer to Section 7.1 for details about the Fire Protection Program.

5.6.2.3 Material Handling Controls

Material handling controls require loads to be handled using safe practices such that the resulting impacts are within the design basis of the container being handled or that impacts do not damage principal SSCs such that they would be unable to perform their safety functions. The design basis for containers (i.e., 3013 canister, 3013 transport cask, MOX fuel transport cask, waste containers) being lifted is discussed in Section 11.4.11. The safety function of the material handling controls is to ensure that primary confinement containers are handled properly such that, if dropped, there would be no release of radioactive material that could cause consequences that exceed 10 CFR §70.61 or that a drop of a load would not damage a principal SSC such that it would not be able to perform its safety function (such as a breach of a primary confinement that could cause consequences that exceed 10 CFR §70.61).

Loads are handled by qualified personnel, following an approved procedure controlling material to be moved, equipment (including specialized lifting fixtures), training, and precautions and limitations for the movement as applicable. Materials that will be handled by operators as part of the normal production process (pre-engineered production lifts) will have the same requirements as any other load. In addition to trained operators and proper procedures, material handling controls will also ensure the proper equipment is used having a sufficient capacity for the type and weight of load being lifted. Controls associated with the safety function of the principal SSC cranes include required testing and surveillance.

Other material handling controls are provided to prevent a postulated overpressurization of the reusable cans containing plutonium dioxide powder causing impact of the can lids with the glovebox. Potential overpressurization of the cans are postulated to occur due to radiolysis (see Section 5.5.2.4.1.3) or oxidation of Pu(III) oxalate. To prevent overpressurization of the cans due to radiolysis, material handling controls are employed. These controls may include control of moisture content of the plutonium dioxide, residence time of the canned material, and/or the design pressure of the reusable can. Overpressurization of the cans from the oxidation of the Pu(III) oxalate may be prevented through one of the following material handling controls: (1) controls on furnace parameters, such as furnace residence time and minimum temperature, to ensure complete oxidation of the plutonium oxalate, or (2) measurement of the Pu(III) content in the plutonium dioxide powder. The specific IROFS required for material handling controls in order to prevent overpressurization of the reusable cans will be identified as part of the ISA.

5.6.2.4 Material Maintenance and Surveillance Programs

The primary means of preventing corrosion-related failures of principal SSCs is through the use of compatible materials within the MFFF fluid systems and to provide separation and segregation of incompatible chemicals. The safety function of the material maintenance and surveillance programs is to supplement these corrosion prevention measures by establishing programs 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).

Material maintenance and surveillance programs consist of periodic system-level walkdowns, as well as non-destructive testing programs that can identify corrosion problems within the facility prior to catastrophic failures occurring, and provide a means of taking corrective actions to prevent such failures. These programs are not required to prevent corrosion which could result in small leaks. The frequency of surveillance and maintenance programs will be established based on industry experience.

5.6.2.5 Process Cell Entry Controls

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 dose in excess of limits while performing maintenance in the process cells. The health physics program for the facility, described in chapter 9, includes process cell access controls during normal operations in order to limit radiation exposures. Work within the process area is performed via radiation work permits that are authorized by radiation protection staff. Work activities within radiation areas are monitored by health physics staff and radiation monitors. Process cells and gloveboxes are sealed during normal operations to avoid personnel exposures to airborne plutonium particulate contamination. Radiation monitors are positioned throughout the facility for fast response to confinement failures. Access to such sealed areas is strictly controlled under the health physics program, which also precludes exposures during accident conditions.

5.6.2.6 Facility Worker Action

Where events are obvious to a facility worker and the worker has time to respond by taking self-protecting action, that action is credited in mitigating radiological or chemical consequences to the worker. Section 5.5 identifies several events that may require facility workers to evacuate the room where an event occurs.

Execution of training/qualification programs and the use of procedures are part of the qualitative demonstration of likelihood with respect to a facility worker's actions to protect themselves (e.g., by evacuation). In such circumstances, the facility worker will be aware of the event, and take appropriate action to minimize radiological or chemical exposures.

Worker actions to take self-protection measures are credited in certain scenarios. Much of the training and procedures that constitute management measures in support of these worker actions are provided under the health physics program. The health physics program is established as good management practice for a facility such as this, and pursuant to 10 CFR 20; it also provides for maintaining exposures ALARA, and provides additional protection features in support of worker safety. Continuous air radiation monitors are positioned close to work locations and within the ventilation air flow from potential release points. This feature provides additional assurance of an immediate response to a confinement failure. Other fixed air monitors are positioned within the process room for general surveillance. Monitors are designed for extremely high plutonium alpha radiation sensitivity – activity as low as 4 DAC-hours is detected (equivalent to doses in the range of a few millirem). Gloves are routinely surveyed for contamination. Gloves are also replaced frequently to prevent loss of confinement due to glove degradation. All workers are provided with respirators that are designed to filter plutonium particulate. The health physics program, including appropriate training with respect to worker evacuation, the use of respirators, etc., is a management measure that supports the principal SSC of worker actions for self-protection. The health physics program would also control activities associated with the longer-term response to and recovery from events to ensure that exposures are maintained within appropriate limits. The basic elements of the program are summarized in Section 9.2 of the CAR.

5.6.2.7 Laboratory Material Controls

Laboratory material controls consist of administrative procedures that will be used to control the quantity of radiological and chemical materials in the laboratory. The safety function of the laboratory material controls program is to limit the extent of any potential explosion by limiting the quantity of hazardous chemicals that may be involved in the explosion and to limit the quantity of radiological/chemical material available for dispersion following a potential explosion.

Procedures will be developed to establish limits on sample size, the number of samples that may be stored and used in the laboratory overall and in any one laboratory location, and the quantity of chemicals, reagents or other hazardous materials that may be stored and used in a laboratory. Procedures will also be developed to ensure laboratory operations are performed in accordance with safe laboratory operating practices.

5.6.2.8 Hazardous Material Delivery Controls

The safety function of hazardous material delivery controls is to 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.

5.6.2.9 Facility Worker Controls

The principal SSC facility worker controls credit the facility worker with taking proper actions prior to commencing an activity that could result in an event with unacceptable dose consequences. This differs from the principal SSC facility worker action where the facility worker is credited with taking self-protective measures to minimize dose consequences as a result of an event. Precautions associated with the radiation protection program (such as the use of a mask) are implemented prior to beginning operations involving, or potentially near to, primary confinements thereby ensuring the facility worker is protected in case radioactive material is released.

Specifically, in cases where the facility worker is performing a task with transient primary confinements 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 dose. Additionally, facility workers take proper actions prior to commencing maintenance activities in AP/MP C3 Areas to prevent and/or limit their exposure.

Similar to facility worker actions, many of the procedures and training that constitute management measures in support of these facility worker controls are provided under the health physics program. These measures provide a basis for the good planning of work tasks associated with the aforementioned activities. The health physics program is established as good management practice for a facility such as this, and pursuant to 10 CFR 20; it also provides for maintaining exposures ALARA, and provides additional protection features in support of worker safety. The basic elements of the program are summarized in Section 9.2 of the CAR.

5.6.3 Sole Principal IROFS

A list identifying IROFS that are the sole item preventing or mitigating an accident sequence whose risk could exceed the performance requirements of 10 CFR §70.61 will be provided in the ISA Summary submitted with the license application for possession and use of SNM.

Table 5.6-1. MFFF Principal SSCs

Principal SSC	Safety Function	SA Design Basis Reference
3013 Canister	Withstand the effects of design basis drops without breaching	11.4.11
3013 Transport Cask	Withstand the design basis fire without breaching	11.4.11
	Withstand the effects of design basis drops without release of radioactive material	
Backflow Prevention Features	Prevent process fluids from back-flowing into interfacing systems.	11.8.7
C2 Confinement System Passive Barrier	Limit the dispersion of radioactive material	11.4.11
C3 Confinement System	Provide filtration to mitigate dispersions from the C3 areas	11.4.11
	Remain operable during design basis fire and effectively filter any release	
	Limit the dispersion of radioactive material	
	Provide exhaust to ensure that temperature in the 3013 canister storage structure is maintained within design limits	
	Provide cooling air exhaust from designated electrical rooms	
C4 Confinement System	Provide design features to ensure that final C4 HEPA filters are not impacted by fire	11.4.11
	Maintain a negative glovebox pressure differential between the glovebox and the interfacing systems	
	Maintain minimum inward flow through small glovebox breaches	
	Remain operable during design basis fire and effectively filter any release	
	Ensure that C4 exhaust is effectively filtered	
	Operate to ensure that a negative pressure differential exists between the C4 glovebox and the C3 area	
	Contain a chemical release within a glovebox and provide an exhaust path for removal of the chemical vapors	

Table 5.6-1. MFFF Principal SSCs (continued)

Principal SSC	Safety Function	SA Design Basis Reference
Chemical Safety Controls*	Ensure that explosive concentrations of hydrogen peroxide do not occur	5.6.2.1
	Ensure a diluent is used that is not very susceptible to either nitration or radiolysis	
	Ensure that quantities of organics are limited from entering process vessels containing oxidizing agents and at potentially high temperatures	
	Ensure that hydrazoic acid is not accumulated in the process or propagated to units that might lead to explosive conditions	
	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 into the high alpha waste of the waste recovery unit	
	Ensure the valance of the plutonium prior to oxalic acid addition is not VI	
	Ensure that nitric acid, metal impurities, and HAN concentrations are controlled and maintained to within safety limits	
	Ensure concentrations of HAN, hydrazine nitrate, and hydrazoic acid are controlled to within safety limits	
	Ensure the proper concentration of hydrazine nitrate is introduced into the system	
	Ensure control of the chemical makeup of the reagents and ensure segregation/ separation of vessels/components from incompatible chemicals	

Table 5.6-1. MFFF Principal SSCs (continued)

Principal SSC	Safety Function	SA Design Basis Reference
Combustible Loading Controls*	Limit the quantities of combustibles in the filter area to ensure that the C4 final HEPA filters are not adversely impacted by a filter room fire	5.6.2.2
	Limit the quantity of combustibles in fire areas containing a storage glovebox and the secured warehouse such that any fire that may occur will not encompass a large fraction of the stored radiological material.	
	Limit the quantity of combustibles in a fire area containing 3013 canisters to ensure that the canisters are not adversely impacted by a fire	
	Limit the quantity of combustibles in a fire area containing 3013 transport casks to ensure that the cask design basis fire is not exceeded	
	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	
	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	
	Limit the quantity of combustibles in a fire area containing transfer containers to ensure that the containers are not adversely impacted by a fire	
	Limit the quantity of combustibles in areas containing the pneumatic transfer system to ensure this system is not adversely impacted	
Criticality Control	Prevent criticality events	6 4
Double-Walled Pipe	Prevent leaks from pipes containing process fluids from leaking into C3 areas	11.8.7

Table 5.6-1. MFFF Principal SSCs (continued)

Principal SSC	Safety Function	SA Design Basis Reference
Emergency AC Power System	Provide AC power to emergency DC system battery charger	11.5.7
	Provide AC power to emergency diesel generator fuel oil system	
	Provide AC power to high depressurization exhaust system	
	Provide AC power to C4 confinement system	
	Provide AC power to emergency control room air-conditioning system	
	Provide AC power to emergency diesel generator ventilation system	
	Provide AC power to emergency control system	
	Provide AC power to seismic monitoring system and seismic isolation valves	
Emergency Control Room Air-Conditioning System	Ensure habitable conditions for operators	11.4.11
Emergency Control System	Provide controls for high depressurization exhaust system	11.6.7
	Provide controls for C4 confinement system	
	Provide controls for emergency control room air-conditioning system	
	Provide controls for emergency AC system	
	Provide controls for emergency DC system	
	Provide controls for emergency generator ventilation system	
	Provide controls for emergency diesel generator fuel oil system	
	Shut down process on loss of power	
	Shut down and isolate process and systems, as necessary, in response to an earthquake	

Table 5.6-1. MFFF Principal SSCs (continued)

Principal SSC	Safety Function	SA Design Basis Reference
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	5.6.2.3
	Prevent load handling events that could breach primary confinements	
Material Handling Equipment	Limit damage to fuel rods/assemblies during handling operations	11.7.7
	Prevent impacts to the glovebox through the use of engineered equipment	
Material Maintenance and Surveillance Programs*	Detect and limit the damage resulting from corrosion	5.6.2.4
MFFF Tornado Dampers	Protect MFFF ventilation systems from differential pressure effects of the tornado	11.4.11
Missile Barriers	Protect MOX Fuel Fabrication Building and Emergency Generator Building internal SSCs from damage caused by tornado- or wind-driven missiles	11.1.7
MOX Fuel Fabrication Building Structure (including vent stack)	Maintain structural integrity and prevent damage to internal SSCs from external fires, external explosions, earthquakes, extreme winds, tornadoes, missiles, rain, and snow and ice loadings	11.1.7
	Withstand the effects of load drops that could potentially impact radiological material	
MOX Fuel Transport Cask	Withstand the design basis fire without breaching	11.4.11
	Withstand the effects of design basis drops without release of radioactive material	
Offgas Treatment System	Provide an exhaust path for the removal of gases in process vessels	11.4.11
Pressure Vessel Controls*	Ensure that primary confinements are protected from the impact of pressure vessel failures (bulk gas, breathing air, service air, and instrument air systems)	11.9.5
Process Cells	Contain fluid leaks within process cells	11.4.11

Table 5.6-1. MFFF Principal SSCs (continued)

Principal SSC	Safety Function	SA Design Basis Reference
Process Cell Entry Controls*	Prevent the entry of personnel into process cells during normal operations	5.6.2.5
	Ensure that workers do not receive a radiological or chemical exposure in excess of limits while performing maintenance in the AP process cells	
Process Cell Fire Prevention Features	Ensure that fires in the process cells are highly unlikely	7.5.3
Process Cell Ventilation System Passive Boundary	Provide filtration to limit the dispersion of radioactive material	11.4.11
Process Safety Control Subsystem		System design basis provided in 11.6.7. As necessary, basis for parameters provided as shown
	Prevent the formation of an explosive mixture of hydrogen within the MFFF facility associated with the use of the hydrogen-argon gas	8.5
	Ensure isolation of sintering furnace humidifier water flow on high water level	11.4.11 (See Sintering Furnace)
	Ensure the temperature of solutions containing HAN is limited to temperatures within the safety limits	8.5
	Control the flowrate into the oxidation column	8.5
	Ensure the temperature of solutions containing organic is limited to temperatures within safety limits	8 5
	Limit the residence time of organics in process vessels containing oxidizing agents and potentially exposed to high temperatures and in radiation fields	8.5
	Ensure the temperature of solutions potentially containing hydrazoic acid is limited to prevent an explosive concentration of hydrazoic acid from developing	8.5

Table 5.6-1. MFFF Principal SSCs (continued)

Principal SSC	Safety Function	SA Design Basis Reference
Process Safety Control Subsystem (continued)	Limit and control conditions under which dry-out can occur	8.5
	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	8.5
	Ensure the normality of the nitric acid is sufficiently high to ensure that the offgas is not flammable and to limit excessive hydrogen production	8.5
	Warn operators of glovebox pressure discrepancies prior to exceeding differential pressure limits	11.4.11
	Shut down process equipment prior to exceeding temperature safety limits	11.4.11
	Ensure the temperature of solutions containing solvents is limited to temperatures within safety limits	8.5
	Ensure the flow rate of nitrogen dioxide/ dinitrogen tetroxide is limited to the oxidation column of the purification cycle	8.5
	Maintain sintering furnace within design limits	11.4.11
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	11.6.7 – for system 11.8.7 – for valves
Sintering Furnace	Provide a primary confinement boundary against leaks into C3 areas	11.4.11
Supply Air System	Provide unconditioned emergency cooling air to the storage vault and designated electrical rooms	11.4.11
Transfer Container	Withstand the effects of design basis drops without breaching	11.4.11

Table 5.6-1. MFFF Principal SSCs (continued)

Principal SSC	Safety Function	SA Design Basis Reference
Waste Containers	Ensure that hydrogen buildup in excess of limits does not occur while providing appropriate confinement of radioactive materials	11.4.11
Waste Transfer Line	Ensure that the waste transfer line is protected from activities taking place outside the MOX Fuel Fabrication Building	10.5
	Prevent damage to the line from external fires, explosions, earthquakes, extreme winds, tornadoes, missiles, rain, and snow and ice loadings	10.5

* Administrative control

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6. NUCLEAR CRITICALITY SAFETY

The Nuclear Criticality Safety Program for the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) will be in accordance with U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 3.71, *Nuclear Criticality Safety Standards for Fuels and Material Facilities.* Regulatory Guide 3.71 provides guidance on complying with the applicable portions of NRC regulations, including 10 CFR Part 70, by describing procedures for preventing nuclear criticality accidents in operations involving handling, processing, storing, and transporting special nuclear material (SNM) at fuel and material facilities. The MFFF will follow the guidelines in this regulatory guide for specific criticality safety standards drafted by Subcommittee ANS-8 (Fissionable Materials Outside Reactors) of the American Nuclear Society Standards Committee for these purposes.

6.1 ORGANIZATION AND ADMINISTRATION

Duke Cogema Stone & Webster (DCS) will establish a criticality safety organization and administration prior to operation of the MFFF. The criticality safety organization will be responsible for implementing a Nuclear Criticality Safety Program. The criticality safety function during the design phase and envisioned for operations is described in the following section.

6.1.1 Criticality Safety Function (Design Phase)

The MFFF Engineering Manager (see Section 4.1.9) is responsible for the design of the facility and site-related interfaces for the MFFF, including the nuclear discipline (within the Facility Design function) that encompasses the criticality safety function during the design phase. The criticality safety function is responsible for the following during the design phase:

- Establish the Nuclear Criticality Safety design criteria
- Provide criticality safety support for integrated safety analyses and configuration control
- Assess normal and credible abnormal conditions
- Determine criticality safety limits for controlled parameters
- Develop and validate methods to support nuclear criticality safety evaluations (NCSEs)
- Perform criticality safety calculations and write NCSEs
- Specify criticality safety control requirements and functionality.

The minimum qualifications for a criticality safety function manager are a Bachelor of Science (BS) or Bachelor of Arts (BA) degree in science or engineering with at least three years of nuclear industry experience in criticality safety. A criticality safety function manager must have experience in the understanding, application, and direction of Nuclear Criticality Safety (NCS) programs and have a familiarity with NCS programs at similar facilities. A criticality safety function manager has the authority and responsibility to assign and direct activities for the criticality safety function.

The minimum qualifications for a senior criticality safety engineer are a BS or BA degree in science or engineering with at least three years of experience in nuclear criticality safety work. A senior criticality safety engineer has the authority and responsibility to conduct activities assigned to the criticality safety function.

The minimum qualifications for a criticality safety engineer are a BS or BA degree in science or engineering with at least one year of nuclear industry experience in criticality safety. A criticality safety engineer has the authority and responsibility to conduct activities assigned to the criticality safety function, with the exception of independent verification of NCSEs.

The MFFF implements the administrative practices for criticality safety, as contained in Section 4.1 of American National Standards Institute/American Nuclear Society (ANSI/ANS)-8.1-1983 (R1988), *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*. The MFFF also implements the administrative practices for criticality safety, as contained in American National Standards Institute/American Nuclear Society ANSI/ANS-8.19-1996, *Administrative Practices for Nuclear Criticality Safety*. See Section 6.4 for more information.

6.1.2 Criticality Safety Function (Operations Phase)

The criticality safety function is anticipated to report to the Regulatory Manager (see Chapter 4), who in turn has the authority to make commitments to the NRC and is accountable for overall safety of the facility. The criticality safety function is administratively independent of production responsibilities and has the authority to shut down potentially unsafe operations. Designated responsibilities of the criticality safety function include the following:

- Establish the Nuclear Criticality Safety Program, including design criteria, procedures, and training
- Provide criticality safety support for integrated safety analyses and configuration control
- Assess normal and credible abnormal conditions
- Determine criticality safety limits for controlled parameters
- Develop and validate methods to support NCSEs
- Perform criticality safety calculations, write NCSEs, and approve proposed change-in-process conditions on equipment involving fissionable material
- Specify criticality safety control requirements and functionality
- Provide advice and counsel on criticality safety control measures, including review and approval of operating procedures
- Support emergency response planning and events
- Assess the effectiveness of the Nuclear Criticality Safety Program through audit programs
- Provide criticality safety postings that identify administrative controls for operators in applicable work areas.

6.3.2 MFFF Criticality Accident Alarm System

The presence of PuO_2 in the MFFF requires continuous control of subcriticality. Criticality safety is based on a rigorous design associated with controlled management of nuclear materials.

Measures are taken by sufficiently reliable means to ensure that the occurrence of a criticality accident is prevented. Nevertheless, a criticality accident alarm system (CAAS) monitors areas in which SNM is handled, used, or stored. Specific areas qualifying for exemption from criticality accident monitoring requirements will be identified and justified for the LA or in a separate exemption request.

The CAAS is intended to do the following:

- Detect an accidental dose rate
- Warn personnel as quickly as possible
- Facilitate evacuation to limit personnel dose in the highly unlikely event of a criticality.

The CAAS is designed in accordance with generally accepted practices and those required by 10 CFR §70.24. ANSI/ANS-8.3-1997, *Criticality Accident Alarm System*, is the main guidance document that defines the features of a criticality alarm system. This standard provides guidance for alerting personnel that an inadvertent criticality has occurred. The main requirement linked to the design of the system is the reliability of actuation of the alarm.

Monitoring is performed by groups of detectors called "monitoring units." The data from the monitoring units are centralized, and audible and visual alarms are provided following detection of a criticality accident. The data concerning the accident are sent in real time to an emergency console.

ANSI/ANS-8.3-1997 provides guidance on the criticality alarm locations, their characteristics, and reliability. Specified design criteria include reliability, system vulnerability, seismic tolerance, failure warning, response time, detection criteria, sensitivity, and spacing. Guidance for alarm testing and employee familiarization is also provided.

The MFFF will render operations safe, by shutdown and quarantine if necessary, in an area where CAAS coverage has been lost and not restored promptly. The allowable number of hours where CAAS coverage has been lost and the MFFF is not shut down will be determined on a process-by-process basis because shutting down certain processes, even to make them safe, may carry a larger risk than being without a CAAS for a short period of time. The MFFF will take compensatory measures (e.g., limit access, halt SNM movement) as necessary when the CAAS system is not functioning due to maintenance.

The CAAS evaluation will take into account the effect of credible shielding in demonstrating the adequacy of the dual alarms to detect a nuclear criticality. The alarm coverage radius will be determined (e.g., through the use of shielding codes). The presence of shielding material will be maintained by controls through good housekeeping practices.

6.3.2.1 Principle of Operation

The MFFF CAAS is composed of the following:

- A detection network
- Data processing and alarm actuation units
- A network of audible and visual alarms
- An off-line processing facility.

6.3.2.2 Detection of Accident Radiation Levels

The CAAS is designed to detect a gamma or neutron dose in the highly unlikely event of a criticality accident.

6.3.2.3 Identification of the Alarm

To reduce the reaction time, and thereby the dose received, of personnel following triggering of the alarm, the alarm is identifiable within one-half second of detector recognition of a criticality accident.

6.3.2.4 Range of the Alarm

The alarm is audible in locations normally occupied by personnel present in the building and in close proximity outside. The alarm is also sent to an emergency console. The alarm takes into account the working environments encountered within the facility.

6.3.2.5 Design Features

The design features regarding operation are as follows:

- **Prevent spurious alarms** – The system is designed to prevent spurious alarms.
- **Allow accident records** – After an accident, records and processing of recorded data are possible.

The design criteria for the MFFF CAAS are as follows:

- **Reliability** – The MFFF CAAS is designed using components that do not require frequent servicing. The system is designed to reduce the effects of non-use, deterioration, power surges, and other adverse conditions. The design of the system is as simple as is consistent with the objectives of ensuring reliable actuation of the alarm signal and avoidance of false alarms.
- **Seismic tolerance** – The MFFF CAAS is designed to remain operational in the event of a seismic shock equivalent to the MFFF site-specific design basis earthquake.
- **System vulnerability** – Components of the CAAS are located or protected to reduce the potential for damage in case of fire, explosion, corrosive atmosphere, or other extreme

6.3.3.2.3 Density Control

Density control involves taking credit for non-optimal SNM density characteristics within process equipment in the performance of criticality safety design calculations. SNM density limits are established in a manner that ensures an adequate margin of subcriticality (including margins to protect against uncertainties in process variables and against limits being accidentally exceeded) using documented and approved methods, standards, or handbooks. Density control is used in facility design applications where the process function is not compatible with a worst-case SNM density assumption (i.e., maximum theoretical density) and is generally used in combination with mass, geometry, and/or moderation control. Justification for the use of density control is provided in NCSEs and the ISA Summary.

Density control parameter limits are established and implemented as follows:

- Conservative assumptions are always made about the density of the fissile material. The NCSEs will fully justify the use of the conservative values of density.

6.3.3.2.4 Isotopics Control

Isotopic abundance (isotopics) control involves taking credit for established worst-case assumptions regarding SNM isotopic abundance in the performance of criticality safety design calculations. Isotopics control includes both the ^{235}U/U concentration (enrichment) and the concentration of fissile and nonfissile plutonium isotopes (e.g., ^{239}Pu, ^{240}Pu, ^{241}Pu), as well as the relative abundance of plutonium to uranium. The presence of ^{240}Pu (5% to 9%) and ^{242}Pu (<0.02%) offsets any contribution from ^{241}Pu (<1%) such that it can be neglected for ^{239}Pu ranges from 90% to 95% as is expected to be the case for the MFFF. This will be demonstrated in the criticality calculation to be referenced in the NCSEs. Justification will be provided in NCSEs and ISA summary. SNM fissile and neutron absorption isotope abundance limits are established in a manner that ensures an adequate margin of subcriticality (including margins to protect against uncertainties in process variables and against limits being accidentally exceeded) using documented and approved methods, standards, or handbooks. Isotopics control is indicated at the point of receipt of fissionable material and may be applied at process stations where down-blending of plutonium content is credited.

Isotopics control is used throughout the MFFF and is used in combination with other control modes (e.g., process variable control). Justification for the use of isotopics control is provided in NCSEs and the ISA Summary.

Isotopics control parameter limits are established and implemented as follows:

- When taking credit for isotopic mixtures, where different isotopic mixtures could coexist, controls are established to clearly label and segregate SNM of different isotopic mixtures. In addition, the determination of isotopic content is based on compliance with the double contingency principle. Consideration is given to sample analysis and verification activities associated with MFFF and vendor-supplied measurements. Vendor data are qualified in accordance with an approved QA plan and are audited by the MFFF QA function. The use of qualified nondestructive assay (NDA) measurement systems is also acceptable in establishing compliance with the double contingency principle.

- Instrumentation used to physically measure isotopics is subject to facility QA measures.

6.3.3.2.5 Reflection Control

Reflection control involves the control of fissile unit geometry and the presence of neutron-reflecting materials in process areas in order to increase neutron leakage from a subcritical fissile system and thereby reduce the calculated subcritical multiplication factor for the system. Although reflection control is generally applied as a passive engineered feature (i.e., configuration of concrete walls or the construction of fixed personnel barriers), reflection control generally also requires surveillance procedures to ensure that neutron-reflecting materials are excluded from the process area or possibly to confirm continued efficacy of personnel barriers. Thus, reflection control is generally less desirable than passive controls such as simple geometry control or a worst-case reflector assumption in terms of hierarchical preference. Justification for the use of reflection control is provided in NCSEs and the ISA Summary. When neutron absorbers are used to limit neutron reflection, neutron absorber control is indicated in lieu of interaction control. Adjacent, contiguous units will be demonstrated acceptable.

Reflection control parameter limits are established and implemented as follows:

- When determining subcritical limits for an individual unit, the wall thickness of the unit and reflecting adjacent materials of the unit are conservatively bounded by the assumed reflection conditions, leaving allowances for transient reflectors as discussed below.
- At a minimum, reflection conditions equivalent to 1-in (2.5-cm) tight-fitting water jacket are assumed to account for personnel and other transient incidental reflectors not evaluated in the unreflected models. In any case, the quantity of water reflection will be demonstrated to be conservative in the NCSE.
- In cases where loss of reflection control can lead to criticality, by itself or in conjunction with another single failure, rigid and testable barriers are established and maintained by facility management measures (i.e., configuration management and maintenance programs).
- In cases where reflection control is not indicated, full water reflection of process stations or fissile units is represented by a minimum of 12 in (30 cm) of tight-fitting water jacket, unless consideration of other materials present in the design (e.g., concrete, carbon, or polyethylene) may be more effective than water.
- Conservative reflection conditions are established when evaluating the criticality safety of arrays. For example, conservative minimum distances from the arrays to reflecting materials (e.g., concrete or water) will be used.

6.3.3.2.6 Moderation Control

Moderation control involves taking credit for non-optimal SNM moderator content or presence within process equipment or areas in the performance of criticality safety design calculations. SNM moderator content limits or exclusion controls for areas are established in a manner that ensures an adequate margin of subcriticality (including margins to protect against uncertainties in process variables and against limits being accidentally exceeded) using documented and approved methods, standards, or handbooks. Moderation control is used in facility design applications where the process function is not compatible with a worst-case SNM moderator content (i.e., optimum moderation) or process/storage area flooding assumption. Moderation control is generally used in combination with mass or geometry control. Moderation control also may require process variable control or other surveillance activities. Justification for the use of moderation control, when needed, is provided in NCSEs and the ISA Summary.

Moderation control is particularly useful in situations where process capacity requirements are not satisfied using mass control alone and where the level of moderation is easily bounded or controlled (e.g., equipment in the powder handling stations confined within gloveboxes).

Potential sources of moderation that must be considered include the following:

- Residual humidity present in powders
- Organic additives (e.g., lubricant, poreformer) used as part of a process
- Moderating fluids (e.g., water or certain oils), which could potentially enter process stations or storage areas under abnormal or accident conditions.

The first two types of moderators (humidity and organic additives) exist during normal operations. Criticality safety calculations employ conservative assumptions to account for moderators normally anticipated to be present in processes (see below). Process stations and areas potentially susceptible to abnormal ingress or introduction of moderating fluids or other materials are identified and evaluated in detail as part of the NCSEs and documented in the ISA Summary.

Moderation control parameter limits are established and implemented as follows:

- Moderation control is implemented consistent with guidance provided in ANSI/ANS-8.22-1997, *Nuclear Criticality Safety Based on Limiting and Controlling Moderators.*
- When process variables can affect the moderation, the SSCs or procedures that affect those process variables are defined as IROFS in NCSEs and the ISA Summary.
- Physical structures credited in NCSEs with performing moderator exclusion functions are designed to preclude ingress of moderator.
- When sampling of moderation properties is required, the sampling program is based on compliance with the double contingency principle. Consideration is given to sample analysis and verification activities associated with MFFF and vendor-supplied measurements. Vendor data are qualified in accordance with an approved QA plan and are audited by the MFFF QA function. The use of qualified NDA measurement systems is also acceptable in establishing compliance with the double contingency principle.
- Fire protection system design and fire-fighting procedures and training programs are developed with appropriate restrictions placed on the use of moderating materials. The effects of credible fire events and the consequences associated with the potential use of

moderating material in fighting such fires are evaluated as applicable. However, in the MFFF moderation-controlled areas, hydrogenous fire-fighting materials are not allowed (see Chapter 7).

- Limits on moderators as fire-fighting agents are established in NCSEs and identified in the ISA Summary. The competing risks from criticality accidents and fires are weighed, which could result in allowing the use of water in cases where the overall risk to the worker and public is minimized.
- Credible sources of moderation are identified and evaluated for potential intrusion into moderator-controlled process stations or areas, and the ingress of moderator is precluded or controlled. Design features or processes required to demonstrate ingress of moderator into moderator-controlled process stations or areas are identified as IROFS in NCSEs and the ISA Summary.
- The effects of varying levels of credible interstitial moderation are evaluated when considering neutron interaction between physically separated fissile units.
- Instrumentation used to physically measure moderator is subject to facility QA measures.
- Drains are provided to prevent water accumulation if that accumulation could lead to unfavorable configurations of fissile material.

6.3.3.2.7 Concentration Control

Concentration control (i.e., exclusive reliance on concentration control) involves the use of concentration-based single-parameter limits established based upon worst-case geometry (i.e., spherical) and SNM fissile composition unless these parameters are controlled by IROFS (i.e., implementation of another [or other] criticality control mode(s) in addition to concentration control). Concentration control is generally applied only to process equipment handling solutions with very low fissile material concentration (secondary streams). Single-parameter limits for concentration are established in a manner that ensures an adequate margin of subcriticality (including margins to protect against uncertainties in process variables and against limits being accidentally exceeded) using documented and approved methods, standards, or handbooks. Concentration control almost always will require process variable control to ensure that concentration limits are not exceeded. Justification for the use of concentration control is provided in NCSEs and the ISA Summary. When the possibility of neutron interaction with other fissile units exists, interaction control or neutron absorber control may be indicated in conjunction with concentration control.

Concentration control parameter limits are established and implemented as follows:

- When process variables can affect the concentration, the SSCs or procedures that affect those process variables are defined as IROFS in NCSEs and the ISA Summary, including assumptions relied on to determine solubility limits.
- Concentrations of SNM in excess of controlled parameter limits are precluded.
- When using a tank containing concentration-controlled solution, the tank is normally closed and locked.

analyses for dissolved materials for conservatism. (Note: the storage of material initially received will be shown to be sub-critical for maximum theoretical density material – 11.46 g/cm^3.)

Since density control in the MFFF is always passive, a result of a bounding assumption controlled by design, and not the result of process control, density control is not listed as a process variable in Table 6-1 or 6-2.

6.3.4.3.2.4 Isotopics Control

Isotopics control includes the following:

- The control of $^{235}U/U$ concentration (enrichment) in the uranium and the concentration of fissile and non-fissile plutonium isotopes (e.g., ^{239}Pu, ^{240}Pu, ^{241}Pu) in the plutonium
- The relative abundance of plutonium to uranium in MOX mixtures.

Concerning plutonium and uranium isotopics, a conservative assumption is made based on the range of isotopics for the incoming products, and this control is not listed as a process variable in Table 6-1 or 6-2. On the other hand, the plutonium content in MOX mixtures is obtained by the MP process. In that case, wherever isotopic control is indicated in Table 6-1 or 6-2, it is also shown as a process variable.

Incoming Plutonium for the AP Process

Incoming plutonium will respect the following conditions (for the main plutonium isotopes):

$$90\% \le \frac{^{239}Pu}{Pu_{total}} \le 95\% \ , \ 5\% \le \frac{^{240}Pu}{Pu_{total}} \le 9\% \qquad (6\text{-}1)$$

Among the impurities, some uranium may be contained in this plutonium:

$$\frac{U}{Pu_{total}} \le 2\% \qquad (6\text{-}2)$$

The isotopics of this uranium verify: $\frac{^{235}U}{U_{total}} \le 93.2\%$

The assumptions used in the criticality calculations are, typically, as follows:

$$\frac{^{239}\mathrm{Pu}}{\mathrm{Pu}_{\mathrm{total}}} = 96\% \ , \ \frac{^{240}\mathrm{Pu}}{\mathrm{Pu}_{\mathrm{total}}} = 4\% \ \text{and} \ \frac{^{235}\mathrm{U}}{\mathrm{Pu}_{\mathrm{total}}} = 0\% \qquad (6\text{-}3)$$

Note: ^{239}Pu is assumed to be 96%, which is larger than the specification value of 95%. As such, the calculations bound the actual fissile isotopic content, which actually includes trace amounts of all other plutonium isotopes. Besides ^{239}Pu, the main other isotope is ^{241}Pu, which is specified to be less than 1%. Preliminary calculations have shown that these values are bounding. For example, calculations have demonstrated that increasing the ^{239}Pu content by 1.0 wt % while decreasing the ^{240}Pu content by a corresponding amount is sufficient to offset any reactivity effect from ^{241}Pu and ^{235}U, such that these isotopes can be omitted when performing application calculations.

It is assumed that the possible uncertainties in the characterization of the plutonium isotopics, including all other impurities, are within the margin between the criticality calculation hypotheses of Equation 6-3 and the nominal values of Equations 6-1 and 6-2.

Extracted Uranium for the AP Process

The uranium contained as an impurity in the incoming plutonium is extracted by the AP process. For the corresponding extracted stream, the following bounding assumption is made for the incoming feed material:

$$\frac{^{235}U}{U_{total}} = 100\% \qquad (6\text{-}4)$$

Polished PuO_2 Entering the MP Process

This plutonium will respect the following conditions:

$$90\% \leq \frac{^{239}Pu}{Pu_{total}} \leq 95\% \;,\; 5\% \leq \frac{^{240}Pu}{Pu_{total}} \leq 9\% \text{ and } \frac{U}{Pu_{total}} \leq 0.01\% \qquad (6\text{-}5)$$

The assumptions used in the criticality calculations are as follows:

$$\frac{^{239}Pu}{Pu_{total}} = 96\% \;,\; \frac{^{240}Pu}{Pu_{total}} = 4\% \text{ and } \frac{^{235}U}{Pu_{total}} = 0\% \qquad (6\text{-}6)$$

These values are bounding, including all other impurities, as noted with respect to equation 6-3 above.

Uranium as UO_2 Used for the MP Process

Dilution UO_2 used in the MP process is depleted uranium satisfying the following condition:

$$\frac{^{235}U}{U} < 0.25\% \qquad (6\text{-}7)$$

The assumptions used in the criticality calculations are as follows:

$$\frac{^{235}U}{U} = 0.3\% \;,\; \frac{^{238}U}{U} = 99.7\% \qquad (6\text{-}8)$$

These values are bounding.

Oak Ridge National Laboratory, June 2002,) have shown that additional, already published experiments also can be used for criticality benchmark validation purposes since they exhibit similar characteristics to MOX powder to be utilized at the MFFF.

6.3.5.4 Nuclear Criticality Safety Evaluations

As part of the initial design process, before starting a new operation with fissionable materials, or before an existing fissionable material operation is modified, NCSEs are performed to ensure that the entire process will be subcritical under both normal and credible abnormal conditions. NCSEs are documented with sufficient detail, clarity, and lack of ambiguity to allow independent evaluation and judgment of results. NCSEs identify the controlled nuclear and process parameters and their associated limits upon which criticality safety depends.

Thus, NCSEs form the basis for criticality safety for operations in which fissionable material is handled. That is, each NCSE evaluates a respective operation to determine credible accident sequences and identifies sufficient controls such that double contingency protection is provided in those cases in which a criticality is credible. Utilizing the results of validated calculational methodologies, the NCSEs demonstrate that both normal and accident conditions meet the required minimum margin of subcriticality. Finally, the IROFS to provide double contingency protection, along with criticality accident sequences, are identified in NCSEs. Features that are required to ensure that the criticality controls identified in the NCSE are sufficiently available and reliable are provided through the implementation of management measures such as procedures, training, maintenance procedures, and surveillance.

An approved design configuration requires criticality safety design input. Figure 6-2 presents an overview of the steps involved in developing an MFFF NCSE. During preliminary design, criticality safety calculations are performed to justify a preliminary design concept. These calculations assess both the normal operating and assumed accident conditions. Where practical, criticality is precluded by demonstrating that the design is subcritical without the need to implement controls, or by making appropriate design changes to render criticality non-credible. In those cases in which it is not practical to make criticality non-credible, criticality control parameters are selected and limits on these parameters are established.

6.3.5.5 Design Control

Criticality safety during design and operation is ensured for the MFFF through design and administrative practices. MFFF design and safety features are documented and controlled through the implementation of a rigorous configuration management program (see Section 15.2). Criticality safety calculations and NCSEs are maintained up to date and consistent with existing facility process and design features and administrative practices. The configuration management program ensures the following:

- Reports validating the method for analyzing criticality are maintained consistent with criticality safety documentation provided in criticality safety calculations and NCSEs.
- NCSEs are maintained consistent with existing facility process and design features and administrative practices and rely only on validated calculational methods.

- Credible optimum conditions (i.e., most reactive conditions physically possible) for each controlled parameter are assumed in criticality safety calculations and NCSEs unless specified controls are implemented to limit the controlled parameter to a specified value or range.
- Variability and uncertainty in a process condition and the subcritical limit are established and considered when applying computational methods to specific design applications.
- Surveillance programs are established and implemented to ensure the continued efficacy of supplemental neutron-absorber materials (e.g., borated concrete or cadmium) during the operational life of the MFFF.
- During license operation, the configuration management program meets the requirements of 10 CFR §70.72, including review of changes for potential criticality concerns.

6.3.6 ISA Commitments

During development of the ISA, criticality controls credited in the NCSEs will be identified and evaluated, and a more detailed description of the CAAS will be provided. This information will be reflected in the license application for possession and use of SNM and/or its accompanying ISA Summary, as appropriate. Section 6.4 provides additional details.

6.4 DESIGN BASES FOR PRINCIPAL SSCs

This section discusses the design bases requirements applicable to the design and operation of criticality safety SSCs. These requirements may be modified during the final design phase in accordance with the configuration management system, described in Section 15.2.

Principal SSCs are described in Chapter 5 of this document. Specific IROFS associated with criticality safety will be identified in the ISA.

Criticality in the MFFF will be prevented. The design features, administrative controls, and management measures to ensure that criticality is prevented will be described in the ISA Summary submitted with the license application for possession and use of SNM. Under normal and credible abnormal conditions, nuclear processes will be designed to be subcritical, including the use of a safety margin, which will account for computational bias, uncertainties, and an appropriate administrative safety margin. The design will provide for criticality control including adherence to the double-contingency principle.

A CAAS will be included in the MFFF design in accordance with the design criteria described earlier in this chapter. (Note that a CAAS does not prevent or mitigate design basis events, and is therefore not considered a principal SSC.)

The Nuclear Criticality Safety Program for the MFFF will be in accordance with Regulatory Guide 3.71. Regulatory Guide 3.71 has been developed to provide guidance on complying with the applicable portions of NRC regulations, including 10 CFR Part 70, by describing procedures for preventing nuclear criticality accidents in operations involving handling, processing, storing, and transporting SNM at fuels and material facilities. This regulatory guide endorses specific nuclear criticality safety standards drafted by Subcommittee ANS-8 (Fissionable Materials

Outside Reactors) of the American Nuclear Society Standards Committee for these purposes. The MFFF criticality design basis includes use of ANSI/ANS standards endorsed by Regulatory Guide 3.71 as follows:

ANSI/ANS-8.1-1983 (R1988), Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors

This standard is part of the design basis of MFFF processes and fissile material handling and storage areas. The standard provides general guidance addressing administrative and technical practices, as well as single-parameter and multi-parameter control limits for systems containing ^{233}U, ^{235}U, and ^{239}Pu. Of particular significance to the MFFF design, ANSI/ANS-8.1-1983(R1988) provides guidance for performing NCS analysis methodology validation. ANSI/ANS-8.1 NCS practices will be referenced in NCSEs to support MFFF design and operational approach. MFFF processes and storage areas that contain plutonium, uranium, or plutonium-uranium fuel mixtures will typically be explicitly evaluated using validated NCS analysis methodology in accordance with ANSI/ANS-8.1 technical practice guidance. However, criticality safety may be demonstrated by reference to ANSI/ANS-8.1 single-parameter and multi-parameter control limits in lieu of analysis.

MFFF operations will comply with the guidance (shall statements) and implement the recommendations (should statements) of ANSI/ANS-8.1-1983 (R1988). Clarifications are noted as follows:

- Section 4.2.2: MFFF process, material handling, or storage area designs will incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible. For the purposes of demonstrating compliance with this requirement, "unlikely" is defined as events or event sequences that are not expected to occur during the facility lifetime, but are considered credible. This commitment is considered applicable to process, material handling, or storage area designs where a criticality accident has been determined to be credible.
- Section 4.2.3: MFFF process design will rely on engineered features where practicable rather than administrative controls. Justifications for use of administrative controls will be provided.
- Section 4.3.2: In cases where an extension in the area(s) of applicability of a NCS analysis methodology is required, the method will be supplemented by other calculational methods to provide a better estimate of bias in the extended area(s). As an alternative, the extension in the area(s) of applicability may be addressed through an increased margin of subcriticality.

Note that Regulatory Guide 3.71 endorses the 1983 version of this standard. The MFFF will reference guidance provided in the most recent Subcommittee ANS-8 working group approved version ANSI/ANS-8.1-1983 (R1988).

ANSI/ANS-8.3-1997, Criticality Accident Alarm System

This standard is part of the design basis of MFFF process and fissile material handling and storage areas. The standard provides general guidance for the design, testing, and maintenance of criticality accident alarm systems at facilities where a criticality accident may lead to excessive exposure to radiation. The scope of guidance provided in ANSI/ANS-8.3-1997 is applicable to both MFFF design and operations.

MFFF operations will comply with the guidance (shall statements) and implement the recommendations (should statements) of ANSI/ANS-8.3-1997 (and the corresponding guidance in Reg. Guide 3.71). Clarifications are noted as follows:

- Section 4.1.3: Overall risk to personnel resulting from hazards that may result from false alarms and subsequent sudden interruption of operations, and relocation of personnel will be evaluated.

ANSI/ANS-8.7-1975, Guide for Nuclear Criticality Safety in the Storage of Fissile Materials

This standard is not part of the design basis of MFFF fissile material storage areas.

ANSI/ANS-8.9-1987, Nuclear Criticality Safety Criteria for Steel-Pipe Intersections Containing Aqueous Solutions of Fissile Materials

This standard has been officially withdrawn by the ANS-8 working group, but continues to be available for reference. This standard will not be referenced as a basis for design for the MFFF. Intersections of process components and piping containing aqueous solutions of fissile materials will be explicitly evaluated using validated NCS analysis methodology in accordance with ANSI/ANS-8.1-1983 (R1988).

ANSI/ANS-8.10-1983, Criteria for Nuclear Criticality Safety Controls in Operations with Shielding and Confinement

MFFF NCSEs performed for each process unit or area will demonstrate compliance with the double contingency principle consistent with guidance provided in Section 4.2.2 of ANSI/ANS-8.1-1983 (R1988). Therefore, the guidance and recommendations provided in ANSI/ANS-8.10-1983 are not part of the design basis of the MFFF.

ANSI/ANS-8.12-1987, Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors

This standard may be reaffirmed or withdrawn in future action by the ANS-8 working group (reference ANS-8 meeting minutes, Albuquerque, New Mexico, March 30, 2000). This standard is not part of the design basis of MFFF process design.

ANSI/ANS-8.15-1981, Nuclear Criticality Control of Special Actinide Elements

This standard is not part of the MFFF criticality design basis, as it is applicable to operations with isolated units containing special actinide nuclides other than ^{233}U, ^{235}U, and ^{239}Pu. Nuclear criticality control of special actinide nuclides will be explicitly evaluated using validated NCS analysis methodology in accordance with ANSI/ANS-8.1-1983 (R1988).

ANSI/ANS-8.17-1984, Criticality Safety Criteria for the Handling, Storage, and Transportation of Light Water Reactor (LWR) Fuel Outside Reactors

This standard is part of the design basis of MFFF fissile material handling and storage areas. The standard provides guidance addressing general safety criteria and criteria for establishing subcriticality for handling, storage, and transportation of LWR fuel rods outside reactor cores. Of particular significance to the MFFF design, ANSI/ANS-8.17-1984 provides general guidance for combining the various bias, uncertainty, and administrative safety margin terms that must be considered when performing criticality calculations in order to establish a final k_{eff} acceptance criteria. Examples of normal and credible abnormal conditions that must be considered when performing NCSEs are also provided in an appendix to the standard.

MFFF operations will comply with the guidance (shall statements) and implement the recommendations (should statements) of ANSI/ANS-8.17-1984. Clarifications are noted as follows:

- Section 4.11: Fuel units and rods will be handled, stored, and transported in a manner that provides a sufficient factor of safety to require at least two unlikely, independent, and concurrent changes in conditions before a criticality accident is possible. This commitment is considered applicable to process, material handling, or storage area designs where a criticality accident has been determined to be credible.

- Section 5.1: The criticality experiments used as benchmarks in computing k_c will have physical compositions, configurations, and nuclear characteristics (including reflectors) similar to those of the system being evaluated. In cases where similar experiments are not available or are not similar in criticality safety significant respects to the design application, alternative analyses will be presented. Alternative analyses will further demonstrate similarity or, in cases where an extension in the area(s) of applicability of a NCS analysis methodology is required, the method will be supplemented by other calculational methods to provide a better estimate of bias in the extended area(s). As an alternative, the extension in the area(s) of applicability may be addressed through an increased margin of subcriticality.

ANSI/ANS-8.19-1996, Administrative Practices for Nuclear Criticality Safety

This standard is part of the design basis of MFFF processes and fissile material handling and storage areas. This standard provides criteria for the administration of a nuclear criticality safety program for operations outside reactors in which there exists a potential for criticality accidents.

MFFF operations will comply with the guidance (shall statements) and implement the recommendations (should statements) of ANSI/ANS-8.19-1996. An exception is noted as follows:

- Section 10: Guidance for planned response to nuclear criticality accidents are addressed by ANSI/ANS-8.23-1997. Therefore, no commitments are made to satisfy the guidance or recommendations of this section.

ANSI/ANS-8.20-1991, Nuclear Criticality Safety Training

This standard is part of the design basis for MFFF operational practices. The standard provides detailed guidance for NCS training for personnel associated with operations outside reactors where a potential exists for criticality accidents.

MFFF operations will comply with the guidance (shall statements) and implement the recommendations (should statements) of ANSI/ANS-8.20-1991. No exceptions or clarifications are noted.

ANSI/ANS-8.21-1995, Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors

This standard is part of the design basis of MFFF processes and fissile material handling and storage areas. The standard provides detailed guidance for use of fixed neutron absorbers used for criticality control.

The MFFF will comply with the guidance of this standard (shall statements) and recommendations (should statements) to assure fixed neutron absorber material integrity and reliability to perform NCS functions. The guidance includes no recommendations that require further clarification and no exceptions are taken.

ANSI/ANS-8.22-1997, Nuclear Criticality Safety Based on Limiting and Controlling Moderators

This standard is part of the design basis of MFFF processes and fissile material handling and storage areas. The standard provides detailed guidance for limiting and controlling moderators to achieve criticality control (i.e., process units or areas where "Yes" is indicated in Tables 6.1 or 6.2 under the moderation control column).

MFFF operations will comply with the guidance (shall statements) and implement the recommendations (should statements) of ANSI/ANS-8.22-1997. Clarifications are noted as follows:

- Section 4.1.7: The design of MFFF fissile material storage areas will be reviewed and administrative controls limiting the introduction of combustible materials during operation applied to ensure an acceptable combustible loading is maintained. Fire protection provisions (i.e., fire suppression type) in areas where fissile material is processed, handled or stored will be justified.

In all cases, no single credible event or failure will result in the potential for a criticality accident. Process designs will incorporate sufficient features such that they can be demonstrated subcritical under both normal and credible accident conditions. For example, in cases where favorable-geometric devices are utilized and no credible means exist by which the device could deform, or by which non-specification fissionable materials can be introduced, the level of safety will be demonstrated to be acceptable.

NCSEs will be performed to ensure the adequacy of criticality controls. The NCSEs will be used to develop the basis of design and facility operations and demonstrate compliance with the double contingency principle. Criticality controls identified as necessary in the NCSEs are flowed into the ISA as IROFS. The ISA also documents a comprehensive systematic review of facility hazards, including criticality, that confirms the acceptability of the selected means of criticality control for process stations and areas within the AP and MP facility designs.

MFFF criticality analyses will follow the guidance provided by ANSI/ANS-8.1-1983 (R1988) in performing criticality analysis method validation.

Critical experiments will be selected to be representative of the systems to be evaluated in specific design applications. The range of experimental conditions, such as material compositions and geometric arrangements, encompassed by a selected set of benchmark experiments establishes the "area(s) of applicability" over which the calculated method bias is applicable. Technical justifications will be provided when extending the area(s) of applicability of a calculational method beyond the range of experimental conditions used in establishing the method bias as required by ANSI/ANS-8.1-1983 (R1988).

Specific guidance regarding the establishment of method bias, the proper accounting for analytical uncertainties, and the determination of subcritical limits in criticality safety analyses provided in ANSI/ANS-8.17-1984 will be followed. A design application (system) is considered subcritical when the calculated multiplication factor for the design application (system) is shown to be less than or equal to an established upper safety limit (USL) that properly accounts for method bias and uncertainty and administrative margin. An appropriate administrative safety margin plus computational bias will be used for MFFF design applications. Justification for use of this value is provided in the Mixed Oxide Fuel Fabrication Facility Criticality Code Validation report submitted separately. Justifications for the remaining design applications will be provided in other reports by the time of the license application.

The design basis for criticality safety can be summarized as follows:

1. Design of facility operations shall comply with the double contingency principle, as stated in ANSI/ANS-8.1-1983 (R1988).

2. Computer calculations shall not exceed a maximum keff, taking all uncertainties and biases into account. Description of calculation methods and their validation, or means of establishing subcritical margins if parameter limits are not based on computer calculations.

3. Facility operations shall be designed to be subcritical under both normal and credible abnormal conditions.

4. Dominant nuclear criticality safety controlled parameters shall be specified for each major process.

5. Design approach shall prefer engineered over administrative controls, and passive over active engineered controls.

6. The facility shall have a criticality accident alarm system that complies with the requirements of 10 CFR 70.24. Description of the detection system and its operating characteristics.

7. The management measures and how they are applied to each controlled parameter shall be described, along with the safety grades for criticality.

8. A description of the organization and administration for NCS, and the key elements of the NCS Program.

9. A description of the technical practices used to determine limits and controls on each controlled parameter, in criticality safety evaluations, including what ANSI/ANS standards are being committed to in whole or in part.

10. Where moderation control is required for subcriticality, a description of the approach to designing the facility to meet both fire safety and criticality safety requirements (including presence and type of fire suppression).

6.5 DESIGN BASES FOR NON-PRINCIPAL SSCs

As discussed in Chapter 14, an NRC-approved Emergency Plan is not required for the MFFF. Nonetheless, MFFF operations will comply with the guidance (shall statements) and recommendations (should statements) of ANSI/ANS-8.23-1997, *Nuclear Criticality Accident Emergency Planning and Response*, without exception. While not considered part of the design basis of principal SSCs, this standard provides guidance for minimizing risks to personnel during emergency response to a nuclear criticality accident outside reactors.

Criticality accident emergency planning and response, while an important programmatic element, is not part of the safety basis.

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Table 6-1. Preliminary Definition of Reference Fissile Medium and Control Methods for Principal AP Process Units (Continued)

Criticality Control Unit	Control Method													Comments
	Physicochemical Characteristics (PC)	Mass (M)	Geometry (G)	Density (D)	Isotopics (I)	Reflection (R)	Moderation (MN)	Concentration (C)	Interaction (IN)	Neutron absorber (A)	Volume (V)	Heterogeneity (H)	Process variable	
KDD Dissolution/Dechlorination														
Electrolyzer	NO PuO_2 + H_2O	NO	YES	YES [1,9] d ≤ 7	NO [1] $^{240}Pu \geq$ 4%	NO	NO	NO	TBD [2]	YES Cd coating	NO	NO	NO	Mass control credited when cooling coil leaks (IROFS failure)
Dechlorination Columns	NO PuO_2 + H_2O	NO	NO	YES [1,9] d ≤ 7	NO [1] $^{240}Pu \geq$ 4%	NO	NO	YES	TBD [2]	NO	NO	NO	NO	
Reception tank	NO PuO_2 + H_2O	NO	YES slab	YES [1,9] d ≤ 7	NO [1] $^{240}Pu \geq$ 4%	NO	NO	NO	TBD [2]	YES Cd coating	NO	NO	NO	
PuO_2 filter	NO PuO_2 + H_2O	NO	YES Cylin -der	YES [1,9] d ≤ 7	NO [1] $^{240}Pu \geq$ 4%	NO	NO	NO	TBD [2]	NO	NO	NO	NO	Double control to guarantee absence of PuO_2 in downstream equipment.
Dilution and sampling tank	YES $Pu(NO_3)_3$ + H_2O [3,8,11]	NO	YES Slab	NO	NO [1] $^{240}Pu \geq$ 4%	NO	NO	NO	TBD [2]	YES Cd coating	NO	NO	PC	

Table 6-1. Preliminary Definition of Reference Fissile Medium and Control Methods for Principal AP Process Units (Continued)

Criticality Control Unit	Control Method													Comments
	Physicochemical Characteristics (PC)	Mass (M)	Geometry (G)	Density (D)	Isotopics (I)	Reflection (R)	Moderation (MN)	Concentration (C)	Interaction (IN)	Neutron absorber (A)	Volume (V)	Heterogeneity (H)	Process variable	
UO2 Dissolution														
Buffer Tank	YES $Pu(NO_3)_3 + H_2O$ [3,6]	NO	NO	NO	NO [1] $^{240}Pu \geq 4\%$	NO	NO	YES [7]	TBD [2]	NO	NO	NO	NO	
KDB Dissolution Unit														
Electrolyzer	NO $PuO_2 + H_2O$	NO	YES	YES [1,9] $d \leq 7$	NO [1] $^{240}Pu \geq 4\%$	NO	NO	NO	TBD [2]	YES Cd coating	NO	NO	NO	
Reception tank	NO $PuO_2 + H_2O$	NO	YES slab	YES [1,9] $d \leq 7$	NO [1] $^{240}Pu \geq 4\%$	NO	NO	NO	TBD [2]	YES Cd coating	NO	NO	NO	
PuO_2 filter	NO $PuO_2 + H_2O$	NO	YES Cylin-der	YES [1,9] $d \leq 7$	NO [1] $^{240}Pu \geq 4\%$	NO	NO	NO	TBD [2]	NO	NO	NO	NO	Double control to guarantee absence of PuO_2 in downstream equipment
Dilution and sampling tank	YES $Pu(NO_3)_3 + H_2O$[3,8]	NO	YES Slab	NO	NO [1] $^{240}Pu \geq 4\%$	NO	NO	NO	TBD [2]	YES Cd coating	NO	NO	PC	
Buffer Tank	YES $Pu(NO_3)_3 + H_2O$ [3,6]	NO	YES Annul-ar	NO	NO [1] $^{240}Pu \geq 4\%$	NO	NO	NO	TBD [2]	YES Cole-manite concrete	NO	NO	NO	Colemanite concrete is a type of borated concrete.

Table 6-1. Preliminary Definition of Reference Fissile Medium and Control Methods for Principal AP Process Units (Continued)

Criticality Control Unit	Control Method													Comments
	Physicochemical Characteristics (PC)	Mass (M)	Geometry (G)	Density (D)	Isotopics (I)	Reflection (R)	Moderation (MN)	Concentration (C)	Interaction (IN)	Neutron absorber (A)	Volume (V)	Heterogeneity (H)	Process variable	
Purification Unit														
Feeding Tank	YES $Pu(NO_3)_3 + H_2O$ [3,6]	NO	YES Annul-ar	NO	NO [1] $^{240}Pu \geq 4\%$	NO	NO	NO	TBD [2]	YES Cole-manite concrete	NO	NO	NO	Colemanite concrete is a type of borated concrete.
Purification pulsed columns: +Extraction +Scrubbing +Diluent washing column 2100	YES $Pu(NO_3)_3 + H_2O$ [3,6]	NO	YES Cylin-der	NO	NO [1] $^{240}Pu \geq 4\%$	NO	NO	NO	TBD [2]	NO	NO	NO	NO	
Purification pulsed columns: +Pu stripping +U scrubbing +Diluent washing column 3100	YES $Pu(NO_3)_3 + H_2O$ [6]	NO	YES Cylin-der	NO	NO [1] $^{240}Pu \geq 4\%$	NO	NO	NO	TBD [2]	NO	NO	NO	NO	

Table 6-1. Preliminary Definition of Reference Fissile Medium and Control Methods for Principal AP Process Units (Continued)

Criticality Control Unit	Control Method													Comments
	Physicochemical Characteristics (PC))	Mass (M)	Geometry (G)	Density (D)	Isotopics (I)	Reflection (R)	Moderation (MN)	Concentration (C)	Interaction (IN)	Neutron absorber (A)	Volume (V)	Heterogeneity (H)	Process variable	
Purification Unit (Continued)														
Pu barrier mixer settlers	YES $Pu(NO)_3$ + H_2O [3,6]	NO	YES	NO	NO [1] $^{240}Pu \geq 4\%$	NO	NO	NO	TBD [2]	YES Cd coating	NO	NO	NO	
U stripping + diluent washing mixer settlers	YES $UO_2(NO_3)_2$ + H_2O [6,12]	NO	YES slab	NO	NO $^{235}U \leq 35\%$	NO	NO	NO	TBD [2]	Yes	NO	NO	NO	
Oxidation columns	YES $Pu(NO_3)_3$ + H_2O [3,6]	NO	YES Cylin-der	NO	NO [1] $^{240}Pu \geq 4\%$	NO	NO	NO	TBD [2]	NO	NO	NO	NO	
Pu Rework Tanks	YES $Pu(NO_3)_3$ + H_2O [3,6]	NO	YES Slab	NO	NO [1] $^{240}Pu \geq 4\%$	NO	NO	NO	TBD [2]	YES Cd coating	NO	NO	NO	
Rafinates Reception, and Recycling, Control Tanks	YES $Pu(NO_3)_3$ + H_2O [3,6]	NO	YES Annul-ar	NO	NO [1] $^{240}Pu \geq 4\%$	NO	NO	NO	TBD [2]	YES Cole-manite concrete	NO	NO	NO	Colemanite concrete is a type of borated concrete.
Slab settler	YES $Pu(NO_3)_3$ + H_2O [3,6]	NO	YES Slab	NO	NO [1] $^{240}Pu \geq 4\%$	NO	NO	NO	TBD [2]	YES Cd coating	NO	NO	NO	

Table 6-1. Preliminary Definition of Reference Fissile Medium and Control Methods for Principal AP Process Units (Continued)

Criticality Control Unit	Control Method													Comments
	Physicochemical Characteristics (PC)	Mass (M)	Geometry (G)	Density (D)	Isotopics (I)	Reflection (R)	Moderation (MN)	Concentration (C)	Interaction (IN)	Neutron absorber (A)	Volume (V)	Heterogeneity (H)	Process variable	
Offgas Treatment Unit														
Offgas Treatment	NO [TBD]	NO	NO	NO	NO	NO	NO	YES [7]	TBD [2]	NO	NO	NO	NO	
Liquid Waste Reception Unit														
Liquid Waste Reception	NO [TBD]	NO	NO	NO	NO	NO	NO	YES [7]	TBD [2]	NO	NO	NO	NO	
Sampling Unit														
Sampling Unit	NO [TBD]	NO	NO	NO	NO	NO	NO	YES [7]	TBD [2]	NO	NO	NO	NO	

NOTES:

[1] Parameter value ranges indicated are selected for use in criticality design calculations to encompass credible optimum conditions without reliance on process variable controls.
[2] To be determined (TBD). Analysis of interaction between components to be evaluated to confirm spacing requirements, or determine if additional criticality control design features or management measures are required to address interaction.
[3] Actual chemical form of Pu Nitrate is $Pu(NO_3)_4$ for most process steps, which is less reactive than $Pu(NO_3)_3$.
[4] Actual chemical form is a mixture of Pu Oxalate and Pu Nitrate. Either chemical form is less reactive than PuO_2F_2.
[5] Interaction limited by geometry (hopper spacing) and cadmium coating of hoppers.
[6] The absence of a more restrictive material is controlled in an upstream unit, which prevents any means of adverse chemical form change.
[7] Concentration controlled by upstream or connected units.
[8] The presence of up to 2% uranium (93.2 w/o ^{235}U) is considered in the evaluation.
[9] Maximum bounding density value is controlled by upstream measurement.
[10] Density value which has been shown to be conservative for identical operations in LaHague. Values will be confirmed during the facility startup test program.
[11] Dilution of ^{235}U to a maximum enrichment of 30% (35% evaluated) occurs in this unit. In all cases, the presence of ^{235}U is considered, in addition to the Pu considered.
[12] Dilution of ^{235}U to a maximum enrichment of 1% occurs in this unit.

Table 6-2. Preliminary Definition of Reference Fissile Medium and Control Methods for MP Process Units

Criticality Control Unit	Control Method													Comments
	Physicochemical Characteristics (PC)	Mass (M)	Geometry (G)	Density (D)	Isotopics (I)	Reflection (R)	Moderation (MN)	Concentration (C)	Interaction (IN)	Neutron absorber (A)	Volume (V)	Heterogeneity (H)	Process variable	
Receiving Area														
PuO_2 3013 storage pit	NO PuO_2 + H_2O	NO $M \leq 5$ kg per container	YES	NO [1] $d \leq 11.46$	NO [1] $^{240}Pu \geq 4\%$	NO [2]	NO [1] $H_2O \leq 1\%$ inside containers	NO	NO [2]	NO	NO	NO	NO	-Incoming plutonium container I D is verified to confirm mass, isotopics, and powder moisture assumptions listed.
PuO_2 Can Opening and Handing Unit	NO PuO_2 + H_2O	YES	NO	YES [1,10] $d \leq 7$	NO [1] $^{240}Pu \geq 4\%$	NO	YES	NO	NO	NO	NO	NO	NO	
PuO_2 buffer storage	NO PuO_2 + H_2O	NO $M \leq 2.5$ kg per container [13]	YES	YES [1,10] $d \leq 3\ 5$	NO [1] $^{240}Pu \geq 4\%$	NO [2]	NO	NO	NO [2]	YES Borated concrete	NO	NO	NO	
Primary dosing (including master blend homogeniz-ing)	NO PuO_2 $+UO_2$ $+H_2O$,	YES	NO	YES [1,6] PuO_2 and $UO_2 \leq 3\ 5$; Recy-clable Scrap ≤ 4.6	YES $^{240}Pu \geq 4\%$[1]	NO	YES [4]	NO	NO	NO	NO	YES	M,I, MN [4]	-Mass of PuO_2 per jar is controlled. -The relative quantity of PuO_2 and UO_2 is controlled; used in downstream units. -Homogeneity of master blend is required by downstream units.

Table 6-2. Preliminary Definition of Reference Fissile Medium and Control Methods for MP Process Units (Continued)

Criticality Control Unit	Control Method													Comments
	Physicochemical Characteristics (PC)	Mass (M)	Geometry (G)	Density (D)	Isotopics (I)	Reflection (R)	Moderation (MN)	Concentration (C)	Interaction (IN)	Neutron absorber (A)	Volume (V)	Heterogeneity (H)	Process variable	
Powder Area														
Primary blend ball milling Scrap milling	NO Master blend	YES	NO	YES [1,6] $d \leq 5.5$	YES $^{240}Pu \geq 4\%$[1]; $M_{Pu}/(M_U + M_{Pu}) \leq 22\%$ [5]	NO	YES	NO	NO	NO	NO	NO	M	-U metal balls are present in the ball-mill and are accounted for as reflector in the criticality calculations
	NO Dis-carded Scrap Pow-der	YES	NO	YES [1,6] $d \leq 5.5$	YES $^{240}Pu \geq 4\%$[1]; $M_{Pu}/(M_U + M_{Pu}) \leq 22\%$ [5]	NO	YES	NO	NO	NO	NO	YES	M,H	Homogeneity of discarded scrap powder is required by downstream unit.
Final dosing	NO Master blend	YES	NO	YES [1,6] $d \leq 5.5$	YES $^{240}Pu \geq 4\%$[1]; $M_{Pu}/(M_U + M_{Pu}) \leq 22\%$ [5] $M_{Pu}/(M_U + M_{Pu}) \leq 6.3\%$ in jar	NO	YES	NO	NO	NO	NO	NO	M,I	The relative quantity of master blend and UO_2 is controlled; used in downstream units.

Table 6-2. Preliminary Definition of Reference Fissile Medium and Control Methods for MP Process Units (Continued)

Criticality Control Unit	Control Method													Comments
	Physicochemical Characteristics (PC)	Mass (M)	Geometry (G)	Density (D)	Isotopics (I)	Reflection (R)	Moderation (MN)	Concentration (C)	Interaction (IN)	Neutron absorber (A)	Volume (V)	Heterogeneity (H)	Process variable	
Powder Area (Continued)														
Homogenizing and pelletizing	NO Master blend	YES	NO	YES [1,6] d ≤ 5.5	YES $^{240}Pu \geq$ 4%[1], %Pu ≤ 22% [5,7]	NO	YES	NO	NO	NO	NO	NO	M	-Homogeneity of final blend is required in downstream equipment and to allow introduction of additives in this unit -Physicochemical characteristics control applied to control pellet dimensions to extent used in downstream units
	NO Final blend	YES	NO	YES [1,6] d ≤ 3 5	YES $^{240}Pu \geq$ 4%[1]; %Pu ≤ 6.3% [5]	NO	YES [4]	NO	NO	NO	NO	YES	M,MN [4], H	
	NO Pellets	YES	NO	NO [1] d ≤ 11	YES $^{240}Pu \geq$ 4%[1]; %Pu ≤ 6.3% [5]	NO	YES	NO	NO	NO	NO	NO [8]	M	

- Fire safety features in C3 areas related to gloveboxes (e.g., minimization of combustible materials, use of inerting systems, capability to inject CO_2, and glovebox ventilation dampers)
- Drainage and holdup systems of firewater following a fire in C2 areas.

Details regarding these features will be available as the design of these features is finalized. Noncombustible storage racks within the MFFF are used for the storage of plutonium oxide, uranium oxide, or mixed oxide in powder, pellet, or rod form. Additionally, the areas where these storage racks are located are free of combustible material storage.

A nonflammable hydrogen/argon mixture is utilized in the MP Area within the sintering furnaces. Prior to being mixed with argon, the hydrogen is contained in high-pressure tube trailers that are situated in the Gas Storage Area. The hydrogen is mixed with the argon in the Gas Storage Area. This mixture is controlled and isolated as appropriate. The long axis of these tube trailers is parallel to the MP Area, as well as the other MFFF processing areas.

7.2.4 Basic Operation and Control Concepts

7.2.4.1 Fire Detection and Alarm System

In the event of a fire at the MFFF, the fire detection and alarm systems sense a fire condition by either smoke and/or heat detectors and notify the operators in the Polishing Control Room and the SRS fire department via the alarm system. The fire detection system provides for audible and visual alarms upon sensing smoke, heat, or the operation of a suppression system control valve. Fire alarms are provided throughout the affected building and at the Polishing Control Room. The detection system also activates the suppression system in the fire area if it is an automatic system and automatic fire dampers, as necessary. Additionally, the detection system activates the glovebox process fire doors. Those suppression systems automatically actuated by the fire detection system are operated by the activation of at least two detectors in the fire area, depending on the fire area.

7.2.4.2 Fire Barrier System

In the event of a fire, the fire barriers prevent the fire from spreading from one fire area to another. The operation of fire dampers is discussed along with the ventilation system in Section 11.4. Redundant principal SSC systems and components that are required to function during or after a fire are separated by fire barriers that are sufficient to ensure that a fire in one train of principal SSC equipment will not affect the operation of the redundant train, even if fire suppression systems fail to operate. The fire protection principal SSC separation criterion is used in the evaluation of each fire area in the FHA. Configurations where fire barriers do not separate redundant principal SSC will be identified and justified.

Automatic fire dampers, when their actuation will not compromise the operation of the confinement system, are provided in the supply ductwork. If automatic fire damper actuation could compromise the confinement system, operators control supply-side fire dampers.

Manually operated fire isolation dampers are provided in the process room exhaust ductwork where it passes through fire barriers.

7.2.4.3 Fire Suppression System

Figures 7-9 through 7-11 and 7-13 through 7-15 illustrate the fire suppression systems for the MFFF. A fire suppression system is shut down for maintenance by manually closing the appropriate system isolation valve(s).

7.2.4.3.1 Water-Based Systems

In the event of a fire in an area protected by a wet-pipe sprinkler system, the heat from the fire opens one or more sprinklers and water is automatically discharged onto the fire. Water flow through an open sprinkler initiates a flow alarm. After the fire is extinguished, manipulation of an isolation valve stops flow. After the opened sprinklers are replaced, opening the isolation valve restores the system to an operable status.

In the event of a fire in an area protected by a preaction sprinkler system, the heat and/or smoke from a fire first actuates the detection system, which opens the preaction valve to allow water to flow into the system. A fire alarm is provided when the detection system is actuated, and a water-flow alarm is provided when the preaction valve opens. When the heat from a fire increases, one or more sprinklers open and water is discharged onto the fire through the open sprinklers. After the fire is extinguished, closing the preaction valve isolation valve stops water flow. After the system is drained and the opened sprinklers are replaced, the preaction valve is reset, the piping downstream of the preaction valve is repressurized with air, and the preaction valve isolation valve is opened.

In the event of a fire in an area protected by a dry-pipe sprinkler system, the heat from the fire opens one or more sprinklers, the compressed air in the system escapes allowing water pressure to open the dry pipe valve, and water is discharged onto the fire through the open sprinklers. Water flow through the system initiates a flow alarm. After the fire is extinguished, the isolation valve is manually closed to stop the water discharge. The system is restored to an operable status by replacing the opened sprinklers, draining the piping, reclosing the dry-pipe valve, pressurizing the system with air, and opening the isolation valve.

In the event of a fire in an area protected by an automatic deluge sprinkler system or water spray sprinkler system, the smoke or heat from a fire actuates a fire detector which alerts the operators in the Polishing Control Room. For an automatic deluge sprinkler system, a fire controller will open the appropriate deluge valve upon detection of a fire. For a water spray sprinkler system, an operator will open the appropriate isolation valve upon detection of a fire. When the valve opens, water flows to and is discharged from all sprinklers on the piping system. After the fire is extinguished, closing the valve stops water flow.

7.2.4.3.2 Carbon Dioxide Systems

In the event of a fire in a glovebox, assuming that no operators are in the affected room, the smoke/heat from a fire is detected by the fire detection system, which alerts the operators in the Polishing Control Room. Operators trained to respond to glovebox fires then manually connect specially configured portable CO_2 bottles to the affected glovebox and actuate the bottles without impact to confinement. After the fire is extinguished, the portable CO_2 bottles that have been used are replaced with fully charged bottles. The use of manually connected portable CO_2 bottles is sufficient since there are minimal ignition sources and low fire loading within the gloveboxes. In addition, fire detectors in gloveboxes provide an early indication of potential fire conditions within a glovebox.

7.2.4.3.3 Clean Agent Systems

In the event of a fire in an area protected by a clean agent system, the smoke/heat from a fire is detected by the fire detection system, and an audible and visual predischarge signal alerts personnel in the room to evacuate and provides adequate time for evacuation. The system then actuates, discharging the contents of the clean agent bottles into the affected space. The supply ventilation to the room is automatically secured coincident with the injection of clean agent. After the fire is extinguished, the clean agent storage bottles are replaced. The reserve quantity of clean agent will be equal to the largest demand for each clean agent storage location. The clean agent reserve, which will be an unconnected reserve, will be maintained on the MFFF site.

7.2.4.3.4 Standpipe Systems

It is not expected that the standpipe systems will be utilized. However, if standpipe systems are utilized, fire department members and properly trained operators operate the standpipe systems closest to the fire. For the standpipe systems that are normally dry, operation of the system requires the opening of an isolation valve. After the fire is extinguished, the standpipe water supply is secured and the standpipe and fire hoses are drained and restored for future use.

7.2.4.3.5 Portable Fire Extinguishers

In the event of a fire in an MFFF building, the person discovering the fire notifies the operators in the Polishing Control Room of the location and extent of the fire. If the fire is small and still in the incipient phase, the person may then use a portable extinguisher located nearby to attempt to quickly extinguish the fire. After the fire is extinguished, the fire extinguisher is replaced or recharged.

7.2.4.4 Fire Protection Water Supply System

The fire protection water supply system is normally in a passive mode awaiting demands on the system. When activated, the fire protection water supply system supplies water to fire hydrants, sprinkler systems, and hose stations as required.

7.2.4.5 Smoke Control System

The smoke control system works in close association with the fire barriers to prevent smoke and combustion gases from traveling through a facility rapidly. Maintaining adjacent areas free of smoke and combustion gases is important to ensure that egress routes are maintained.

Within the MP and AP Areas, the ventilation systems provide for smoke control during a fire as follows:

- The safe havens, when in use (e.g., an evacuation due to a fire), have their own dedicated HVAC system that will keep the safe havens and the associated corridors from the safe havens to the stairwells (if any) at a positive pressure with respect to surrounding building areas.
- The stairwells are normally maintained at a slightly negative pressure in relation to the safe havens.

Therefore, in the event of a fire, the pressure cascade from the safe havens to the stairwells ensures that the smoke infiltration during a fire in the MP or AP Area is minimized.

7.2.5 Interfaces

The MFFF fire protection systems interface with the following SSCs:

- **SRS fire protection water distribution system** – The SRS fire protection water distribution system provides water to the MFFF underground firewater loop.
- **SRS fire detection and alarm system** – The MFFF fire protection system control, supervisory, and alarm devices are wired to the SRS fire detection and alarm system, which will notify the SRS fire department in the event of a fire alarm.
- **Security systems** – The MFFF fire protection system control, supervisory, and alarm devices are wired to the CAS and SAS. This provides indication to security, which will be involved with the assessment, evacuation and response to fires within the Material Access Area.
- **HVAC systems** – HVAC systems include fire dampers to assist in the control of possible fires. Airlocks providing access into process rooms are ventilated by supply and exhaust ducts that are independent of the supply and exhaust ducts for the process room itself and are typically separated from the process rooms by fire-rated barriers (as shown on Figures 7-1 through 7-8a). This design allows the ventilation of the airlock to be maintained even in the event of a pressure perturbation in the process room. Airlocks are used for personnel and equipment access from one confinement zone to another. The airlock consists of a minimum-leakage door and is ventilated by the highest adjacent confinement zone ventilation system (i.e., a C2/C3 airlock is ventilated by the HDE system). (Refer to Chapter 11.4 for additional HVAC system details.)
- **Nitrogen system** – The nitrogen system (included for process reasons) at the MFFF also assists the fire protection systems by providing an inert atmosphere in a majority of the MFFF process gloveboxes during normal operations. Use of nitrogen in lieu of air minimizes the potential for a possible fire initiating within these gloveboxes. Note, however, for conservatism in the safety assessment (refer to Section 5.5.2.2), the nitrogen system is not identified as a principal SSC relied on for fire prevention in the gloveboxes.
- **Gloveboxes** – The fire protection systems provide extinguishing systems to gloveboxes throughout the MFFF.
- **Facility structures** – The facility structures include structural boundaries that also serve as fire-rated barriers.

safety control subsystem senses an object within the collision zone of the fire door, the closing of the fire door is inhibited by the process safety control subsystem until the collision zone is clear. Otherwise, upon detection of a fire, the process safety control subsystem stops the process operations and ensures that the fire doors are closed.

- Fire isolation dampers located in the ventilation exhaust of process rooms in areas with dispersable radioactive material are manually closed. Ventilation supply fire dampers are automatic.

- MFFF buildings containing principal SSCs are designed as Type I construction in accordance with the applicable requirements of NFPA 220-1995.

- Process room ventilation exhaust will normally remain open during a fire, and the C3 dynamic confinement system (in the form of the High Depressurization Exhaust System) will ensure that any potential releases caused by a fire are filtered. Filters with fire screens are provided at each exhaust outlet from process rooms containing gloveboxes to protect the final HEPA filters. (Refer to Section 11.4 for additional details.)

- The final MDE, HDE, POE and VHD HEPA filters are qualified for the maximum temperature loading anticipated to result from credible fires within the MOX Fuel Fabrication Building. (Refer to Section 11.4 for additional details.)

- The final MDE, HDE, POE and VHD HEPA filters are qualified to maintain design flow for the maximum soot loading and maximum differential pressure anticipated to result from credible fires within the MOX Fuel Fabrication Building. (Refer to Section 11.4 for additional details.)

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8.4 CHEMICAL ACCIDENT CONSEQUENCES

8.4.1 Analysis

Consequence analysis follows the guidance found in NUREG/CR-6410. Conservatism is embedded in the source term and the ground-level release models.

The analysis to determine the effects at the CAB to the public is based on the following assumptions:

- A wind speed of 2.2 meters per second and F stability class, indicative of 95% "worst-case" meteorological conditions at SRS;

  Note: The 95% wind speed of 2.2 meters per second was calculated from the 95% χ/Q value from the ground-level release application of the ARCON96 code applied at a distance of 100 meters. The ARCON96 code was driven by five years of hourly SRS meteorological data. The calculation assumes an F-stability class to quantify σ_y and σ_z. The 100-meter distance is selected because it represents the site worker location. This technique yields a site-specific 5% meteorological condition (F stability class @ 2.2 m/second wind speed) that is more applicable than adopting the 40 CFR §68.22 meteorology, which is generalized for the entire United States.

- A wind direction that transports the puff kernel and/or plume centerline directly over the receptor of concern (conservative), thereby eliminating any crosswind dispersion;

- An ambient temperature of 25°C (77°F) and 50 percent humidity; representative of late-spring to early-autumn conditions;

- A ground level release (conservative);

- No mechanical or buoyancy plume rise (conservative);

- A rural (i.e., flat terrain) topography (conservative);

  Note: The forest canopy morphology at SRS is more accurately characterized as urban terrain relative to atmospheric turbulence intensity.

- Neutrally buoyant gas model (conservative).

  Note: Heavy gas models result in lower downwind concentrations, which are less conservative. This is due to density differences (e.g., Colenbrader model within ALOHA) that entrain clean air within the sides of the pancake-like dense gas plume.

These bounding assumptions envelop uncertainties inherent in realistic analyses.

Data in Tables 8-2a through 8-2d were used to perform chemical consequence analyses associated with the largest credible unmitigated spill or loss of containment accident involving each of these chemicals.. Airborne concentrations were calculated at distances correlating to the site worker (100 meters) and members of the public (CAB). These concentrations were then compared to the TEELs presented in Table 8-5. From this comparison, a consequence category was established (low, intermediate, high) using the guidance outlined in Table 8-6. These consequence categories correspond to those identified in 10 CFR §70.61.

It should be noted that for the chemicals identified in Tables 8-2a through 8-2d whose onsite inventory is not yet established or is based on preliminary data, the analysis is based on a conservative projection for that chemical. Nonhazardous chemicals and gases identified in Table 8-2d were not evaluated. Except for oxygen, exposure to these gases poses an asphyxiant hazard only. Gas concentrations at asphyxiation levels are not credible at the distances corresponding to the CAB. Gas concentrations at asphyxiation levels may be credible for very large leaks at the distance corresponding to the site worker. Oxygen has no established toxicity limit.

Results of the chemical consequences calculation indicate that for all chemicals to which the requirements of 10 CFR §70.61 apply, unmitigated consequence categories fall within the acceptable range for site workers and members of the public, with the exception of those releases described in Section 5.5.2.10.6.3. Thus, no principal SSCs are required for the protection of site workers and members of the public, except as identified in Section 5.5.2.10.6.3.

Nitric acid leaks or spills in the Aqueous Polishing area of the MFFF were also modeled at temperatures up to the boiling point of nitric acid. The evaporation rate of the nitric acid was calculated utilizing an indoor wind speed of approximately 0.01 meters/second. The consequences of these nitric acid leaks or spills over the full range of temperatures were calculated to be low for the site worker and members of the public.

Uranium dioxide powder releases from the Secured Warehouse, including evaluations of fire and seismic events, are calculated to be low consequence events for the site worker and members of the public. More detailed analyses based on final design and operations are in progress to confirm the results for the site worker. If features such as combustible load controls are required to meet the criteria for the site worker, the features will be identified as IROFS in the ISA.

For the facility worker, the chemical consequences are estimated to be low, except as identified in Section 5.5.2.10. Calculations will be performed for the ISA to confirm this estimate. Principal SSCs have been defined for radiological events, and these SSCs are expected to be applicable to process units where chemicals mix with radiological material, except as identified in Section 5.5.2.10. Furthermore, for chemical exposures that could affect the facility worker in performing a required safety function in the Emergency Control Room, the Emergency Control Room Air Conditioning System is identified as a principal SSC (see Section 5.5.2.10). In the unlikely event that the ISA performed as part of detailed design identifies events that are not bounded, additional SSCs will be identified to ensure that chemical risks are acceptable.

8.4.2 Latent Impacts

There are no residual, long-term impacts to facility workers, site workers or the public that could result from an acute chemical exposure to licensed material or hazardous chemicals produced from licensed material. There are only two "potential carcinogens" at MFFF (i.e., chemicals on the list of "potential carcinogens"). The two chemicals are hydrazine and uranium (soluble and insoluble). Plutonium and other radionuclides may have carcinogenic effects; however, plutonium and other radionuclides are addressed in section 5.5.

For evaluating site workers exposed to a chemical release, the calculated concentration of an airborne chemical at 100 meters is compared to a TEEL-2 value. For evaluating the public exposed to a chemical release, the calculated concentration of an airborne chemical at the controlled area boundary is compared to a TEEL-1 value.

The TEEL determination process considers latent health effects (i.e., cancer). The determination process (for TEEL-2 and TEEL-3 values) selects hierarchy-based values first, if available, followed by toxicity-based values. TEEL-2 values are based on Emergency Response Planning Guideline (ERPG-2) values when available, or on Permissible Exposure Limits (PEL), Threshold Limit Values (TLV), or Recommended Exposure Limit (REL) ceiling (C) values, or on 5 x TLV-Time Weighted Average (TWA) values, in order of availability, followed by toxicity-based values. TEEL-2 values, along with ERPG, PEL, TLV, or REL ceiling (C) values, take into account latent health effects (i.e., cancer) where appropriate. TEEL-3 values are based on Emergency Response Planning Guideline (ERPG-3) values when available or on Immediately Dangerous to Life and Health (IDLH) values, in order of availability, followed by toxicity-based values. Since the ERPG committee considers latent health effects, TEEL-3 values also take into account latent health effects (i.e., cancer) where appropriate. TEEL-1 values are less than or equal to TEEL-2 values and ensure that exposures do not result in latent health effects.

Therefore, by using the TEEL values as limits, the chemical consequence analysis has taken into account latent health effects (i.e., cancer) from the two potential carcinogens at MFFF.

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8.4.3 Uncertainty

Estimates of risks are often accompanied by uncertainty because of the complexity of the postulated scenarios and physical models used to describe them. At this stage of the design, conservative models were utilized for the chemical releases with the intent to bound any anticipated uncertainty. Uncertainties associated with more detailed consequence analyses performed for the ISA will be described in the license application for possession and use of SNM.

8.5 PROCESS SAFETY INFORMATION

8.5.1 Process Safety Controls

The MFFF includes three basic facilities:

- **Reagent Processing Building** – This building is the front end of the process, where reagents for the process are prepared and transported to the processing units.
- **AP Area** – This area is the location of the primary chemical processing (Aqueous Polishing).
- **MP Area** – This area contains the manufacturing unit for the production of fuel assemblies (MOX Process).

Each of these facilities has control requirements that are incorporated into the overall design of the control system for process safety control. The control system will be designed to be available and reliable.

Reagents are stored and chemical mixtures are prepared in the Reagent Processing Building and in the reagent storage area of the AP Area. The AP facility is broken down into process functional units, which are functionally made up of one or more subunits performing elementary unit operations. The breakdown into functional units allows each unit to be operated relatively independently of other functional units.

Process storage and operation conditions are controlled to prevent unintended exothermic and potential autocatalytic reactions in the Reagent Processing Building and AP Area. Autocatalytic and exothermic reactions of chemicals are prevented through control of the process parameters (e.g., reactant concentration, temperature, catalyst concentration in solution, and pressure) that affect the reactions.

Significant chemical-related risks and associated design bases information are discussed in the following sections.

8.5.1.1 Hazards Associated with Hydrogen Gas

This section discusses the hazards associated with hydrogen as used or produced in the various processes within the MFFF. The following text discusses the flammable and explosive nature of hydrogen and provides the basis for the limits to be applied in the design of the processes using or producing hydrogen to assure the risks associated with hydrogen hazards satisfy the performance requirements of 10 CFR §70.61. The subsections that follow this section discuss the specific hazards identified in Section 5.5 associated with hydrogen (i.e., hazards associated with hydrogen-argon mixture in sintering furnace, radiolysis, and electrolysis).

Flammability Phenomena

Hydrogen is flammable over a wide range of concentrations in air. The values typically quoted are for concentrations of hydrogen in air at standard atmospheric temperatures and pressures (i.e., 4% through 74% by volume of hydrogen). The leanest mixture that burns completely is 9%; however, hydrogen flames will propagate in the upward direction at concentrations as low as 4% because of the high diffusivity of hydrogen. The flammability limits of hydrogen have been found to be consistent for gas pressures below 1 atm up to 100 atm.

The flammability limits are affected by temperature and by various concentrations of inert diluents, see Figure 8.5.1.1-1 for gas mixtures containing argon. Increasing the temperature tends to lower the lower flammability limit (LFL) and raise the upper flammability limit (UFL) for hydrogen in air, until the spontaneous ignition temperature is reached. At that point any amount of hydrogen coming into contact with oxygen burns with a slow flame (less than 1 m/s at less than 8% H_2 in air). Increasing the temperature of a mixture of pure hydrogen in air will cause the LFL to decrease from 9 to 5.4%, and the UFL to increase from 74 to 88%. This effect is different when hydrogen is diluted with an inert gas such as argon.

As shown in Figure 8.5.1.1-1, flammable mixtures of hydrogen in air can be made nonflammable by the addition of enough inert gas, such as argon, provided sufficient controls are placed on the environment in which the mixed gas is used. Different diluents have different levels of inerting efficiency which must be accounted for in evaluating the potential risks for creating explosive mixtures.

Explosion Phenomena

Hydrogen gas mixtures can become explosive if a sufficient amount of fuel and oxidant is distributed throughout the mixture while the mixture is not exposed to an ignition source or it is below the spontaneous ignition temperature. Even if the mixture is exposed to an ignition source or raised to high enough temperature, the mixture will only ignite and explode under certain conditions. The explosiveness of the mixture depends on the gas concentration, temperature, pressure (i.e., the flammability limits), the container surface conditions and the container size. Gas concentrations below or above the LFL and UFL are nonexplosive. Because the flammability limits vary with temperature and gas composition, these variables are considered when choosing the applicable lower and upper explosive limits (the LEL and UEL).

Outside of the sintering furnace in the BMP and BAP, the MFFF intends to control combustible gas concentrations to levels below 50% of the LFL to ensure that the LEL is not exceeded and to important parameter that limits the quantity of hydrazoic acid in the system. The yield of hydrazoic acid from the reaction between hydrazine and nitrous acid is determined predominately by both the relative reaction rates of the nitrous acid reaction with hydrazine and hydrazoic acid, and the concentration of hydrazine present in the system, which is added to the Purification Cycle at 0.14 mol/L. A yield of 39.3% or less is necessary (0.055/0.14) to ensure limiting conditions are not present in the AP processes.

Thus, the design basis to control the risk related to hydrazoic acid explosions is as follows: ensure the hydrazoic acid yield is 39.3% or lower, ensure a maximum hydrazine concentration of 0.14 moles per liter is used, and ensure a maximum temperature of 60°C where these chemicals are used in the AP process. DCS will perform analysis in the ISA to establish a bounding hydrazoic acid yield and implement any necessary controls to ensure that the hydrazoic yield is below 39.3%, which ensures that the critical concentration of 0.055 mol/L of hydrazoic acid is not exceeded.

It should be noted that that the corresponding limitations on the hydrazoic acid yield assume adiabatic conditions. DCS is currently investigating more realistic heat transfer that may be utilized in the ISA to justify the use of a larger threshold partial pressure (i.e., greater than 19 Torr, which is the theoretically calculated partial pressure of hydrazoic acid).

In addition to the previously identified design basis, sampling controls are also implemented to ensure that the process of transforming the hydrazoic acid to sodium azide within the Solvent Recovery Unit is effective to ensure that hydrazoic acid does not accumulate in the process to a limiting concentration due to the continuous injection of hydrazine into the Purification Cycle. This sampling control also ensures that azides are not formed within the extraction and diluent washing pulse columns of the Purification Cycle (i.e., PULS2000 and PULS2200) due to the potential presence of metal impurities within these columns.

An additional case involves the evaporation of hydrazoic acid in solution at low temperatures (e.g., approximately 20°C) and subsequent condensation of the hydrazoic acid in the ventilation system. In this case, it is theoretically possible to reach a limiting for the hydrazoic acid concentration to reach the explosive threshold in the condensing aqueous solution of 0.055 mol/L (limiting value based on theoretical threshold partial pressure). At higher temperatures (i.e., greater than approximately 20°C), the gaseous phase contains sufficient water vapor to ensure that if any vapor is condensed, limiting concentrations of hydrazoic acid cannot be obtained. The partial pressure of hydrazoic acid will be dramatically reduced, however due to the dilution in the ventilation system; further unrealistically low temperatures would need to be present in the ventilation system in order for hydrazoic acid condensation to occur. Consequently, DCS will perform additional analyses during the ISA to determine if any additional controls are necessary to preclude the condensation of hydrazoic acid inside the ventilation system.

8.5.1.9 Metal Azides

The azide anion, N_3 forms adducts with metallic cations. Metal azides, formed in basic media from metallic cations and hydrazoic acid interaction, are slightly soluble to non-soluble (e.g., Ag or Zr) in aqueous media. Characteristics of the bond between the anion and the cation, which form the azide salt, can cause these compounds to become unstable under specific conditions. The most unstable azide salts are the heavy metallic salts that form covalent bonds with N_3^-.

Most azides in pure chemical form decompose when heated. Azide salts are thus not stable when placed in dry conditions at temperatures far above 135°C. With the exception of the calcining furnace, this is the limiting temperature within the AP Process.

With the exception of hydrazoic acid, the AP process precludes any significant production of azides. This is accomplished by the removal of a significant fraction of the impurities in the plutonium feedstock introduced into the front end of the Purification Cycle (i.e., into the extraction pulse column, PULS2000) and by the absence of hydrazoic acid from the columns and tanks that may contain these impurities. The absence of hydrazoic acid from the front end of the Purification Cycle is assured due to sampling controls whose function is to detect hydrazoic acid prior to reintroducing solutions into the front end of the Purification Cycle (e.g., TK1000 or PULS2000).

In the plutonium stripping pulsed column (PULS3000) and equipment downstream of this column, hydrazoic acid is present due to the introduction of hydrazine into the plutonium barrier mixer-settler (MIXS4000) which feeds PULS3000 and subsequent downstream equipment. In the event that metal azides are formed within this Purification Cycle equipment, the azides will reside in the aqueous phase which is introduced into the oxidation column (CLMN6000) within the Purification Cycle prior to transfer to a downstream unit. Within the oxidation column, the azides will be destroyed due to the presence of nitrous acid which reacts with the azide to produce a nitrogen gas.

Finally, prior to being introduced into the calcining furnace, the solution is sampled to further ensure that azides are not introduced into the furnace whose temperature may exceed 140°C. This sampling measurement which ensures that azides are not present is identified as a principal SSC. In addition, the Process Safety Control Subsystem is also identified as a principal SSC to ensure that equipment potentially containing azides are not exposed or raised to temperatures that could exceed 135°C.

As discussed previously, azides in a dry environment are also unstable with respect to shocks due to the weak intermolecular force holding the azide together. Consequently, to ensure that conditions do not exist to create this potential hazard, administrative controls have been identified as the principal SSC to ensure that tanks potentially containing azides are not left dry. Previously identified process controls and the sampling controls to limit the presence of hydrazoic acid in process vessels are also used to preclude this potential explosion event.

Additional details on specific azides that could potentially be formed within the AP Process are provided below.

Plutonium and Uranium Azides

The azide anion can form soluble weakly bonded azido complexes with uranium (U) and plutonium (Pu) at molar ratios of HN_3/Pu and HN_3/U less than one. Considering that the bounding hydrazoic acid (HN_3) concentration developed in the previous section is 0.055 mol/L, the Pu/U concentration in process vessels in which this condition could exist is very low. Furthermore, the production of hydrazoic acid which may be formed in the process via CAR Equation 8.5-7 is limited by the quantity of nitrous acid that is available to react with the hydrazine to form hydrazoic acid, which could potentially form uranium or plutonium azides. In addition, the hydrazoic acid that may be present in the system is distributed between the organic and aqueous phases further limiting the quantity of uranium and plutonium azide that may be produced. The quantity of nitrous acid present in the system is limited by the moderate temperatures, controlled with principal SSCs, as described in Section 8.5.1.8, and the low acidity, approximately 1 N HNO_3.

Silver Azide (AgN_3)

Contact of hydrazoic acid with silver nitrate in the process can form silver azide salts in accordance with the following:

$$HN_3 + AgNO_3 \rightarrow AgN_3 + HNO_3 \qquad (8.5\text{-}15)$$

The initial silver concentration upstream of the Purification Cycle is approximately 0.011 mol/L. TBP liquid/liquid extraction operates with a decontamination factor for silver of approximately 2×10^5. No silver has ever been detected downstream of the extraction step in operating installations at the Cogema UP3 facility, based on mass spectrometry detection threshold for silver of 9.3×10^{-9} mol/L. The silver nitrate concentration reaching the "Pu stripping" (PULS3000) and "Pu barrier" (MIXS4000) purification steps can therefore be assumed to be less than 5.5×10^{-8} mol/L ($0.011/2 \times 10^5$) under anticipated conditions.

The credited principal SSC required to meet the performance requirements of 10 CFR §70.61 is the Process Safety Control Subsystem, which ensures the temperatures in process vessels that may potentially contain hydrazoic acid are maintained below 140°C, which is below the thermal decomposition temperature of silver azide.

As described above, the presence of silver azide is limited to equipment within the Purification Cycle downstream of the plutonium stripping pulse column (PULS3000). This limitation on the location of the silver azide is attributed to a process that destroys azides and hydrazoic acid that may have formed in the Purification Cycle and Solvent Recovery unit. As previously stated, sampling controls which have been identified as a principal SSC confirm the effectiveness of the destruction of both azides and hydrazoic acid prior to transfers of solutions for processing by downstream units.

Sodium Azide (NaN_3)

Sodium azide results from the reaction between sodium cations and azide anions as follows:

$$2HN_3 + Na_2CO_3 \rightarrow 2NaN_3 + H_2CO_3 \qquad (8.5\text{-}16)$$

$$HN_3 + NaOH \rightarrow NaN_3 + H_2O \qquad (8.5\text{-}17)$$

In the Solvent Recovery unit, sodium (in the form of sodium carbonate and sodium hydroxide) is added to the solvent washing mixer-settler (MIXS1000). This sodium reacts with the hydrazoic acid formed in the Purification Cycle producing sodium azide. The maximum concentration of azide in the system is 0.058 M Thus, as in nitric acid media, the solubility of sodium azide is approximately 6.3 M at 25°C, the minimum concentration of sodium needed for sodium azide to precipitate would be 684 M ($[Na^+][N_3^-] = 6.3^2$), i.e., 342 M of Na_2CO_3. Such value cannot be reached as the solubility of Na_2CO_3 in water at 25°C is equal to 4 M, so that the concentration of sodium azide formed as a result of the neutralization reactions is limited within safety requirements. Consequently, no additional safety controls are required.

To limit the propagation of the sodium azide within the AP process, DCS will incorporate a process to destroy the sodium azide. This process relies on the addition of sodium nitrite followed by acidification.

As previously discussed, the sampling principal SSC will ensure the effectiveness of the process to destroy sodium azide. This destruction is necessary prior to the introduction of the waste stream containing the sodium azide into acidified solutions due to the possible liberation of hydrazoic acid from the solution which is possible if the normality of the solution is in excess of 0.426 M nitric acid.

8.5.1.10 Nitrogen Dioxide/Dinitrogen Tetroxide

Dinitrogen tetroxide is stored in cylinders in the Reagents Processing Building in liquefied form. Instrument air is injected into the cylinder to transfer the liquid into an electric boiler, also located in the Reagents Processing Building, where it is vaporized to gaseous nitrogen dioxide and other NOx gases prior to entry into the aqueous polishing area.

Under normal operations, the vaporized gases are reacted with the hydrazine, HAN, and hydrazoic acid that are present with plutonium nitrate in the oxidation column (CLMN6000) 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 is required).

However, if the process fails (e.g., the flow of plutonium nitrate with hydrazine, HAN, and hydrazoic acid is deterministically assumed to be 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. As described in section 5.5.2.10, the flow of nitrogen dioxide/dinitrogen tetroxide is limited to the oxidation column such that chemical consequences to the site worker are acceptable. The design basis value is the TEEL-2 limit for nitrogen dioxide/dinitrogen tetroxide listed in Table 8-5. This is the value that will not be exceeded during normal and off-normal conditions. To exceed this value, preliminary calculations indicate a flow rate in excess of approximately 44 kg/hr is necessary. The normal flow rate is approximately 1.3 kg/hr. Calculations will be performed as part of detailed design (and summarized in the ISA) to determine the appropriate means to assure the TEEL-2 limit is not exceeded.

8.5.2 Design Bases During Normal Operations

Chemical process and control system descriptions and their associated design bases are provided in Sections 11.3, 11.6, and 11.8.

8.5.3 Chemical Process Safety Design Features

Principal SSCs related to chemical process safety are discussed in Section 5.5 and the design basis associated with these features are provided in Section 8.5.1. Specific setpoint ranges will be identified as part of detailed design and provided as part of the ISA Summary submitted with the license application for possession and use of SNM.

8.5.4 Principal SSCs

Principal SSCs are discussed in Section 5.5.

8.5.5 Graded Approach to Safety

The application of graded controls on principal SSCs and IROFS according to their safety function and significance is described in Section 15.1.

8.5.6 Management Measures

Management measures are described in Chapter 15.

8.6 CHEMICAL PROCESS SAFETY INTERFACES

Chemical safety related to storage, handling, and processing of licensed material (and hazardous chemicals produced from license material) is provided through integration of chemical safety analyses with the ISA (see Chapter 5). Controls established for chemical safety are consistent with those established for radiological safety and criticality safety, as are the associated management measures. Accordingly, the chemical safety program is conducted under the same elements of programmatic infrastructure described in Chapters 4, 12, and 14, and interfaces with the management measures discussed in Chapter 15.

8.6.1 Organizational Structure

The Duke Cogema Stone & Webster (DCS) MFFF organization structure is described in Chapter 4, including designation of positions within the DCS organization responsible for principal SSCs. Principal SSCs are established for radiological, chemical, and criticality control in accordance with 10 CFR §70.61. Thus, the positions responsible for principal SSCs, as indicated in Chapter 4, also are responsible for chemical safety. Chapter 5 also indicates positions responsible for the conduct of the ISA. Since the ISA includes evaluation of chemical hazards, these positions also are responsible for the conduct of chemical safety analysis.

As indicated in Chapter 4, DCS will maintain continuity of control over principal SSCs during and following the transition from design and construction to operations. This control will also extend to chemical safety as an integrated component of the ISA process.

8.6.2 Human Factors

Human factors engineering for personnel activities relied on for safety is discussed in Chapter 12. The MFFF is a highly automated facility based in large part on existing facilities. Criteria for human factors engineering are applied to the design of principal SSCs with associated personnel activities for operation or maintenance. These operations will include those associated with chemical processes, both inherently (i.e., the AP and MP processes are intrinsically chemical processes) and explicitly (i.e., the scope of human factors engineering is associated with control of principal SSCs whose function is protection against radiological, chemical, and criticality hazards).

8.6.3 Emergency Management

An emergency plan is not expected to be required to be submitted for approval (see Chapter 14). However, the MFFF emergency management program will be integrated with the SRS and F-Area emergency preparedness programs, which include appropriate consideration of chemical-related accidents.

8.6.4 Quality Assurance

The quality assurance program provides confidence that principal SSCs provide adequate protection against potential radiological, chemical, and criticality hazards. SSCs and personnel actions relied on for chemical safety are controlled under the same program as those established for radiological and criticality hazards. The DCS MOX Project Quality Assurance Plan (MPQAP) is described in Section 15.1.

8.6.5 Configuration Management

The configuration management program will provide oversight and control of design bases and modifications (both temporary and permanent) to SSCs and management measures relied on for safety, including those associated with chemical safety. The MFFF configuration management program is described in Section 15.2.

8.6.6 Maintenance

The MFFF maintenance program is described in Section 15.3. Surveillance, preventative and corrective maintenance, and post-maintenance testing are applied to principal SSCs as appropriate to help ensure their reliability and availability. Chemical safety SSCs are included as part of this maintenance program.

8.6.7 Training and Qualification

Qualification of personnel and training to conduct IROFS activities are applicable to those functions that involve principal SSCs for protecting against radiological, chemical, and criticality hazards. Personnel responsible for performing activities involving chemical safety will be qualified and trained in accordance with the MFFF training program, as described in Section 15.4.

8.6.8 Plant Procedures

Activities associated with principal SSCs are conducted in accordance with appropriate procedures. In the operating MFFF, plant procedures govern operations, maintenance, emergency response, and administrative actions and ensure that principal SSCs are operated in a manner consistent with the ISA. Plant procedures associated with SSCs relied on for chemical safety will take into account chemical hazards, as well as radiological and criticality hazards, as appropriate for the activity. MFFF plant procedures are described in Section 15.5.

8.6.9 Audits and Assessments

Audits and assessments will be used to determine the effectiveness of management measures, including those associated with chemical safety. Audit and assessment attributes (including independence of auditors from personnel responsible for the chemical safety activities being audited, reports to management, and so forth) are consistent with those for other principal SSCs. The MFFF audits and assessments program is described in Section 15.6.

8.6.10 Incident Investigations

Incident investigation activities will identify corrective actions for and root causes of incidents that affect principal SSCs for chemical safety, as appropriate. As necessary, such investigations will identify actions to preclude recurrence of the incident. These incident investigations will be conducted in accordance with an incident investigation program used for all principal SSCs, described in Section 15.7.

8.6.11 Records Management

Chemical safety records are controlled in accordance with the configuration management system, the requirements of the MPQAP, and the records management program described in Section 15.8. Chemical safety records are processed and retained in the same manner as records associated with other principal SSCs and related programs.

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Assembly Area – In this area, rods are loaded into assemblies and the assemblies are inspected and stored. The functions of the Assembly Area are to receive fuel rods and the required fuel assembly components and to assemble, inspect, and store completed MOX fuel assemblies. The Assembly Area is composed of the following units:

- Assembly Mockup Loading Unit
- Assembly Mounting Unit
- Assembly Dry Cleaning Unit
- Assembly Dimensional Inspection Unit and Assembly Final Inspection Unit
- Assembly Handling and Storage Unit
- Assembly Packaging Unit.

Waste Area – In this area, solid radioactive waste generated during the MOX process is processed, stored and packaged for shipment. The Waste Area is composed of the following units:

- Filter Dismantling Unit
- Maintenance and Mechanical Dismantling Unit
- Waste Storage Unit
- Waste Nuclear Counting Unit

The MOX process is shown in Figure 11.2-1. Block diagrams of the MOX process are provided in Figures 11.2-2 and 11.2-3. Table 5.5-3 lists the radioactive inventory for each facility location.

11.2.2.1 UO_2 Receiving and Storage Unit

The function of the UO_2 Receiving and Storage Unit is to receive and store depleted UO_2 for use in the manufacture of MOX fuel assemblies. Storage facilities consist of the external Secured Warehouse Building and a UO_2 buffer storage room within the MOX Process Area of the MOX Fuel Fabrication Building. The Secured Warehouse Building is located adjacent to the MOX Fuel Fabrication Building. UO_2 is delivered to the Secured Warehouse Building in palletized drums. Within the drums, the uranium is contained in double vinyl bags, separately sealed, under a nitrogen atmosphere. The drums are placed within the Secured Warehouse Building for temporary storage. When required, drums are transferred to the MOX Process Area. The drums are staged in a buffer storage area in close proximity to the UO_2 drum emptying room.

The major equipment associated with this unit is the pallet truck and forklift.

The UO_2 Receiving and Storage Unit interfaces with the UO_2 Drum Emptying Unit and the MMIS system with its embedded Material Control and Accounting (MC&A) application.

11.2.2.2 UO_2 Drum Emptying Unit

The function of the UO_2 Drum Emptying Unit is to open UO_2 drums and vinyl bags and pour the contents into a UO_2 receiving hopper in full confinement conditions in a nitrogen atmosphere. The unit controls UO_2

powder feeding to the dosing units. All incoming and outgoing UO_2 drums from the drum storage room are identified and weighed.

In addition, powder samples can be taken. When a powder sample is taken, the vial is identified and weighed before being sent manually to the lab.

The major equipment associated with this unit is as follows (Figure 11.2-4):

- Drum buffer storage
- Data acquisition keyboard and display system with manual bar code reader for drum identification
- Drum Scale
- Pallet truck
- Drum-tilting device and associated storage
- Handling monorails
- Two pouring stations with associated glovebox, funnels, and UO_2 receiving hopper
- Feeding lines and control valves
- Collection station for the empty vinyl bags and desiccant
- Scale and its associated bar code reader for sample vials.

As necessary, a provision of full drums is transferred from the warehouse into the buffer storage area. A drum is manually transferred from the buffer storage area to the UO_2 drum emptying room where the drums are identified and weighed. The UO_2 powder is emptied into the UO_2 receiving hopper.

The UO_2 Drum Emptying Unit interfaces with both the Primary and Final Dosing Units.

11.2.2.3 PuO_2 Receiving Unit

The PuO_2 Receiving Unit is located in the MOX Fuel Fabrication Building. It receives and opens PuO_2 shipping packages. The PuO_2 3013 Storage Unit is located in the MOX Process Area and transfers 3013 containers from the shipping package to a 3013 storage pit. The unit also performs required nuclear assay, container weighing, identification, and tracking functions.

The major equipment associated with these units is as follows:

- Cargo restraint transporter (CRT)
- Shipping package (SAFKEG or 9975 type)
- Monorail cranes
- Cask and containment vessel opening stations
- Powered conveyors and turntables
- 3013 container
- Transfer cask
- Traveling crane
- Multiplier counter and gamma isotopic analysis system

containing two stages of HEPA filters), and an exhauster before being released through the stack. Details of the final filtration units are found in Section 11.4.9.

11.3.2.13.3 Process Chemistry

This section is not applicable to this unit.

11.3.2.13.4 Process Equipment

Figure 11.3-23 provides a simplified drawing of the Offgas Treatment Unit.

11.3.2.13.5 Chemical Process Inventories

The normal inventories of radionuclides and chemicals involved in this unit are provided in Tables 11.3-25 and 11.3-26, respectively.

11.3.2.13.6 Chemical Process Ranges

The Offgas Treatment Unit operates continuously. The NO_x scrubbing column is designed to treat approximately 20N m^3/h, including additional air. The designed capacity of the column pulsation air extraction is 150N m^3/h. The main ventilation line (offgas scrubbing and filters) is designed to process approximately 300N m^3/h, including additional air. The main flows of this unit are provided in Table 11.3-27.

11.3.2.13.7 Chemical Process Limits

Normal operating parameters are described in Section 11.3.2.13.6. Principal SSCs are described in Chapter 5. Specific operating limits and the associated IROFS will be provided in the ISA.

11.3.2.14 Liquid Waste Reception Unit (KWD)

The Liquid Waste Reception Unit receives liquid waste from the AP process for temporary storage and pre-treatment before sending it offsite to SRS or the WSB for final treatment and disposal.

11.3.2.14.1 Function

The Liquid Waste Reception unit is dedicated to the reception, storage, and pre-treatment of the low level, high alpha, stripped uranium and organic waste streams.

- The low level liquid waste stream is comprised of the following: (1) room HVAC condensate, rinsing water from laboratories, and washing water from sanitaries which are potentially non-contaminated and are collected as low –low level liquid waste; (2) the distillate stream from the acid recovery unit which is contaminated and slightly acidic; and (3) miscellaneous floor washes from C2/C3 rooms and overflows or drip tray material from some of the reagent tanks in the AP building.

- The high alpha waste is a combination of three waste streams: americium, alkaline waste and excess acid. The americium stream collects americium and gallium nitrates and all of the silver used in the dissolution unit, along with traces of plutonium. The alkaline waste stream from the solvent recovery unit contains dilute caustic soda, sodium carbonate, sodium azide, and traces of plutonium and uranium. The excess acid stream from the acid recovery unit contains high alpha activity excess acid.

- The stripped uranium (< 1% U-235) waste stream receives the contents of the uranium dilution tanks in the purification cycle.

- The excess solvent/organic liquid waste stream receives the organic waste constitutes from the solvent recovery unit.

11.3.2.14.2 Description

Low Level Liquid Waste

Chemical waste tank #1, TK2050, collects overflows/drip tray contents from the de-mineralized water, nitric acid, manganese nitrate, and decontamination solution systems in a common header. It also collects overflows/drip tray contents from the sodium hydroxide and sodium carbonate systems in a separate common header. The tank is equipped with 1.5 N nitric acid and 0.1N sodium hydroxide addition systems for pH adjustment, a cooling loop to provide a means to remove the heat of reaction from acid/alkali reaction, a mixer, MIX2050, to provide agitation to aid mixing in the tank, and a manual sampling point. After pH adjustment, the low level waste is pumped to tank TK1000/TK2000.

Floor wash waste tank TK2060 collects the floor washes from all the uncontaminated C2 and C3 rooms in the AP area. These streams are generated in the course of routine housekeeping activities in these rooms and are separate from the overflows/drip tray streams that are collected in tank TK2050. The tank is equipped with a manual sampling point. The low level waste is periodically pumped to tank TK1000/TK2000.

Chemical waste tank #2, TK2070, is dedicated to oxalic acid service. It collects oxalic acid overflows/drip tray contents. The tank is equipped with a manual sampling point. The low level waste is pumped to portable drums for off-site disposal. The vents from these three tanks are collected in a vent header and routed to a nitric acid system scrubbing column.

Low level waste buffer tanks TK1000 and TK2000 collect the low, low level waste from room HVAC condensate, rinsing water from laboratories, washing water from sanitaries, and the contents of tank TK2060. These tanks also collect the distillate from the acid recovery unit, seal water from the vacuum radiation monitoring system, and the chemical wastes from tank TK2050. Tanks TK1000 and TK2000 operate in parallel. Three way valves are used to direct the flow to one of the two tanks. These tanks serve as buffer tanks and transfer the material to reception tank TK3000 for pH adjustment and sampling. A set of redundant pumps are used for the transfer. Piping and valves around the tanks and pumps allow the tank contents to be re-circulated to the tanks for mixing or to spray nozzles to wash down the tanks from the inside. Mixing is provided using the recirculation stream with an eductor.

In the unlikely event of a release of firewater in the corridors, the firewater drains into a sump. A pump transfers the firewater to tank TK3000 via a seal pot. Tank TK3000 is used to adjust the pH of the material using 1.5N nitric acid and 0.1N sodium hydroxide. A cooling loop provides means to remove the heat of acid/alkali reaction. In-tank mixing is provided using a re-circulation loop with an eductor. After sampling, a pump transfers the tank contents to tank TK4000 which is the final holding point before materials are pumped off-site to Savannah River Site (SRS). If the sampled material in tank TK4000 does not meet the SRS waste acceptance criteria (WAC), the stream may be recycled to acid recovery unit tank TK1500 for further processing.

High Alpha Liquid Waste

Alkaline waste tank TK4010 receives via a steam jet alkaline waste from the solvent recovery unit. Sodium nitrite is then added to TK4010 prior to acidification in TK4015 to destroy the sodium azide. A sampling measurement is then performed to ensure that the azide has been destroyed prior to combining the alkaline waste with other waste streams in TK4030.Americium reception tank TK4020 receives via a steam jet the high americium stream from the acid recovery unit. The excess acid stream from the acid recovery unit is transferred directly to tank TK4030.

The alkaline waste, americium and excess acid streams, are mixed in the batch constitution tank TK4030. Bubbling air is provided to this tank to aid in mixing its contents. The composite stream is referred to as "high alpha liquid waste." The tank is equipped with automatic sampling capabilities and a means to add 1.5N nitric acid for pH adjustment. This stream is transferred via a steam jet to tank TK4040.

The high alpha storage tank TK4040 serves as a holding point and along with TK4050, provides ninety day storage for the high alpha waste. The tank is equipped with automatic sampling capabilities and can transfer its contents via a steam jet to TK4050.

High alpha buffer tank TK4050 is the final holding point before off-site transfer for treatment. A pump is used to transfer the high alpha waste to the off-site waste solidification building. The tank is provided with a line for low level distillate from the acid recovery unit to rinse the off-site waste transfer line at the end of each transfer.

The transfer line from the liquid waste reception unit to off-site is of double piped construction and equipped with a leak detection system to provide warning of an event that requires corrective action.

All tanks in the high alpha system are vented to the offgas treatment unit's scrubbing column.

Stripped Uranium Liquid Waste

Stripped uranium reception tank TK3010 operates in parallel with tank TK3020 and receives material from the purification unit's isotopic dilution tank. The contents of tanks TK3010 and TK3020 are transferred via steam jet to tank TK3030. Stripped uranium buffer tank TK3030 is equipped automatic sampling capabilities, a means to add 1.5N nitric acid, and bubbling air to aid in mixing the tanks contents. The contents of TK3030 are transferred via steam jet to tank TK3040.

Stripped uranium transfer tank TK3040 is the final holding point before the stripped uranium is pumped off-site for treatment in the waste solidification building. The tank is provided with an input line for addition of low level distillate from the acid recovery unit. The distillate is used to rinse the off-site waste transfer line at the end of each transfer. The transfer line from this tank to the waste solidification building is of double pipe construction and equipped with a leak detection system.

Solvent/Organic Liquid Waste

Waste solvent is pumped from the solvent recovery tank KPB TK2000 to an intermediate holding tank where it is sampled to assure compliance with SRS WAC. The intermediate tank is fitted with mixing and sampling capabilities. Once the batch is confirmed to be in compliance with the SRS WAC, the solvent batch is transferred to a carboy located in a dedicated enclosure near the reagents building. The carboy is lifted and loaded onto a flatbed truck using an overhead monorail-mounted crane and driven to SRS for processing using existing procedures.

The annual amount of solvent transferred offsite ranges between 2800 to 4000 gallons. The maximum number of carboys transferred per year is 15.

11.3.2.14.3 Process Chemistry

This section is not applicable to this unit.

11.3.2.14.4 Process Equipment

Figures 11.3-23 through 11.3-26 provide simplified drawings of the Liquid Waste Reception Unit.

11.3.2.14.5 Chemical Process Inventories

The normal inventories of radionuclides and chemicals involved in this unit are provided in Tables 11.3-28 and 11.3-29, respectively.

11.3.2.14.6 Chemical Process Ranges

The Liquid Waste Reception unit operates continuously. The main flows for this unit are provided in Table 11.3-30.

11.3.2.14.7 Chemical Process Limits`

Normal process parameters are described in 11.3.2.14.6. Principal SSCs are described in Chapter 5. Specific operating limits and associated IROFs will be provided in the ISA.

maintaining a continuous negative differential pressure between the process cell and the C2 confinement zones.

The system exhausts air from the process cells in the AP Area, rooms that are not normally accessible and contain welded process equipment (all welded fittings). Air is supplied near the ceiling and removed near the floor (above the level of potential liquid spills).

Exhaust flow is maintained by one of two 100%-capacity exhaust fans located downstream of two 100%-capacity final filtration units. The exhaust fans discharge to the MOX Fuel Fabrication Building exhaust stack.

The ductwork incorporates manual and automatic dampers and controls to distribute and regulate the movement of air through each cell. Fire-rated protective features are provided when ductwork passes through a fire barrier into another fire area.

Components of the Process Cell Exhaust System can be tested periodically for operability and required functional performance. Airflow can periodically be measured in the exhaust ducts. The operating sequence that would bring the spare components into service and transfer to alternate power sources can be tested periodically.

11.4.2.4.3 Major Components

The Process Cell Exhaust System contains the following major components:

- Two 100%-capacity, variable-speed, centrifugal fans with direct-drive motors.
- Two 100%-capacity final filtration units. The filter trains are described in more detail in Section 11.4.9.1.

The ductwork in the Process Cell Exhaust System upstream of the final HEPA filter units is welded stainless steel. The ductwork downstream of the final HEPA filter housings is welded galvanized steel.

11.4.2.4.4 Control Concepts

The variable-speed exhaust fans maintain constant pressure at the inlet to the final filters with respect to the atmosphere. The system is designed so that one fan is capable of meeting normal and abnormal flow requirements. The other fan is in standby. The standby fan automatically starts upon loss of negative pressure at the final filter housing.

The control circuits for the Process Cell Exhaust System are normally interlocked with the control circuits of the VHD Exhaust System to allow a permissive start. Failure of the Process Cell Exhaust System stops the Supply Air System to prevent reverse flow conditions. Failure of the Process Cell Exhaust System does not result in a condition adversely effecting safety.

Flow instrumentation is provided downstream of each exhaust fan to monitor the system flow rates. Temperature detectors are provided in the ductwork upstream of each final filtration unit to provide an alarm in the event of high temperature in the ductwork. Pressure controls are provided to vary the operating fan speed to maintain a constant pressure differential in the process cells, nominally -0.72 to -0.88 in WG (-180 to -220 Pa), with respect to the atmosphere.

11.4.2.4.5 System Interfaces

The process cell exhaust fans are powered from the normal and standby power supplies. The system interfaces with the VHD Exhaust System.

11.4.2.5 Medium Depressurization Exhaust System

11.4.2.5.1 Function

The functions of the MD Exhaust System are as follows:

- Maintain a negative pressure differential between the C3 (process room) and C2 confinement zone
- Filter contaminants from the exhaust air prior to discharge through the exhaust stack
- Maintain an environment suitable for operating personnel
- Provide a common exhaust stack for discharge of process vents and ventilation exhaust.

11.4.2.5.2 Description

The MD Exhaust System is depicted schematically on Figure 11.4-11. The MD Exhaust System provides confinement of radioactive materials within the MOX Fuel Fabrication Building by maintaining a continuous negative differential pressure between the C2 and C1 (environment) confinement zones.

The system exhausts air from rooms in the MOX Fuel Fabrication Building designated as C2 confinement areas, except those rooms requiring cooling during emergency operation. The rooms in the C2 confinement zone consist largely of process unit control rooms, electrical rooms, and manufacturing process rooms for operations associated with the following: 3013 container receiving, unpacking, and nondestructive assay activities; rod storage and inspection; assembly mounting, inspection, and storage; and fuel cask loading.

Exhaust flow is maintained by one of two 100%-capacity exhaust fans located downstream of the final filtration units. Sufficient spare filtration units are provided to permit removal of one unit for service and testing while maintaining 100% flow capacity. The exhaust fans discharge to the MOX Fuel Fabrication Building exhaust stack.

The ductwork incorporates manual and automatic dampers and controls to distribute and regulate the movement of air through each room. Fire-rated protective features are provided when ductwork passes through a fire barrier into another fire area.

Components of the MD Exhaust System can be tested periodically for operability and required functional performance. Airflow can periodically be measured in the exhaust ducts. The operating sequence that would bring the spare components into service and transfer to alternate power sources can be tested periodically.

Exhaust flows from the process vent systems and the VHD Exhaust System, HD Exhaust System, and Process Cell Exhaust System are combined and discharge through a common exhaust stack. The stack effluent is monitored. Chapter 10 describes the stack monitoring systems.

11.4.2.5.3 Major Components

The MD Exhaust System contains the following major components:

- Two 100%-capacity, variable-speed, centrifugal fans with direct-drive motors.
- Multiple final filtration units. The filter trains are described in more detail in Section 11.4.9.1.

The ductwork upstream of the final HEPA filter units is welded stainless steel with flanged joints where the ductwork connects to equipment and in-line components. The ductwork downstream of the final HEPA filter units is welded galvanized steel.

11.4.2.5.4 Control Concepts

The variable-speed exhaust fans maintain constant pressure at the inlet to the final filters with respect to the atmosphere. The system is designed so that one fan is capable of meeting normal and abnormal flow requirements. The other fan is in standby. The standby fan automatically starts upon loss of negative pressure at the final filter housing.

The control circuits for the MD Exhaust System are normally interlocked with the control circuits of the HD Exhaust System and Supply Air System to prevent operation of the ventilation systems unless the HD Exhaust System is operating. This design ensures that the pressure differentials in the process rooms and rooms comprising the C3, C2, and C1 confinement zones maintain a pressure gradient from the highest to lowest pressure such that the C3 confinement zone is more negative than the C2 confinement zone and the C2 confinement zone is more negative than the C1 confinement zone.

Flow instrumentation is provided downstream of each exhaust fan to monitor the system flow rates. Temperature detectors are provided in the ductwork upstream of each final filtration unit to provide an alarm in the event of high temperature in the ductwork. Pressure controls are provided to vary the operating fan speed to maintain a constant pressure differential in the process rooms, nominally -0.2 to -0.4 in WG (-50 to -100 Pa), with respect to the atmosphere.

11.4.2.5.5 System Interfaces

The MD exhaust fans are powered from the normal and standby power supplies. The system interfaces with the HD Exhaust System and the Supply Air System.

11.4.2.6 Supply Air System

11.4.2.6.1 Function

The functions of the Supply Air System are as follows:

- Maintain a pressure differential between the C4 (gloveboxes), C3 (process rooms), process cells, and C2 (rooms) confinement zones
- Provide a source of unconditioned air for emergency cooling of the 3013 storage vault and emergency electrical rooms
- Maintain an environment suitable for operating personnel
- Maintain an environment suitable for the process, manufacturing, electrical, and laboratory equipment.

11.4.2.6.2 Description

The Supply Air System is depicted schematically on Figure 11.4-11. The Supply Air System supplies conditioned outside air to rooms and spaces designated as C2, process cell, and C3 confinement zones in the MOX Fuel Fabrication Building. The supply air fans draw air from the outside, through two sets of filters, heaters, and cooling coils, to condition the air for distribution in the MOX Fuel Fabrication Building. The supply air filter housing also contains freeze protection to permit continued operation of the emergency air supply in cold weather. Supply airflow is maintained by one of two 100%-capacity fans.

Rooms in C2 areas with high heat loads, principally electronics rooms, are provided with unit coolers to supplement cooling capability of the supply air. Additionally, duct-mounted cooling coils are provided where necessary to further cool the supply to meet ambient temperature criteria.

The ductwork incorporates manual and automatic dampers and controls to distribute and regulate the movement of air to each room. Fire-rated protective features are provided when ductwork passes through a fire barrier into another fire area.

Components of the Supply Air System can be tested periodically for operability and required functional performance. Airflow can be measured in the supply ducts. The operating sequence that would bring the spare components into service and transfer to alternate power sources can be tested periodically.

11.4.2.6.3 Major Components

The Supply Air System contains the following major components:

- Two 100%-capacity, variable-speed, centrifugal fans with direct-drive motors
- One set of multi-stage electric heating coils
- One set of multi-bank cooling coils and multiple supplemental cooling coils
- One prefilter bank (atmospheric dust filters)

After power to the furnace is tripped, no safety systems are required to maintain primary confinement.

11.4.7.8 Vessels

Vessels provided in the AP systems that provide a primary confinement function are welded construction and are vented by the Offgas Treatment System. Vessels that may require access are located in gloveboxes, which provide primary confinement.

11.4.8 Fire Protection and Confinement

In the event of a fire, nuclear materials must be confined. Fire and nuclear material confinement barriers generally include a group of rooms, constituting a volume capable of containing the radioactive products that may be released by a fire within the area. Figure 11.4-14 provides an overview of the fire and nuclear material confinement barriers for process rooms.

The fire areas are surrounded by fire-rated barriers. Access to rooms is via a confinement airlock with a separate HVAC exhaust duct. Fire dampers capable of operating at high temperatures are placed on the room HVAC inlet and exhaust. Exhaust system components are designed with the proper temperature rating so that they can perform their required function under the conditions that may exist in the event of a fire. Air stream dilution is used to protect the final filter stage before the stack. The dilution factor depends on the temperature of the fire, the flow rate, and the flow of dilution air. Fire detection and suppression are described in Chapter 7.

For areas with no dispersible nuclear material, fire dampers are provided on the inlet and exhaust that are closed automatically upon sensing high temperature or upon activation of the gas suppression system.

For areas with dispersible nuclear material and without gloveboxes (e.g., waste storage and polishing cells), the main objective is to maintain differential pressure between the room and the surrounding areas. In case of fire, the fire damper on the HVAC inlet is automatically closed in order to limit air supply to the fire. The exhaust fire isolation damper is manually closed if set thresholds (e.g., temperature of exhaust, temperature at the last filtration level before the stack, pressure drop at the last filtration level and low flow rate at the stack) are exceeded.

For areas with gloveboxes, a change in the HVAC configuration could impair the pressure gradient between gloveboxes and the room. No modification in the HVAC configuration is expected in the case of an incipient fire that can be suppressed immediately. For the case of a larger fire, the main confinement principle is to maintain differential pressure between the room and the surrounding areas. The fire damper on the room HVAC inlet is automatically closed. The fire isolation valve on the glovebox HVAC inlet and exhaust are manually closed. The exhaust fire isolation damper (room) and/or fire isolation valve (glovebox) is manually closed if set thresholds (e.g., temperature on exhaust, temperature at the last filtration level before the stack, pressure drop at the last filtration level, low flow rate at the stack) are exceeded.

11.4.9 Final Filtration Units

The final filtration units provide the last stages of HEPA filtration prior to the air being discharged to the stack. These units are installed in the VHD Exhaust System, HD Exhaust System, Process Cell Exhaust System, MD Exhaust System, and Offgas Treatment System. The final filters are capable of operating during a fire in rooms that are exhausted through the filters and to safely handle products of combustion.

Each of the final filtration units consists of a filter assembly housing, a two stage spark arrester, a pre-filter, and two stages of HEPA filters. The final filter housings are stainless steel, bag-in/bag-out type and are equipped with necessary test ports to permit in-place testing of HEPA filter stages with dioctyl phthalate (DOP) to monitor system efficiency. Dampers are provided so that filter housings can be completely isolated from the HVAC system during filter replacement.

The first stage spark arrester is made of a stainless steel wire mesh. The second stage spark arrester is made of a stainless steel mesh with interwoven fiberglass designed to remove particles greater than 1 micron. The complete spark arrester assemblies are designed and fabricated to the same temperature ratings as the exhaust pipe/duct in which they are installed. Frames are metallic construction. The spark arresters are fabricated of noncombustible materials and are designed to pass design flow rates under fully loaded conditions without structural failure.

Pre-filters are fiberglass media filters with metallic frames and nominal efficiencies between 60% and 85%. Continuous filter temperature rating is nominally 400°F (204.5°C).

HEPA filters are fabricated of glass media with metallic frames and silicone gaskets. The filters are at least 99.97% efficient and can operate in continuous service at 450°F (232°C). The filters can withstand a differential pressure of 10 in WG (2488 Pa) without failure.

The final filtration units, exhaust plenums, exhaust fans, and associated control devices are located as far as practicable from a postulated fire, where they are not exposed to the fire's direct effects. Redundant trains are located in separate fire areas. The integrity of the final filtration units is not degraded by fire and smoke.

Analyses based on final design are in progress to demonstrate that the HEPA filters are protected from fire and other operating conditions and to demonstrate that the ventilation systems LPF is 10^{-4} or better. See Section 5.4.4.4 for information on operating conditions that will damage HEPA filters.

11.4.10 Design Basis for Non-Principal SSCs

The design of the ventilation and air-conditioning systems is in accordance with the applicable standards and guidelines published by the following organizations:

- Air Moving and Conditioning Association
  - AMCA-1999, *Standards Handbook*
- American Conference of Governmental Industrial Hygienists

- Supply Air System components:
  - Emergency air duct
  - Inlet filters
  - Pressure boundary upstream of the inlet filters
  - Tornado dampers
- Offgas Treatment Unit (Scrubbing function is not credited in the accident analysis)
  - Pressure boundary
  - Final filters
  - Exhaust Fans

11.4.11.1.1 Design Basis Standards

The design of the HVAC systems and confinement for the MFFF is consistent with the criteria and design guidance provided in Regulatory Guide 3.12, *General Design Guide for the Ventilation System of Plutonium Processing and Fuel Preparation Plants*. One noted exception to this Regulatory Guide is that there are no adsorbers in the filter lines, therefore the heaters and water mist spray for fire protection of final HEPA filters are not required.

The design of the principal ventilation SSCs is developed in accordance with the following codes and standards (as applicable to each SSC):

- Energy Research and Development Administration
  - ERDA 76-21 *Nuclear Air Cleaning Handbook*, 2nd edition
- American Society of Mechanical Engineers
  - AG-1-1997, *Code on Nuclear Air and Gas Treatment*
  - B31.3- 1996, *Process Piping, including 1998 Addenda*
  - N509-1989 (R1996), *Nuclear Power Plant Air-Cleaning Units and Components*
  - N510-1989 (R1995), *Testing of Nuclear Air-Treatment Systems*
- National Fire Protection Association
  - NFPA 801-1998, *Fire Protection for Facilities Handling Radioactive Materials.*

11.4.11.1.2 C2 Confinement System Passive Barrier

Additional design basis associated with this PSSC is as follows:

- Two stages of HEPA filters prior to discharge to the atmosphere;
- Spark arrestors and prefilters in each final filtration assembly;
- Each HEPA stage shall be field tested to have an efficiency of 99.95 percent (1E-4 analytical assumption);
- Fire-rated dampers between designated fire areas;
- In-place HEPA filter testing capability in accordance with ASME N510 for the final filtration assemblies;

- Final filters and downstream ductwork remain structurally intact during and after design basis earthquakes and withstand the effects of tornadoes.

11.4.11.1.3 C3 Confinement System

Additional design basis associated with this PSSC is as follows:

- C3 zone pressure is maintained at a negative pressure relative to atmosphere during normal and transient operation;
- Designed to maintain system exhaust safety function assuming single active component failure;
- Redundant 100 percent capacity final filter assemblies with two stages of HEPA filters prior to discharge to the atmosphere;
- Spark arrestors and prefilters in each final filter assembly upstream of the HEPA filters;
- Two 100 percent capacity fans in C3 exhaust system;
- Manual or automatic fire-rated dampers between designated fire areas;
- In-place HEPA filter testing capability in accordance with ASME N510 for the final filtration assemblies;
- Each HEPA stage shall be field tested to have an efficiency of 99.95 percent (1E-4 analytical assumption);
- Provide emergency cooling capability for selected areas;
- Fans are powered from normal (non-PSSC), standby (non-PSSC), and emergency power supplies (PSSC);
- Remains operational after facility fires and design basis earthquakes and withstand the effects of tornadoes

11.4.11.1.4 C4 Confinement System

Additional design basis associated with this PSSC is as follows:

- C4 zone pressure maintained at negative pressure with respect to C3 process room during normal operation and transients;
- Designed to maintain system exhaust safety function assuming single active component failure;
- Redundant 100 percent capacity final filter assemblies with two stages of HEPA filters prior to discharge to the atmosphere;
- Spark arrestors and prefilters in each final filter assembly upstream of the HEPA filters;
- Four 100 percent capacity fans in C4 exhaust system;
- Manual actuated fire isolation valves between designated fire areas;
- VHD Exhaust system is designed to maintain a 125-ft/min (38.1-m/min) face velocity across a design basis glovebox breach. The design basis breach is equal to the larger area of either two 8-in (20.3-cm) glove ports or the maximum credible glovebox breach;
- In –place HEPA filter testing capability in accordance with ASME N510 for the final filtration assemblies;
- Each HEPA stage shall be field tested to have an efficiency of 99.95 percent (1E-4 analytical assumption);

- Fans are UPS powered from normal (non-PSSC), standby (non-PSSC), and emergency power supplies (PSSC)

11.4.11.1.5 Emergency Generator Ventilation System

Additional design basis associated with this PSSC is as follows:

- One 100 percent capacity air conditioning unit for each switchgear room;
- One 100 percent capacity roof ventilator for engine room cooling during standby (engine fan cools room during operation);
- Fans are powered from normal (non-PSSC), standby (non-PSSC), and emergency (PSSC) supplies;
- Remains operational after facility fires and design basis earthquakes and withstand the effects of tornadoes

11.4.11.1.6 Emergency Control Room Air Conditioning System

- Maintain habitable environment in emergency control room
- Dual emergency control room air intakes with continuous monitoring for hazardous chemicals
- Maintain a positive pressure with respect to surrounding areas
- One 100 percent capacity (per control room) filtration assembly (using pre-filter, two HEPA filter stages, and chemical filters) for control room air supply
- In-place HEPA filter testing capability for HEPA filter assemblies in accordance with ANSI-N510;
- One 100 percent capacity (per control room) air handling unit;
- One 100 percent capacity exhaust fan and one 100 percent capacity booster fan;
- Each HEPA stage shall be field tested to have an efficiency of 99.95 percent
- Fans are powered from normal (non-PSSC), standby (non-PSSC), and emergency (PSSC) supplies;
- Remains operational during and after facility fires and after design basis earthquakes and withstand the effects of tornadoes

11.4.11.1.7 High Depressurization Exhaust System

See C3 Confinement System above for additional design basis associated with this PSSC.

11.4.11.1.8 Process Cell Ventilation System Passive Barrier

Additional design basis associated with this PSSC is as follows:

- Two stages of HEPA filters prior to discharge to the atmosphere;
- Spark arrestors and prefilters in each final filtration assembly;
- Each HEPA stage shall be field tested to have an efficiency of 99.95 percent (1E-4 analytical assumption);
- Manual or automatic fire-rated dampers between designated fire areas;

- In-place HEPA filter testing capability in accordance with ASME N510 for the final filtration assemblies;
- Final filters and ductwork remain structurally intact during and after design basis earthquakes and withstand the effects of tornadoes

11.4.11.1.9 Supply Air System

Additional design basis associated with this PSSC is as follows:

- Provide supply air for emergency cooling;
- HEPA filter stages for building air supply for static confinement;
- Each HEPA stage shall be field tested to have an efficiency of 99.95 percent (1E-4 analytical assumption);

11.4.11.1.10 MFFF Tornado Dampers

Additional design basis associated with this PSSC is as follows:

- Withstand the effects of design basis tornadoes;
- Remains operational after facility fires and design basis earthquakes

11.4.11.1.11 Offgas Treatment System

Additional design basis associated with this PSSC is as follows:

- Two stages of HEPA filters prior to discharge to the atmosphere;
- Spark arrestors and prefilters in each final filtration assembly;
- Each HEPA stage shall be field tested to have an efficiency of 99.95 percent (1E-4 analytical assumption);
- Fire-rated dampers between designated fire areas;
- In-place HEPA filter testing capability in accordance with ASME N510 for the final filtration assemblies;
- Final filters and ductwork remain structurally intact during and after design basis earthquakes and withstand the effects of tornadoes

11.4.11.2 Gloveboxes and Glovebox Pressure Controls

Gloveboxes are designed to provide a confinement barrier for hazardous material. They are designed to remain functional during and after a design basis earthquake.

Design provisions that minimize the potential for a breach of confinement resulting from dropped loads include the following:

- Use of highly automated processes with complementary hard-wired logic for safe material handling within the glovebox, which precludes human handling incidents

- SRS interface data highway
- International Atomic Energy Agency (IAEA) monitoring data highway (as applicable).

11.5.2.4.2 Emergency Communication Systems

Dedicated, non-PBX telephone lines will be provided as follows:

- From the MFFF Operations Support Center to SRS Area Emergency Coordinators
- From the MFFF Fire Alarm System to the SRS Operations Center
- Between the MFFF Operations Support Center and the SRS Safety System/Alarm Public Announcement System
- From the MFFF Operations Support Center to the SRS Operations Center, Emergency Operations Center, and Technical Support Center.

Each safe haven will be provided with communication systems, consisting of the telephone, intercom, and public address systems.

11.5.2.5 Monitoring, Testing, Protection, and Breaker Control

The electrical distribution system is designed to be monitored from the utility control system or locally at meters and displays for each bus and major component. The electrical system is also designed to allow periodic testing while operating. The electrical loads are dispersed between buses such that redundant loads are unaffected if one bus is being tested. The normal AC system buses are provided with alternate feeds to facilitate maintenance. Both the standby and emergency generators have synchronizing capability to allow for full-load testing. There are two standby and two emergency generators so that one may be taken out of service for testing while the other remains available for use. For ease of maintenance, switchgear cubicles are "draw-out construction" (i.e., the breaker has the ability to be withdrawn from and inserted into the cubicle by a racking mechanism and to disengage and engage the bus with the same mechanism). The inverters used for PLC power and for the 120-V vital AC system have maintenance bypasses.

For principal SSCs, MFFF will comply with the periodic and surveillance testing guidance presented in IEEE standards 308, 765, 387, 450 and 338 (as clarified in Regulatory Guide 1.118).

The breakers for the normal electrical system can be controlled from the utility control system or locally. The breakers for the emergency electrical system are controlled from the associated emergency control room or locally. The controls for the emergency electrical system are hard wired.

Protective devices are provided for the electrical distribution system to remove faulted equipment from service, provide automatic supervision of manual/automatic operations, and initiate automatic operations or switching for shutdown or continued safe operation as required.

11.5.3 Major Components

The major components of the electrical system include the following:

- Incoming transformers
- 4,160-VAC normal switchgear
- 480-VAC normal switchgear
- 480-Volt Switchboards
- 480-VAC normal MCCs
- Standby generators
- 120/208-V Essential Inverter System
- 4,160-VAC emergency switchgear
- 480-VAC emergency switchgear
- 480-VAC emergency MCCs
- Emergency generators
- 480-VAC emergency UPS
- Emergency 125-VDC system
- Normal 125-VDC system
- 120-VAC Vital Inverter System.

11.5.3.1 Incoming Transformers

The incoming transformers are 13.8- to 4.16-kV, oil-filled, 15/20/25-MVA, pad-mounted transformers. The transformers have a "self-cooled oil to air" rating of 15 MVA and two "forced air" ratings of 20 and 25 MVA. The transformers are provided with 2-2½% taps above and 2-2½% taps below nominal. The transformers are provided with primary-side lightning arresters and are connected delta-wye with the neutral resistance grounded.

11.5.3.2 4,160-VAC Normal Switchgear

The 4,160-VAC normal switchgear is metal-clad, 5-kV type consisting of vertical sections housing various combinations of circuit breakers and auxiliaries, bolted to form a rigid metal-clad switchgear assembly. The main switchgear bus is made of copper, and the bus and all supports are constructed to withstand the stresses that would be produced by the momentary interrupting ratings of the associated circuit breakers. Circuit breakers are vacuum-type, horizontal draw-out breakers. The normal switchgear is constructed and rated for a three-phase, three-wire, 5-kV system. Control power for the circuit breakers is provided at 125 VDC.

11.5.3.3 480-VAC Normal Switchgear

The 480-VAC normal switchgear lineups consist of free-standing, low-voltage, metal-enclosed switchgear assemblies with low-voltage circuit breakers, nonsegregated phase bus, and protective and metering devices. Control voltage is 125 VDC.

Each 480-VAC switchgear lineup includes a main supply breaker and a tiebreaker that connects each switchgear lineup to the appropriate alternate switchgear lineup tiebreaker. These tiebreakers are sized according to the rating of the main breaker for the switchgear lineup and the expected bus loading. Each switchgear bus is provided with ground detection, and each breaker is provided with the appropriate protective package (i.e., instantaneous, short time adjustable, long time adjustable and ground) based on the load being supplied.

interfaces are accomplished via qualified isolation devices. The emergency control system controls are hard-wired.

11.5.6 Design Basis for Non-Principal SSCs

The applicable codes and standards for the normal and standby systems are provided in this section.

11.5.6.1 Normal AC Power System

The normal AC power system is designed using the guidance of National Fire Protection Association (NFPA) 70-1999, *National Electric Code*. The connections to offsite power are designed in accordance with Institute of Electrical and Electronic Engineers (IEEE) 765-1995, *Standard for Preferred Power Supply for Nuclear Generating Stations*, for the purpose of providing reliable power for normal operation and conditions. Grounding systems and equipment will comply with NFPA 70, IEEE 665-1995, *Guide for Generating Station Grounding* and IEEE 142-1991, *Recommended Practice for Grounding of Industrial and Commercial Power Systems*. Lightning protection complies with NFPA 780-1999, *Standard for the Installation of Lightning Protection System*. The normal AC power system equipment is designed to operate after a Uniform Building Code (UBC) earthquake.

MFFF will comply with the periodic and surveillance testing guidance presented in IEEE standards 765.

11.5.6.2 Standby AC Power System

The standby AC power system is designed in accordance with the guidance of NFPA 70-1999, *National Electric Code*, and serves loads set forth in NFPA 110, *Standard for Emergency and Standby Power Systems*, and IEEE 446-1995, *Recommended Practices for Emergency and Standby Power Systems for Industrial and Commercial Applications*. Additional standby systems are provided to support systems or equipment components whose operating continuity is determined to be vital for protection of health, life, property, and safeguards and security systems. Interior lighting systems are designed in accordance with the guidance of the Illuminating Engineering Society (IES) Lighting Handbook. Exit and emergency lighting systems comply with NFPA 101-1997, *Safety to Life from Fire in Buildings and Structures*, and NFPA 110-1996, *Emergency and Standby Power Systems*. The standby power source equipment is designed to operate after a UBC earthquake.

11.5.6.3 Normal DC Power System

The batteries are sized using the guidance of IEEE 485-1997, *IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications*. The design and installation of the normal DC system complies with the guidance of IEEE 484-1996, *Recommended Practice for Installation of Vented Lead Acid Batteries for Stationary Applications*. In addition, battery rooms shall meet the requirements identified in NFPA 110, *Standard for Emergency and Standby Power Systems*. The normal power source equipment is all designed to operate after a UBC earthquake. The insulation between the batteries and racks is acid and moisture resistant. A material that does not absorb and hold moisture is used.

11.5.7 Design Basis for Principal SSCs

This section discusses the design basis requirements applicable to the design and operation of the emergency AC and DC Power systems.

Principal SSCs are identified in Chapter 5. IROFS associated with this system will be identified in the ISA, along with the required start time for the emergency generators.

11.5.7.1 Emergency AC Power System

The emergency AC power system is designed to provide highly reliable power to redundant principal SSCs. The emergency AC power system is a fully redundant and independent system designed to provide power with credible single failures. Emergency AC power is seismically qualified and located in areas where the maximum expected variations in environmental parameters are within the normal design range of the equipment. Should any equipment be expected to operate in conditions outside of normal design ranges, the equipment will then be qualified for the expected environment. Raceways and cable trays are seismically supported and separated from redundant emergency train equipment. Cables exposed to building areas in cable trays are flame-retardant.

The fundamental design of the emergency AC power system is in accordance with IEEE 308-1991, *IEEE Standard Criteria for Class 1E Power Systems for Nuclear Generating Stations.* Components of the emergency AC power system are designated as Class 1E. Power cables associated with PSSCs are routed in conduit. Electrical independence and separation of the system are maintained using the guidance of IEEE 384-1992, *Standard Criteria for Independence of Class 1E Equipment and Circuits*, except that where circuit breakers and fuses are used as isolation devices, two will be placed in series. DCS will route PSSC power cables in conduit to minimize the likelihood of any interaction between divisional cables and between divisional and non-divisional cables. The emergency AC power system is also designed so that no single failure will prevent the system from performing its intended function in accordance with the guidance of IEEE 379-1994, *IEEE Standard Application of the Single Failure Criterion to Nuclear Power Generation Station Safety Systems.* Cables used in open cable trays are qualified for fire propagation and environmental effects using the guidance of IEEE 383-1974, *IEEE Standard for Type Test of Class 1E Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations.*

The emergency generator units are designed and qualified in accordance with IEEE 387-1995, *IEEE Standard Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations.* A loss of offsite power test will be performed at the MOX facility on a frequency that will be determined when the complete facility test and maintenance program is developed.

The MFFF Emergency Diesel Fuel Oil Storage System (EGF) has been designed to comply with ANSI / ANS 59-51-1997 and to meet requirements of NFPA 30 (1996), "Flammable and Combustible Liquids Code" and NFPA 37 (1998), "Standards for the Installation and Use of Stationary Combustion Engines and Gas Turbines."

Emergency AC power system equipment is qualified for design basis seismic events and normal, off-normal, and design basis accident environmental conditions. The basis of seismic qualification is analysis or test in accordance with IEEE 344-1987, *IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Generating Stations.* Environmental qualification complies with IEEE 323-1983, *IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations.* Mechanical equipment seismic qualification considers attached piping loads, thermal loads and live loads such as fluid sloshing, and in addition, applied loads meet or exceed accelerations corresponding to their installed location.

The protection for the emergency electrical system is designed in compliance with IEEE 741-1997, *IEEE Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations.* Circuit breakers will be tested periodically to ensure that they trip within a specified tolerance of the manufacturer's published time-current trip curves for the models involved. Details of the maintenance and test program will be developed at a later date prior to operation.

Upon the loss of standby power, the emergency AC power system provides power to principal SSC loads. Each independent train of emergency components is capable of performing all necessary safety functions. The emergency AC power system is composed of the following:

- Emergency generators
- 4,160-V emergency buses
- 480-V emergency system
- 480-V UPS
- 120-V vital AC power system
- Associated switchgear and MCCs.

The emergency generator units are connected to an associated 4,160-V switchgear bus and are capable of being stopped or started locally. Emergency generator A can also be started from emergency control room A. Similarly, emergency generator B can be also be started from emergency control room B. Each generator is sized to have sufficient capacity to start and accelerate associated principal SSC loads. A redundant electric starting system with redundant batteries is supplied for each generator, sized to allow for five cranking cycles. A fuel oil day tank is provided for each generator to allow for storage of eight hours, up to a maximum of 660 gallons, of fuel oil. The independent fuel oil supply tanks provide sufficient storage capacity to allow each emergency generator to operate continuously for seven days.

Each emergency AC power system bus, whether 4,160 V or 480 V, is independent of the corresponding bus on the opposite train. Each bus is rated and braced for the maximum short-circuit current available at the bus.

A dedicated 480-V UPS is provided for each of four VHD fans. Each UPS consists of a rectifier and inverter and a battery bank capable of supplying power to the VHD fans for one hour upon loss of AC power.

The 120-V vital AC power system supplies power to principal SSC I&C loads. The system consists of two independent and redundant power sources, train A and train B, each with sufficient capacity to supply its own vital bus loads. Each vital bus is supplied from a UPS with a one-hour battery backup capacity.

UPS design and procurement complies with the guidance of IEEE 944-1986, *IEEE recommended Practice for the Application and Testing of Uninterruptible Power Supplies for Power Generating Stations.*

MFFF will comply with the periodic and surveillance testing guidance presented in IEEE standards 308, 387, and 338 (as clarified in Regulatory Guide 1.118).

11.5.7.2 Emergency DC Power System

The emergency batteries are sized using the guidance of IEEE 485-1997, *IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications.* The design and installation of the emergency batteries complies with the guidance of IEEE 484-1996, *Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications.* The insulation between the batteries and racks is acid and moisture resistant. A material that does not absorb and hold moisture is used. In addition, battery rooms shall meet the requirements identified in NFPA 110, *Standard for Emergency and Standby Power Systems.*

The emergency DC power system is designed using the guidance of IEEE 308-1991, *IEEE Standard Criteria for Class 1E Power Systems for Nuclear Generating Stations.* Electrical independence and separation of the system are maintained using the guidance of IEEE 384-1992, *Standard Criteria for Independence of Class 1E Equipment and Circuits*, except that where circuit breakers and fuses are used as isolation devices, two will be placed in series. The emergency DC power system is also designed so that no single failure will prevent the system from performing its intended function in accordance with the guidance of IEEE 379-1994, *IEEE Standard Application of the Single Failure Criterion to Nuclear Power Generating Station Safety Systems.*

Emergency DC power system equipment is qualified for design basis seismic events and all normal, off-normal, and design basis accident environmental conditions. The basis of seismic qualification is analysis or test in accordance with IEEE 344-1987, *IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Generating Stations.* Environmental qualification complies with IEEE 323-1983, *IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations.* Cables used are qualified using the guidance of IEEE 383-1974, *IEEE Standard for Type Test of Class 1E Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations.* The emergency DC system complies with the design and application guidance provided in IEEE 946-1992, *"IEEE recommended Practice for the Design of Safety-Related DC Auxiliary Power Systems for Nuclear Power Plants".*

The emergency DC power system is composed of the following:

- Two 60-cell lead acid batteries

- Two associated battery chargers
- Two DC distribution panels.

Each battery has an ampere-hour capacity sufficient to supply its loads for one hour without the assistance of the associated charger. The chargers have ample capacity to supply the steady-state loads under any plant condition and are able to recharge the associated battery to a fully charged condition from the design minimum charged state within 24 hours. Each train of DC power is redundant and independent.

MFFF will comply with the periodic and surveillance testing guidance presented in IEEE standards 308, 450 and 338 (as clarified in Regulatory Guide 1.118).

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for seven days. A seven day period allows the necessary steps to be taken to restore the dilution air supply to all items of equipment subject to radiolysis risk.

The emergency pressurized air supply tanks and piping are seismically qualified in accordance with Section 11.

11.9.5.2 Pressure Vessel Controls

Administrative controls will ensure pressure vessels for mechanical utility systems, reagent systems, bulk gas systems, breathing air systems, service air and instrument air systems which may be subject to overpressurization events and impact primary confinements, are located in the facility away from principal SSCs or are otherwise protected such that failure of the non-principal SSC's will have no impact on the principal SSCs and ensure that primary confinements are protected.

11.9.5.3 Emergency Diesel Generator Fuel Oil System

The Design Basis for the Emergency Diesel Generator Fuel Oil System is described in Section 11.5.7.

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