DUKE COGEMA
STONE & WEBSTER

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555

20 December 2002
DCS-NRC-000123

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

Reference: 1) R. H. Ihde (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-000114, 31 October 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 provided in 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. Enclosure 3 identifies the list of effective pages (i.e., dated 10/31/02 or 12/20/02).

Each of these changes has been discussed previously with the NRC staff. The main purpose of these changes is to update information based on a revised consequence analysis. In addition, some other minor changes were made as discussed at recent NRC public meetings.

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

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Sincerely,

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Enclosures:
1) Change Pages to the Mixed Oxide Fuel Fabrication Facility Construction Authorization Request (non-proprietary)
2) Construction Authorization Request 12/20/02 Update Instructions
3) Construction Authorization Request List of Effective Pages

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Enclosure 1

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

25 copies enclosed

Enclosure 2
Construction Authorization Request 12/20/02 Update Instructions

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

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

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

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

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

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

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

5.5.2.1.6.4 Leaks of AP Process Vessels or Pipes Within Process Cells

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

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

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

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

5.5.2.1.6.5 Backflow From a Process Vessel Through Utility Lines

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

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

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

5.5.2.1.6.6 Rod Handling Operations

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

To reduce the risk to the facility worker associated with this event group, both prevention and mitigation features are utilized to implement the safety strategy. The principal SSCs utilized to prevent this event from occurring are the material handling equipment and material handling

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fire prevention features. The fire prevention features that effectively reduce the likelihood of the fire event in the AP process cells to highly unlikely include the following:

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

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

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

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

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

5.5.2.2.6.2 AP/MP C3 Glovebox Areas

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

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

All Gloveboxes

To reduce the risk to the public, site worker, and the environment associated with this event group, a safety strategy utilizing mitigation features is adopted. The principal SSCs identified to implement this safety strategy are the C3 and C4 confinement systems. The safety function of the C3 confinement system is to remain operable during a design basis fire and effectively filter any release. Note that the static portion of the C4 confinement system (e.g., the glovebox) may be damaged as a result of the fire; however, the active portion of the C4 confinement system will remain operational and will effectively filter any release.

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

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

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

Storage Gloveboxes

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

5.5.2.2.6.3 C1 and/or C2 Areas

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

<u>3013 Canister</u>

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

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

<u>3013 Transport Cask</u>

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

<u>Fuel Rod</u>

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

MOX Fuel Transport Cask

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

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

Waste Container

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

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

Transfer Container

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

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

Final C4 HEPA Filter

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

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

5.5.2.3.2 Causes

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

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

5.5.2.3.3 Specific Locations

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

5.5.2.3.4 Unmitigated Event Consequences

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

5.5.2.3.5 Unmitigated Event Likelihood

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

5.5.2.3.6 Safety Evaluation

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

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

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

- C4 confinement
- Outside the MOX Fuel Fabrication Building
- Facilitywide.

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

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

5.5.2.3.6.1 AP Process Cells

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

To reduce the risk to the facility worker and the environment associated with this postulated event group, a safety strategy utilizing mitigation features is adopted. The principal SSCs identified to implement this safety strategy are the process cell for the facility worker and the process cell ventilation system passive boundary for the environment. The safety function of the process cell is to contain fluid leaks (e.g., through the use of drip trays) within the process cells. The safety function for the process cell ventilation system passive boundary is to ensure that the process cell exhaust is effectively filtered. Process cell entry controls are also identified as a principal SSC for the facility worker. The safety function of the process cell entry controls is to prevent the entry of personnel into process cells during normal operations, thus no load handling occurs in a process cell during normal operations. Additionally, process cell entry controls ensure that facility workers do not receive a radiological exposure in excess of limits while performing maintenance in the AP process cells.

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

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

5.5.3 Bounding Consequences Assessment

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

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

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

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

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

Tables 5.5-26 and 5.5-27 summarize the radiological consequences and EC ratio for the bounding events and bounding low consequence events, respectively. Radiological consequence limits are presented in Table 5.4-1. To satisfy the environmental consequences established in Table 5.4-1, the EC ratio must be less than one (see Section 5.4.4.3).

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

5.5.3.1 Loss of Confinement

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

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

The bounding low consequence loss of confinement event is a drop of waste drums located in the truck bay (see Section 5.5.3.3 for a description of this event). The bounding radiological consequences associated with this event are provided in Table 5.5-27.

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

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

5.5.3.2 Internal Fire

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

The bounding fire event is a fire in the fire area containing the Final Dosing Unit. This unit contains polished plutonium powder for the purpose of down blending the mixed oxide powder to the desired blend for fuel rod fabrication. This fire area is postulated to contain the largest source term for this event type and consequently produces the largest consequences. The evaluation conservatively assumes that a fire occurs in this fire area and impacts the powder found in this area, resulting in a release of radioactive material. The maximum amount of Pu in this fire area is 136 lb (62 kg, see Table 5.5-3b) of PuO_2 powder. Due to the low combustible loading in this fire area, just a small fraction of this material would be expected to be involved in the fire. However, the evaluation conservatively uses the entire fire area inventory in the consequence analysis. The bounding respirable release fraction (RF times ARF) is based on a fire release mechanism for a powder and is equal to 6 x 10^{-4} (NRC 1998b).[1] Radioactive material made airborne by this event will be filtered prior to being released from the MFFF by a credited filtration system, which is either the VHD or HDE system. The leak path factor (LPF) associated with these systems is conservatively assigned at 1.0 x 10^{-4} (see Section 5.4.4.4 for additional information related to the LPF).

The bounding low consequence fire event is a fire involving waste drums located in the truck bay. Waste drums are stored inside the MFFF, then moved to the truck bay and placed on a truck for transportation off of the MFFF site. Waste drums contain small amounts of radioactive material, and only a small number of waste drums are transported at one time, thus the maximum MAR estimated to be involved in the fire is 80 grams of unpolished plutonium powder. The associated ARF is 5 x 10^{-4}, the RF is 1.0, and the DR and LPF are both conservatively established at 1.0. Fires that could impact a larger number of waste drums in the waste drum storage area would be effectively filtered, thus producing lower consequences than this event.

As shown in Tables 5.5-26 and 5.5-27, the radiological consequences at the site boundary and to the nearest site worker are low. Consequences to the facility worker are also acceptable since the worker is trained and evacuates the area prior to a significant release of radioactive material. Additionally, the EC ratio is less than one and thus satisfies the performance requirements of 10 CFR §70.61.

The MFFF utilizes many features to reduce the likelihood and consequences of these events as well as other fire-related events. Key features include fire barriers, minimization of combustibles and ignition sources, ventilation systems with fire dampers and HEPA filters, qualified canisters and containers, fire suppression and detection systems, and facility worker action (including local fire brigades). Credit for any or all of these considerations would significantly reduce the likelihood and consequences of these and other fire events.

5.5.3.3 Load Handling

A load handling hazard arises from the presence of lifting or hoisting equipment used during either normal operations or maintenance activities. A load handling event occurs when either the lifted load is dropped or the lifted load or lifting equipment impacts other nearby items.

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[1] The bounding respirable release fraction (RF times ARF) is based on a fire release mechanism for a powder. Although NUREG/CR-6410 (NRC 1998b) cites an ARF of 6 x 10^{-3} and an RF of 0.01 for fires involving nonreactive powders, the technical basis discussion notes that higher RF values were obtained based on tests done with PuO_2 in a high temperature calcining furnace. Since the MFFF has a similar calcining furnace, the release fractions were adjusted to a more conservative value (RF was increased by a factor of 10 to 0.1) based on the technical discussion in NUREG/CR-6410. Therefore, a bounding respirable release fraction of 6 x 10^{-4} was used for the calculation of radiological consequences for this fire event.

The bounding load handling event is a drop event involving the glovebox in the Jar Storage and Handling Unit. This glovebox holds jars containing MOX powders with up to 20% polished plutonium. This glovebox is postulated to contain the largest source term for this event and therefore produces the largest consequence. The glovebox is postulated to be impacted during maintenance operations by either a lifting device or a lifted load outside of the glovebox, damaging a portion of the glovebox and causing some of its contents to drop to the floor, resulting in a release of radioactive material. The maximum amount of plutonium in this glovebox is approximately 557 lb (254 kg) of polished plutonium powder. Due to the large glovebox size, there is no known mechanism that could damage the entire glovebox and just a small fraction of this amount would be involved in the event. However, the evaluation conservatively uses the entire glovebox inventory in the consequence calculations (i.e., the damage ratio is assumed to be one). The bounding respirable release fraction (RF times ARF) is based on the drop release mechanism for powders and is equal to 6×10^{-4} (NRC 1998b). Radioactive material made airborne by this event will be filtered prior to being released from the MFFF by a credited filtration system, which is either the VHD or HDE system. The leak path factor (LPF) associated with these systems is conservatively assigned at 1.0×10^{-4} (see Section 5.4.4.4 for additional information related to the LPF).

The bounding low consequence load handing event involves waste drums located in the truck bay. Waste drums are stored inside the MFFF, then moved to the truck bay and placed on a truck for transportation off of the MFFF site. Waste drums contain small amounts of radioactive material, and only a small number of waste drums are transported at one time, thus the maximum MAR estimated to be involved in the load handling event is 80 grams of unpolished plutonium powder. The associated ARF is 2×10^{-3}, the RF is 0.3, and the DR and LPF are both conservatively established at 1.0.

As shown in Tables 5.5-26 and 5.5-27, the radiological consequences at the site boundary and to the nearest site worker are low. Consequences to the facility worker are also acceptable since the worker is trained and evacuates prior to a significant release of radioactive material, or has taken precautions during maintenance activities. Additionally, the EC ratio is less than one and thus satisfies the performance requirements of 10 CFR §70.61.

The MFFF utilizes many features to reduce the likelihood and consequences of this event as well as other load-handling events. Key features include loadpath restrictions, facility worker action (including crane-operating procedures, maintenance procedures, and operator training), qualified canisters, reliable load-handling equipment, and ventilation systems with HEPA filters. Credit for any or all of these considerations would significantly reduce the likelihood and consequences of these and other load handling events.

5.5.3.4 Criticality Event

The MFFF processes are designed to preclude a criticality event through the use of reliable engineered features and administrative controls. Adherence to the double contingency principle, as specified in ANSI/ANS-8.1 (ANSI/ANS 1983), is employed. Simultaneous failure of the design features and administrative controls is highly unlikely.

Although criticality events at the MFFF are prevented, a generic hypothetical criticality event is evaluated. A source term of 10^{19} fissions in solution is evaluated consistent with guidance provided in Regulatory Guide 3.71 (NRC 1998c). Airborne releases and direct radiation result from the criticality. However, the direct radiation contribution to the site worker and the public is negligible due to the shielding provided by the building and the distance to these receptors. The evaluation is based on 91.5 lb (41.5 kg) of unpolished plutonium, the maximum tank inventory of plutonium in solution. Airborne releases are calculated consistent with the guidance of Regulatory Guide 3.35 (NRC 1979). The leak path factors for gases and particulate are 1.0 and 1×10^{-4} (NRC 1978a), respectively, where credit is taken for the filtration system remaining effective for the duration of a criticality event. The radiological consequences associated with this hypothetical event for the public and site worker are shown in Table 5.5-26.

As shown in Table 5.5-26, the radiological consequences at the site boundary and to the nearest site worker would be low. The radiological consequences to a facility worker, however, could exceed the performance requirements of 10 CFR §70.61; for this reason and as a requirement of 10 CFR §70.61(d), this event type is prevented.

5.5.3.5 Explosion Event

Internal explosion events within the MFFF result from the presence of potentially explosive mixtures and potential over-pressurization events. The MFFF processes are designed to preclude explosions through the use of highly reliable principal SSCs. Although explosion events at the MFFF are highly unlikely, a generic hypothetical explosion event within the MOX building is evaluated.

The evaluation conservatively assumes that an explosion occurs and involves the entire material at risk within a process cell. The maximum source term in any process cell is approximately 165 lb (75 kg) of unpolished plutonium in the cell containing the dilution and buffer tanks of the dissolution unit. The evaluation conservatively uses the entire process cell inventory in the consequence calculation (i.e., the damage ratio is assumed to be one). The bounding respirable release fraction (RF times ARF) is conservatively based on the explosive detonation release mechanism and is equal to 0.01 (NRC 1998b). Radioactive material made airborne by this event will be filtered prior to being released from the MOX Fuel Fabrication Building. The effective bounding leak path factor associated with this event is 1×10^{-4} (NRC 1978a). The bounding radiological consequences associated with this event for the public and site worker are provided in Table 5.5-26.

As shown in Table 5.5-26, the impacts to the public and the site worker would be low. The radiological consequences to a facility worker could exceed the performance requirements of 10 CFR §70.61; hence, this event type is prevented.

5.5.3.6 Direct Radiation Exposure

A direct radiation hazard arises from the presence of radioactive material within the MFFF. Direct radiation exposure events include those events that result in a radiation dose from radiation sources external to the body. Due to the nature of the radioactive material present in the MFFF (and the distance to the public and site receptors), there are no accidents at the MFFF that produce a significant direct radiation exposure hazard to the public, site worker, or facility worker.

5.5.3.7 Chemical Releases

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

5.5.4 Likelihood Assessment

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

5.5.4.1 Likelihood Assessment Results

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

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

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

The MFFF general design philosophy, design bases, system design, and commitments to applicable management measures are based on standard nuclear industry practices. Past precedent regarding the conservative nature of traditional engineering practices provides reasonable assurance that the likelihood requirements of 10 CFR §70.61 will be satisfied by the final design. Principal SSCs either are IROFS or presumed to be IROFS (pending results of the ISA), and are controlled as Quality Level 1 in accordance with the management measures described in Chapter 15. These management measures include design, procurement, installation, testing, and maintenance (as appropriate) in accordance with the MOX Project Quality Assurance Plan to ensure adequate availability and reliability, based on the results of the ISA. These elements ensure that applicable industry codes and standards are utilized, adequate safety

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

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

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

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

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

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

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

Event Group	Principal SSC	Safety Function
AP Process Cells	Process Cell Fire Prevention Features	Ensure that fires in the process cells are unlikely.
AP/MP C3 Glovebox Areas	C3/C4 Confinement Systems	Remain operable during design basis fire and effectively filter any release.
	Fire Barriers	Contain/limit fires to a single fire area
	Combustible Loading Controls [For Storage Gloveboxes ONLY]	Limit the quantity of combustibles in fire areas containing a storage glovebox such that any fire that may occur will not encompass a large fraction of the stored radiological material.
C1 and/or C2 Areas - 3013 Canister	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing 3013 canisters to ensure that the canisters are not adversely impacted by a fire.
C1 and/or C2 Areas - 3013 Transport Cask	3013 Transport Cask	Withstand the design basis fire without breaching.
	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing 3013 transport casks to ensure that the cask design basis fire is not exceeded.
C1 and/or C2 Areas - Fuel Rod	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing fuel rods to ensure that the fuel rods are not adversely impacted by a fire.
C1 and/or C2 Areas - MOX Fuel Transport Cask	MOX Fuel Transport Cask	Withstand the design basis fire without breaching.
	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing MOX fuel transport casks to ensure that the cask design basis fire is not exceeded.
C1 and/or C2 Areas - Waste Container	None Required	N/A
C1 and/or C2 Areas - Transfer Container	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing transfer containers to ensure that the containers are not adversely impacted by a fire.

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

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

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

Event Group	Principal SSC	Safety Function
AP Process Cells	Process Cell Fire Prevention Features	Ensure that fires in the process cells are highly unlikely
AP/MP C3 Glovebox Areas	C3/C4 Confinement Systems	Remain operable during design basis fire and effectively filter any release.
	Fire Barriers	Contain/limit fires to a single fire area
	Combustible Loading Controls [For Storage Gloveboxes ONLY]	Limit the quantity of combustibles in fire areas containing a storage glovebox such that any fire that may occur will not encompass a large fraction of the stored radiological material.
C1 and/or C2 Areas - 3013 Canister	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing 3013 canisters to ensure that the canisters are not adversely impacted by a fire.
C1 and/or C2 Areas - 3013 Transport Cask	3013 Transport Cask	Withstand the design basis fire without breaching.
	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing 3013 transport casks to ensure that the cask design basis fire is not exceeded.
C1 and/or C2 Areas - Fuel Rod	Combustible Loading Controls	Limit the quantity of combustibles in a fire area containing fuel rods to ensure that the fuel rods are not adversely impacted by a fire.
C1 and/or C2 Areas - MOX Fuel Transport Cask	MOX Fuel Transport Cask[a]	Withstand the design basis fire without breaching.
	Combustible Loading Controls[a]	Limit the quantity of combustibles in a fire area containing MOX fuel transport casks to ensure that the cask design basis fire is not exceeded.
C1 and/or C2 Areas - Waste Container	None Required	N/A
C1 and/or C2 Areas - Transfer Container	None Required	N/A

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

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

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

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

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

Bounding Accident[a]	Maximum Impact to Site Worker (mrem)	Maximum Impact to Person at Controlled Area Boundary (mrem)	Effluent Concentration Ratio
Internal Fire	<100	<0.5	<0.2
Load Handling	<150	<1.0	<0.2
Hypothetical Explosion Event	<750	<5.0	N/A[b]
Hypothetical Criticality Event	<2200	<12	N/A[b]

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

[b] These event types are prevented by design, hence the effluent concentration ratio (applicable to likely and unlikely events) is not applicable.

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

Bounding Accident[a]	Maximum Impact to Site Worker (mrem)	Maximum Impact to Person at Controlled Area Boundary (mrem)	Effluent Concentration Ratio
Internal Fire	<500	<4	<0.3
Load Handling	<500	<4	<0.7
Hypothetical Explosion Event[b]	N/A	N/A	N/A
Hypothetical Criticality Event[b]	N/A	N/A	N/A

[a] The bounding loss of confinement event is bounded by the load handling event listed.
[b] There are no bounding unmitigated low consequence events associated with these event types.

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 to 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 5A-6. Unmitigated Events; Cladding and Rod Control Workshop (continued)

Event Type/Workshop or Location/ Event Number	Unmitigated Event Description/Specific Location/Hazard Sources	Cause
Loss of Confinement / Dispersal of Nuclear Material MFFF-Cladding and Rod Control Workshop RD-11 E-3	The fracture of one or multiple fuel rods while utilizing fuel rod handling equipment results in breach of confinement, and dispersal of radiological materials. Specific Location: X-Ray Inspection Unit Rod Tray Handling Rod Tray Loading Rod Inspection and Sorting Helium Leak Test Rod Storage Rod Scanning Mode: Normal Operation Hazard Sources: Radiological Material (maximum inventory in fuel rod or fuel rods)	1. Human error or equipment failure
External Exposure MFFF-Cladding and Rod Control Workshop RD-7 E-4	Operator is inadvertently exposed to excessive direct radiation in the MFFF-Cladding and Rod Control Workshop resulting in excessive radiation exposure. Specific Location: Rod Cladding and Decontamination X-Ray Inspection Unit Rod Tray Handling Rod Tray Loading Rod Inspection and Sorting Helium Leak Test Rod Storage Rod Scanning Rod De-cladding Unit Mode: All Hazard Sources: Maximum Direct Radiation Source	1. Human error or equipment failure 2. Unplanned or unintended exposure to x-rays

Table 5A-6. Unmitigated Events, Cladding and Rod Control Workshop (continued)

Event Type/Workshop or Location/ Event Number	Unmitigated Event Description/Specific Location/Hazard Sources	Cause
Criticality MFFF-Cladding and Rod Control Workshop RD-8 E-5	Re-configuration of fissile material potentially results in nuclear criticality and the release of radiological material. Specific Location: Rod Cladding and Decontamination X-Ray Inspection Unit Rod Tray Handling Rod Tray Loading Rod Inspection and Sorting Helium Leak Test Rod Storage Rod Scanning Rod De-cladding Unit Mode: All Hazard Sources: Fissile and Radiological Material	1. Excessive quantity of fissile material is accumulated in process unit 2. Improper placement of fissile material outside of criticality safe storage locations 3. Introduction of moderator (e g., internal flooding of process unit) 4. Human error or equipment failure
Load Handling MFFF-Cladding and Rod Control Workshop RD-9 E-6	The drop of a load onto fuel rods while utilizing miscellaneous load handling devices results in breach of confinement, and dispersal of radiological materials. Specific Location: X-Ray Inspection Unit Rod Tray Handling Rod Tray Loading Rod Inspection and Sorting Helium Leak Test Rod Storage Rod Scanning Mode: All Hazard Sources: Radiological Material (maximum inventory in fuel rod or rods)	1. Human error or equipment failure

Table 5A-7. Unmitigated Events, Assembly Workshop (continued)

Event Type/Workshop or Location/ Event Number	Unmitigated Event Description/Specific Location/Hazard Sources	Cause
External Exposure MFFF-Assembly Workshop AS-5 E-4	Operator is inadvertently exposed to excessive direct radiation in the MFFF-Rod/Assembly Workshop resulting in excessive radiation exposure. Specific Location: Assembly Packaging Assembly Mockup Loading Assembly Handling and Storage Assembly Mounting Unit Assembly Dry Cleaning Assembly Dimensional Inspection Assembly Final Inspection Mode: All Hazard Sources: Maximum Direct Radiation Source	1. Human error or equipment failure
Criticality MFFF-Assembly Workshop AS-6 E-5	Re-configuration of fissile material potentially results in nuclear criticality and the release of radiological material. Specific Location: Assembly Packaging Assembly Mockup Loading Assembly Handling and Storage Assembly Mounting Unit Assembly Dry Cleaning Assembly Dimensional Inspection Assembly Final Inspection Mode: All Hazard Sources: Fissile and Radiological Material	1. Excessive quantity of fissile material is accumulated in process unit 2. Improper placement of fissile material outside of criticality safe storage locations 3. Introduction of moderator (e.g., internal flooding of process unit) 4. Human error or equipment failure

Table 5A-7. Unmitigated Events, Assembly Workshop (continued)

Event Type/Workshop or Location/ Event Number	Unmitigated Event Description/Specific Location/Hazard Sources	Cause
Load Handling MFFF-Assembly Workshop AS-7 E-6	A suspended fuel assembly in motion impacts an object or another assembly while utilizing a crane or hoisting equipment and results in breach of confinement, and dispersal of radiological materials. Specific Location: Assembly Handling and Storage Assembly Dry Cleaning Assembly Dimensional Inspection Mode: Normal Operation Hazard Sources: Radiological Material (maximum inventory of two fuel assemblies)	1. Human error or equipment failure
Load Handling MFFF-Assembly Workshop AS-8 E-6	The drop of a load onto an assembly or assemblies while utilizing miscellaneous load handling devices results in breach of confinement, and dispersal of radiological materials. Specific Location: Assembly Packaging Assembly Mockup Loading Assembly Handling and Storage Assembly Mounting Unit Assembly Dry Cleaning Assembly Dimensional Inspection Assembly Final Inspection Mode: All Hazard Sources: Radiological Material (maximum inventory of fuel assembly or assemblies)	1. Human error or equipment failure

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- The assembly characteristics (if applicable).

Note: Other characteristics (e.g., density) could be considered as being part of the physicochemical characteristics, but they are listed as control modes (in Section 6.3.4.3.2). The various physicochemical forms for the MFFF processes are described in the following sections. The isotopic composition of the fissile material, including impurities, is discussed in Section 6.3.4.3.2.4.

6.3.4.3.1.1 Chemical Form

In the MP process, no chemical transformations take place. As a consequence, the oxide form of the fissile medium (PuO_2 or UO_2, as applicable) is always assumed.

For the AP process, a conservative assumption concerning the chemical form of the fissile matter is made for each step of the process, taking into account not only the nominal conditions but also the possible process upsets (e.g., failure of a PuO_2 filter or unwanted soda introduction that may cause precipitates) defined based on the double contingency principle. The different chemical forms used in the criticality analyses are as follows:

- PuO_2
- $Pu(NO_3)_4$
- $Pu(NO_3)_3$
- Plutonium oxalate.

6.3.4.3.1.2 Pellet Diameter (MP Process)

In some cases, the reference fissile medium is an array of pellets. In such cases, the pellet diameter is part of the definition of the reference fissile medium (as well as the pellet density and the plutonium content).

Note: For broken pellets, fragments, and grinding dust, the diameter of the original pellet is not controlled. Instead, bounding assumptions are used to evaluate the material.

The process values for pellets are as follows:

• Green standard pellets:	9.5 mm to 11.5 mm	(estimated value)
• Sintered standard pellets:	7.9 mm to 9.6 mm	(estimated value)
• Ground standard pellets:	7.84 mm to 9.49 mm	(nominal value)
• Green recycled-scrap pellets:	12.6 mm	(estimated value)
• Sintered recycled-scrap pellets:	10.49 mm	(nominal value).

Depending on the type of products that are likely to be contained or handled by each unit (i.e., green or sintered pellets, standard pellets, or recycled-scrap pellets), including those in an off-normal situation as defined by the safety analysis, the appropriate range of diameters is studied in the criticality calculations.

6.3.4.3.1.3 Rod Characteristics (MP Process)

In some cases, the reference fissile medium is an array of rods. In such a case, the rod geometry and material are part of the definition of the reference fissile medium (as well as the pellet density and the plutonium content).

The nominal values are as follows:

- Pellet diameter: 7.84 mm to 9.49 mm (standard ground pellet)
- Clad material: M5 zircalloy or zircalloy-4
- Clad thickness: 0.571 mm to 0.635 mm
- Clad outer diameter: 9.14 mm to 10.9 mm
- Active fuel stack height: 3,614 mm to 3,658 mm.

These parameters are important to the final product. The impact of a variation of these parameters on the calculated effective neutron multiplication factor (k_{eff}) will be justified based upon the criticality calculations and evaluated by the NCSEs.

6.3.4.3.1.4 Assembly Characteristics (MP Process)

In some cases, the assembly geometry is part of the definition of the reference fissile medium (as well as the rod characteristics and the plutonium content).

The process values are as follows:

- Number of rods: 204 to 264
- Rod lattice arrangement: 15×15 or 17×17
- Rod pitch: 12.60 mm to 14.43 mm.

These parameters are important to the final product. The impact of a variation of these parameters on the calculated effective neutron multiplication factor (k_{eff}) will be justified based upon the criticality calculations and evaluated by the NCSEs.

6.3.4.3.2 Choice of the Criticality Control Mode

Criticality safety in the MFFF is ensured by application of one or more of the following control modes, as well as by the control of the physicochemical forms of the fissile material (see Section 6.3.4.3.1):

- Geometry control
- Mass control
- Density control
- Isotopics control
- Reflection control
- Moderation control
- Concentration control
- Interaction control

- Neutron absorber (e.g., boron) control
- Volume control
- Heterogeneity control
- Process variable control.

Each of the available methods of control listed above is described in detail in Section 6.3.3. The criticality control methods to be implemented for each of the major AP and MP process units and areas are summarized in Tables 6-1 and 6-2, respectively. Detailed descriptions of the AP and MP processes are provided in Sections 11.3 and 11.2, respectively. The rationale for choosing the criticality control method for the different types of MFFF process units and areas is provided in the following sections.

6.3.4.3.2.1 Geometry Control

Geometry is the preferred control mode and is used for the following:

- Storage areas containing large quantities of fissile materials
- Process equipment whenever this imposed geometry is compatible with its process function, which is the case for most equipment of the AP process and for some pellet or rod handling equipment of the MP process.

The choice of geometry control implies the following:

- A thorough control of the equipment dimensions during design and fabrication.
- The nominal dimensions of the different pieces of equipment are defined taking into account possible deformations or changes in geometry due, for example, to corrosion, bulging, or the design basis earthquake, as applicable. The following accidental situations are among those considered:
  - Design basis earthquake – Seismic design of the structures guaranteeing the geometry as applicable
  - Leaks of chemical process vessels – Design of favorable-geometry drip trays.

Note: In the case of storage areas, geometry control involves not only the specification of the dimensions of the storage containers but also, for example, the specification of the pitch between the containers and sometimes of distances to concrete walls. In that case, neither reflection control nor interaction control as such is indicated (see Sections 6.3.4.3.2.5 and 6.3.4.3.2.8, respectively). However, neutron absorber control is sometimes used in combination with geometry control (see Section 6.3.4.3.2.9).

In the MFFF, all identified instances of geometry control are passive, controlled by design, and not the result of process control. As a consequence, geometry control is not listed as a process variable in Table 6-1 or 6-2.

6.3.4.3.2.2 Mass Control

Mass control is applied to several MP process units where the process function is not compatible with geometry control alone. Mass control can be used in combination with moderation control so that the mass limit is compatible with the quantity used in the process equipment.

Mass control can be implemented to eliminate unfavorable geometry concerns such as when the shape and size of the equipment is not compatible with the limits that would be imposed if geometry control alone were used. Typically, design calculations are performed assuming that the limiting mass of material is introduced to the unit or component of interest, and that favorable spherical geometry conditions are achieved (i.e., all the mass contained in a component or several components is assumed concentrated in a single sphere). In such cases, process variable control may be required to ensure that mass limits are maintained within the values assumed in the design calculation.

Mass control can be applied in conjunction with geometry control to MP processes involving the storage and handling of fissionable material in fixed-geometry components, or in fixed-geometry containers where interaction between multiple units is of concern. Significant benefits, compared to the implementation of geometry control alone, are achieved by taking advantage of limits imposed by the process function. For example, mass limits are imposed on J60 and J80 jars for the criticality control of the units where process operations take place (e.g., dosing, mixing, ball milling). In cases like the Jar Storage and Handling Unit, mass values corresponding to containers with less than full volume capacity at theoretical densities may be assumed when demonstrating that an interacting array geometry design is acceptable. In such cases, process variable control is required to ensure that mass limits are maintained within the values assumed in the design calculation, in addition to restrictions on geometry or other applicable neutron interaction control features accounted for in the design analysis.

Where mass control is identified in Table 6-1 or 6-2, it is also listed in the process variable column since it is controlled in that case as a result of the process.

6.3.4.3.2.3 Density Control

Density control is used in the cases of PuO_2 and MOX powders. However, in the case of sintered pellets (and most of the time also for green pellets), the maximum theoretical density of the sintered medium is used as a conservative assumption.

In the case of powders, conservative assumptions are made, based on process experience feedback, for the different types of products depending on the step in the process.

For example:

- PuO_2 that is incoming to the dissolution unit: $d \leq 7$ gm/cm^3
- Polished PuO_2, final blend, grinding dust, fresh UO_2: $d \leq 3.5$ gm/cm^3

Note: The assumed density of PuO_2 powder being dissolved (of ≤ 7 gm/cm^3) is quite high and, based upon experience, would not actually be expected. Values have been used in criticality

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	
Milling Unit KDM (cont.)														
Milling	NO $PuO_2 + H_2O$	YES	NO	NO [1] $d \leq 11.46$	NO [1] $^{240}Pu \geq 4\%$	NO	YES	NO	NO	NO	NO	NO	PC	Milling lower density
Sampling	NO $PuO_2 + H_2O$	YES	NO	NO [1] $d \leq 11.46$	NO [1] $^{240}Pu \geq 4\%$	NO	YES	NO	NO	NO	NO	NO	NO	
Sample pneumatic	NO $PuO_2 + H_2O$	YES	NO	NO [1] $d \leq 11.46$	NO [1] $^{240}Pu \geq 4\%$	NO	YES	NO	NO	NO	NO	NO	NO	
Prepolishing buffer storage	NO $PuO_2 + H_2O$	NO	YES Array of cylinders	NO [1] $d \leq 11.46$	NO [1] $^{240}Pu \geq 4\%$	NO	NO	NO	NO	YES Cole-manite concrete	NO	NO	NO	Colemanite concrete is a type of borated concrete.
Milling pneumatic transfer (arrival)	NO $PuO_2 + H_2O$	YES	NO	YES [1,9] $d \leq 7$	NO [1] $^{240}Pu \geq 4\%$	NO	YES	NO	NO	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	
Milling Unit KDM (cont.)														
Reusable can emptying	NO PuO_2 + H_2O	YES	NO	YES [1,9] d ≤ 7	NO [1] $^{240}Pu \geq 4\%$	NO	YES	NO	NO	NO	NO	NO	NO	
Dosing hopper	NO PuO_2 + H_2O	NO	YES Slab	YES [1,9] d ≤ 7	NO [1] $^{240}Pu \geq 4\%$	NO	NO	NO	NO	YES Cd coating	NO	NO	NO	
Recanning Unit KDR														
Convenience can packaging	NO PuO_2 + H_2O	YES	NO	NO [1] d ≤ 11.46	NO [1] $^{240}Pu \geq 4\%$	NO	YES	NO	NO	NO	NO	NO	NO	
Inner can packaging	NO PuO_2 + H_2O	YES	NO	NO [1] d ≤ 11.46	NO [1] $^{240}Pu \geq 4\%$	NO	YES	NO	NO	NO	NO	NO	NO	
Outer can packaging	NO PuO_2 + H_2O	YES	NO	NO [1] d ≤ 11.46	NO [1] $^{240}Pu \geq 4\%$	NO	YES	NO	NO	NO	NO	NO	NO	

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)														
Jar storage and handling unit	NO Arrays of J60 and J80 Jars	YES [13] J60 master blend ≤ 60 kg; J60 PuO_2 ≤ 13.2 kg, J80 total ≤ 80 kg, J80 PuO_2 ≤ 5 kg	YES	YES [1] PuO_2 ≤ 3.5 [6]; UO_2 ≤ 3.5 [6]; Master blend ≤ 5.5 [6]; Scraps ≤ 11;	YES ^{240}Pu ≥ 4%[1]; J60 %Pu ≤ 22% [5]; J80 Master blend %Pu ≤ 22% [5]; J80 Scraps %Pu ≤ 6.3% [5]	NO [2]	YES [14] %H2O <= 5% in the jars	NO	NO [2]	NO	NO	NO	NO	

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)														
Scrap Processing Unit	NO Scrap pellets	YES	NO	NO d ≤ 11	YES $^{240}Pu \geq$ 4%[1]; %Pu ≤ 6.3% [5]	NO [2]	YES [14]	NO	NO [2]	NO	NO	YES [5,7]	NO	
	NO Scrap powder	YES	NO	YES [6] d ≤ 5.5	YES $^{240}Pu \geq$ 4%[1]; %Pu ≤ 22% [5]	NO [2]	YES [14]	NO	NO [2]	NO	NO	YES [5,7]	NO	
Powder Auxiliary Unit	NO MOX Powder	YES	NO	YES [6] d ≤ 5.5	YES $^{240}Pu \geq$ 4%[1]; %Pu ≤ 22% [5]	NO [2]	YES [14]	NO	NO [2]	NO	NO	YES [5,7]	NO	
	NO MOX Pellets	YES	NO	NO d ≤ 11	YES $^{240}Pu \geq$ 4%[1]; %Pu ≤ 6.3% [5]	NO [2]	YES [14]	NO	NO [2]	NO	NO	YES [5,7]	NO	

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	
Pellet Process Area														
Pellet storage	YES Array of pellets [9]	NO	YES	NO d ≤ 11	YES $^{240}Pu \geq$ 4%[1]; %Pu ≤ 6.3% [5]	NO [2]	NO	NO	NO [2]	YES	NO	YES [8]	NO	-Isolation shields provided for interaction control between boats.
Sintering furnace	YES Array of pellets [9]	NO	YES	NO d ≤ 11	YES $^{240}Pu \geq$ 4%[1]; %Pu ≤ 6.3% [5]	NO [2]	NO	NO	NO [2]	NO	NO	YES [8]	NO	
Grinding	YES pellets [9]	YES	NO	NO d ≤ 11	YES $^{240}Pu \geq$ 4%[1]; %Pu ≤ 6.3% [5]	NO	YES	NO	NO	NO	NO	YES [8]	M	

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	
Pellet Process Area (Continued)														
Pellet inspection and sorting, Quality Control and Manual Sorting	YES pellets [9]	YES	NO [15]	NO $d \leq 11$	YES $^{240}Pu \geq 4\%$[1]; $\%Pu \leq 6.3\%$ [5]	NO	YES	NO	NO	NO	NO	YES [8]	NO	-Physicochemical characteristics control applied to verify pellet dimensions.
Pellet tray-baskets storage	YES Array of pellets [9]	NO	YES	NO $d \leq 11$	YES $^{240}Pu \geq 4\%$[1]; $\%Pu \leq 6.3\%$ [5]	NO [2]	NO	NO	NO [2]	YES	NO	YES [8]	NO	-Interaction between storage units controlled by isolation shields.
Scrap pellet storage	YES Final blend pellet scraps [9]	NO	YES	NO $d \leq 11$	YES $^{240}Pu \geq 4\%$[1]; $\%Pu \leq 6.3\%$ [5]	NO [2]	NO	NO	NO [2]	YES	NO	YES [8]	NO	-Interaction between storage units controlled by isolation shields.
Scrap box loading, Pellet Repackaging, Pellet Handling	YES Array of pellets [9]	YES	NO	NO $d \leq 11$	YES $^{240}Pu \geq 4\%$[1]; $\%Pu \leq 6.3\%$ [5]	NO	YES	NO	NO	NO	NO	YES [8]	NO	

- Control of combustible materials.

These additional protection features incorporate selected recommendations of NRC Information Notice 92-14, *Uranium Oxide Fires at Fuel Cycle Facilities*. Consideration of recommended administrative controls (operator training, process unit operator attendance, etc.) will be addressed in facility procedures.

8.5.1.6.2 PuO_2

Although PuO_2 is unreactive in air, sub-stoichiometric compounds of plutonium can be formed as a result of partial oxidation of plutonium metal. These compounds can be pyrophoric and when exposed to an oxidizing atmosphere could rapidly form PuO_2 while releasing heat. To control this hazard the MFFF will ensure that a stable PuO_2 form is introduced to the MFFF.

Plutonium feed material is received at the MFFF from the Pit Disassembly and Conversion Facility (PDCF). A small quantity of feed material (alternate feed stock) will initially be supplied from alternate sources until the PDCF is operational. To ensure stability of the MFFF Pu feed material, both of these sources will supply PuO_2 satisfying the requirements of DOE-STD-3013-2000, *Stabilization, Packaging, and Storage of Plutonium-Bearing Materials*. Specifically, the requirement that oxide material be placed in a continuously oxidizing atmosphere at a material temperature of at least 950° C for a minimum of two hours ensures a stable product. Not only does this requirement eliminate sub-stoichiometric plutonium oxides and finely divided metal, it also achieves the following additional stabilization objectives:

- Elimination of organic materials
- Reduction of water content to less than 0.5 wt% and reduction of quantities of species that may produce water
- Minimization of potential for water readsorption above the 0.5% threshold
- Stabilization of any other potential gas-producing constituents

DOE-STD-3013-2000 accepts two methods of verification that materials have been adequately stabilized. These methods are 1) testing of every container loading or 2) use of a "qualified process" for stabilization and packaging that would reduce the requirements for materials testing. Details of the method to verify the receipt of stabilized material will be addressed in the ISA.

The formation of sub-stoichiometric oxides is associated with the conversion of plutonium metal to oxide. The conversion process step associated with MFFF aqueous polishing converts plutonium oxalate to plutonium dioxide. The formation of sub-stoichiometric oxides during this conversion process is not a concern as reduction of the Pu (IV) oxalate does not occur.

It should also be noted that the thermal power generated by the decay of plutonium has been taken into account in the design. The design basis values are as follows:

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

See section 5.5.2.1.6.9 for additional details regarding the effects of decay heat.

8.5.1.7 Plutonium (VI) Oxalate

Plutonium oxalate is produced in the VI valence state in the plutonium dissolution unit and dechlorination unit, where it is reduced utilizing H_2O_2 to Pu (IV) prior to entering the purification unit. In addition, Pu (VI) is produced within the oxalic mother liquor recovery unit. This material is then re-introduced into the purification unit. Within the oxalic precipitation and oxidation unit, the plutonium oxalate is precipitated via the addition of oxalic acid. In case of misoperation, Pu (VI) instead of Pu (IV) could be introduced within the oxalic precipitation and oxidation unit. The Pu (VI) oxalate could then be introduced into the calcining furnace, which would create a hazard as discussed below.

Experimental evidence performed using differential thermal analysis (DTA) has evaluated the activation energy and order of the reaction for the thermal decomposition of $PuO_2C_2O_4{:}3H_20$ in air. The DTA curve for Pu (VI) oxalate shows a broad endothermic peak (due to dehydration) with a maximum at 142°C and a sharp exothermic peak (oxidation of the oxalate) with a maximum at 219°C. The dehydration enthalpy was determined to be 13 kcal/mole and the exothermic reaction was found to be -25 kcal/mole. Although not particularly exothermic, the decomposition is rapid and can be explosive. (Plutonium (VI) is likely to be reduced to Pu (III) as an intermediate oxidation state in this reaction, but, as with Pu(IV) oxalate, the final product will be PuO_2.) Therefore, DCS has implemented a preventative safety strategy to satisfy the performance requirements of 10 CFR §70.61.

The design basis to control this hazard is to preclude the introduction of Pu(VI) oxalate into heated equipment where temperatures in excess of 219°C are credible. In addition, controls will be in place to ensure that temperatures do not exceed 219°C where plutonium (VI) oxalate may be present (e.g., in the oxalic mother liquor recovery unit and in the oxalic precipitation and oxidation unit). The specific temperature setpoints will be determined during final design.

8.5.1.8 Hydrazoic Acid

Hydrazoic acid, also known as hydrogen azide (HN_3), is formed when hydrazine (N_2H_4 or $N_2H_5^+$) is oxidized by nitrous acid (equation 8.5-7). Further oxidation leads to the formation of nitrous oxide and nitrogen gases (Equation 8.5-8).

$$N_2H_5^+ + HNO_2 \rightarrow HN_3 + 2H_2O + H^+ \qquad (8.5\text{-}7)$$

$$HN_3 + HNO_2 \rightarrow N_2O + N_2 + H_2O \qquad (8.5\text{-}8)$$

The competitive nature of the hydrazoic acid formation reaction (equation 8.5-7) and its scavenging reaction (equation 8.5-8) initially establishes preferable generation of hydrazoic acid due to the faster reaction kinetics associated with nitrous acid and hydrazine (equation 8.5-7).

10. ENVIRONMENTAL PROTECTION

The components of the Mixed Oxide (MOX) Fuel Fabrication Facility (MFFF) Environmental Protection Program include the following:

- The Radiation Safety Program, which is established to control and assess the level of radioactive releases to the environment during normal and anticipated off-normal operations, minimize facility contamination, and minimize waste generation
- The Effluent Monitoring Program, which is established to measure and monitor the radioactive effluents released from the facility
- The Environmental Monitoring Program, which is established to monitor potential environmental impacts from operations.

10.1 RADIATION SAFETY PROGRAM

The Radiation Safety Program is described in Chapter 9. That portion of the Radiation Safety Program related to protection of the environment is given herein.

10.1.1 ALARA Goals for Effluent Control

Effluent control begins with the facility design by limiting the material capable of becoming a radioactive effluent. The MFFF processes generate minimal airborne radioactive effluents, and no radioactive liquid effluents are released directly to the environment.

The as-low-as-reasonably-achievable (ALARA) goal for airborne radioactive effluents released from the MFFF is 20% of the effluent concentrations from 10 CFR Part 20, Appendix B, Table 2, Column 1. Additionally, the goal for total effective dose equivalent to the individual member of the public likely to receive the highest dose from the facility, based on estimates for normal operations, is less than 10 mrem/yr. Normal operating release values are calculated at the restricted area boundary (RAB). The dispersion model calculates the X/Q for the 50 % annual average for a receptor at the closest point to the stack (170.6 ft [52 m]). The X/Q value is 2.5E-4 sec/m^3. The maximum dose contribution is from Pu-239 and the concentration is 7.25E-16 microCi/ml, which is less than the ALARA goal and the constraint on air emissions of 10 CFR §20.1101(d). Procedures will be established to report exceedances of the constraint level in accordance with 10 CFR §20.2203 and to take prompt corrective action to prevent recurrence.

An ALARA goal for radioactive liquid effluents is not provided since the facility design precludes the release of radioactive liquid effluents to the environment.

10.1.2 Effluent Controls to Maintain Public Doses ALARA

As previously indicated, the MFFF does not discharge any radioactive liquid directly to the environment. The only nonradioactive liquid effluent is from storm drains. The sanitary drains are not in radiation areas.

Radioactive airborne effluents from the MOX processing (MP) and aqueous polishing (AP) process areas are filtered and released through the stack located on the roof of the MOX Fuel

Fabrication Building. Design features that support reduced airborne effluent releases to maintain public doses ALARA include the placement and use of filter banks containing a minimum of two stages of high-efficiency particulate air (HEPA) filters. These filters minimize environmental releases by removing particulates present in ventilation exhaust. Spaces with the greatest potential for generating airborne contaminants in the effluent (i.e., gloveboxes) are exhausted through these filters prior to discharge to the environment. Design features of the AP ventilation system also take into account potentially corrosive materials.

Specific decontamination factors have not been established for all filters but are expected to be more than adequate to reduce the total radioactivity to acceptable levels. The experience at the MELOX and La Hague facilities is that the concentrations of airborne effluents are less than the minimum detectability of continuous air monitors (CAMs) and samples evaluated in the laboratory.

The combined MP and AP airborne effluents are monitored with two monitoring systems, including two CAMs and two fixed air samplers, with each unit provided air representative of that present in the stack. A representative sample of the particulate effluent from the stack is collected continuously for determination of quantities and average concentrations of radionuclides released. The sampling is conducted regardless of the concentration of radioactive material in the effluent, which is expected to be negligible under normal operating conditions.

Trending of results from effluent monitors, samplers, and other MFFF airborne monitoring equipment provides early indications of elevated radiation environments. Procedures will be developed to identify evaluations and actions to be taken when the concentrations of airborne radioactivity exceed prescribed limits.

To investigate elevated stack releases and/or anomalies, sample connections are installed at key locations in the MP and AP process area ventilation ducts. The placement and use of sample connections are based on the risk to facility workers, site personnel, and members of the public. The potential for leakage from process systems, equipment, and confinements is also considered. The evaluation focuses on the equipment and spaces with the higher potential for leakage or airborne contaminants (e.g., AP process cells, and AP and MP gloveboxes) as determined by experience at the MELOX and La Hague facilities. During MFFF operations, elevated readings from CAMs and/or fixed air samplers will be used to identify the need to perform maintenance or to take other action to reduce effluent releases. Following a loss of offsite power, the CAMs and fixed air samplers obtain power from the uninterruptible power supply (UPS) and emergency diesel power sources.

10.1.3 ALARA Reviews

ALARA reviews and reports to management include the development of trending charts so that analytical results and effluent monitor readings can be trended against the goals. Abnormal increases in the trending of either the monitor readings or the analytical results are reported to MFFF management as soon as practical. To ensure that releases are maintained ALARA, management is informed of the trends measured against the goals on a quarterly basis. Annually, the goals are reevaluated and new goals are established for the upcoming year.

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- Use of impact-resistant materials for window panels
- Design of the glovebox floor to withstand the impact of potential load drops
- Use of barriers or guides to prevent the fall of containers and other equipment inside the glovebox and to protect windows from external impact.

Gloveboxes and their principal SSCs are designed and fabricated in accordance with the following codes and standards:

- ANSI N690-1994, *Specification for the Design, Fabrication and Erection of Safety Related Steel Structures for Nuclear Facilities*
- AWS D1.1-2000, *Structural Welding Code*

Gloveboxes are designed with pressure/vacuum-relief devices that prevent over-pressurizing gloveboxes and excessive negative pressures.

The glovebox ventilation will provide sufficient flow to compensate for in-leakage rate of 0.25 percent of the glovebox volume per hour at -4.0 in WG (-1000 Pa).

Redundant pressure sensors monitor differential pressure with respect to the process room and alert the operators to upset conditions. The instruments remain operational following facility fires in unaffected areas, tornadoes, and design basis earthquakes.

11.4.11.3 3013 Canisters

The 3013 inner and outer canisters are designed according to the specifications in DOE-STD-3013-2000, *Stabilization, Packaging, and Storage of Plutonium-Bearing Materials.*

11.4.11.4 3013 Transport Casks

The 3013 Transport casks are designed for applicable requirements of 10 CFR Part 71.

11.4.11.5 MOX Fuel Transport Cask

The MOX fuel transport casks are designed and certified separately in accordance with 10 CFR Part 71.

11.4.11.6 Waste Containers

MOX transuranic wastes are packaged in waste containers designed to DOT Type A Specification 7A and are vented and filtered, as appropriate.

11.4.11.7 Transfer Containers

Transfer containers are designed to withstand applicable events. These events will be identified in the ISA.

11.4.11.8 Sintering Furnace Confinement Boundary

The sintering furnace provides a primary confinement boundary function. The design basis for the sintering furnace is as follows:

The seals for the sintering furnace are designed for peak temperature of 316°C. The furnace is shutdown with no damage to the confinement barrier if overheating or low cooling flow conditions exist.

The furnace shell and airlocks are designed to withstand an over pressure of 2.5 bar (36.3 psi). The furnace shell leak tightness is specified at 5E-5 leaked vol/hr at 2.2 psi. To prevent furnace overpressure conditions, the following controls are implemented:

- High humidifier water level isolates the humidifier water feed line to prevent excessive moisture carryover to the furnace and subsequent over pressure due to rapid steam generation.
- Hydrogen hazards are prevented as discussed in Section 8.5.
- The furnace is designed to operate at a slight overpressure. Pressure control and overpressure protection are provided by redundant pressures controls.
- The furnace is designed to maintain its confinement function during the design basis earthquake.

11.4.11.9 Process Cell

Process cell leak confinement is performed by drip trays. The drip tray design basis is to contain the maximum inventory of the largest vessel in the cell. Drip trays are fully welded and designed to withstand a design basis earthquake.