DUKE COGEMA
STONE & WEBSTER

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DCS-NRC-000085

Subject: Docket Number 070-03098
Duke Cogema Stone & Webster
Mixed Oxide Fuel Fabrication Facility
Construction Authorization Request
Clarification of Responses to NRC Request for Additional Information

As part of the review of Duke Cogema Stone & Webster's (DCS') Mixed Oxide Fuel Fabrication Facility (MFFF) Construction Authorization Request (CAR), NRC Staff requested clarifications of DCS' responses to NRC's Request for Additional Information (RAI). These clarifications were discussed during a series of teleconferences and on-site reviews between NRC Staff and DCS. The majority of the clarifications are noted in the NRC on-site review summaries from A. Persinko to E. Leeds dated 03 November 2001, 06 November 2001, 18 December 2001, 28 February 2002, and from T. Johnson to E. Leeds dated 30 January 2002. DCS provided part of the requested information by letters DCS-NRC-000074 dated 05 December 2001, DCS-NRC-000081 dated 07 January 2002, DCS-NRC-000082 (Proprietary) and DCS-NRC-000083 (Non-Proprietary) both dated February 11, 2002.

Enclosure A to this letter provides additional responses to NRC clarification requests. The responses address clarifications regarding electrical, nuclear criticality safety, confinement/ventilation, fire protection, instrumentation and control, safety analysis and chemical safety, physical security, mechanical/material handling, financial considerations, radiological consequences, polycarbonate report, site description, and structural. If you have any questions, please contact me at (704) 373-7820.

Sincerely,

K L Ashe for

Peter S. Hastings, P.E.
Licensing Manager

Enclosures: A. Responses to NRC Clarification Requests
B. Natural Phenomena for MFFF Design

NMSS01 public

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Enclosure A
Responses to NRC Clarification Requests

ELECTRICAL

Clarification Requested:

RAI 162: On Page 23 of the DCS's January 7, 2002, response, DCS quotes Section 5.2 of the Institute of Electrical and Electronics Engineers (IEEE) Std-484, "IEEE Recommended Practice for Installation Design and Installation of Vented Lead- Acid Batteries for Stationary Applications," as requiring "acid resistant insulation" between battery cells and steel racks. Regulatory Guide (RG) 1.128, "Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants," requires not just "acid resistant" but also "moisture resistant" insulation. Will the insulation also be moisture resistant {28 February 2002, item 7A}.

Response:

The insulation between the batteries and racks will be acid and moisture resistant. A material that does not absorb and hold moisture will be used.

Clarification Requested:

RAI 162: Regarding page 23 of DCS's January 7, 2002, response, Item 6: RG 1.128 states that the "shoulds" in the listed sections of IEEE Std 484 must be treated as "shalls." DCS needs to clarify its commitment to RG 1.128 and its application of "shoulds" and "shalls" {28 February 2002, item 7B}.

Response:

DCS is only committed to the wording of the IEEE standard and any additional commitments made through correspondence with the NRC. DCS has not committed to RG 1.128. To the extent practical, DCS intends to implement the guidance identified in the standard with "shoulds." There are some instances where replacing "should" with "shall" adds no value to the guidance or makes the guidance impractical for demonstrating compliance. For example, the standard indicates that the charging system and main distribution "should be as close as practical." Replacing should with shall adds no value to this guidance. DCS believes the standard is worded appropriately for the nature of the guidance provided.

Clarification Requested:

On Page 22 of DCS's January 7, 2002, response, Item 1 states that subsection 4.1.4 of RG 1.128 requires that the hydrogen concentration be limited to less than 2% at any location in the battery area. DCS also quotes that IEEE Std 484-1996 requires the hydrogen concentration to be less than 2% of the total volume of the battery area. Thus, RG 1.128 requirement covers every area while IEEE Std-484 requirement is an average across the whole room. DCS should address these different requirements. According to the National Fire Protection Association (NFPA) 801, "Standard for Facilities Handling Radioactive Materials", the concentration of hydrogen

ELECTRICAL

must be kept below 25% of lower flammability limit (LFL) or lower explosive limit (LEL) where the LFL for hydrogen is 4% by volume. Also NFPA 70E, "Standard for Electrical Safety Requirements for Employee Workplaces," requires that ventilation systems limit hydrogen accumulation to no more than 1%. DCS should address these NFPA requirements in contrast to those of RG 1.128 and IEEE Std-484 and describe to which requirements it is adhering.

Response:

DCS is committed to IEEE 484-1996. The battery room ventilation, both normal and emergency, will limit the hydrogen accumulation to less than 2% of the total volume of the battery area. DCS is not committed to Regulatory Guide 1.128. In practical terms, only one hydrogen sensor would be located in a battery room at a location that would give the best indication of an H_2 accumulation. DCS does not believe that locating multiple sensors in a battery room and averaging the readings would be reasonable or practical. DCS believes that the proposed design meets the intent of both the IEEE standard and the regulatory guide. DCS's position on hydrogen explosion limits in NFPA 801 is that that standard is applicable to enclosed spaces, e.g. tanks and confined spaces, where hydrogen could accumulate. The battery room is well ventilated. DCS is not commited to NFPA 70E. DCS is committed to NFPA 111 for battery rooms. This standard (NFPA 111) requires 2 air changes per hour to limit accumulation of gases.

Clarification Requested:

Section 5.4 of IEEE Std 484-1996 states that for batteries the ventilation system shall limit hydrogen accumulation to less than a specific value. Also a prior version of this standard stated that the ventilation system should maintain the battery room temperature within design temperatures. Review of the CAR indicates that although the emergency diesel generator building HVAC systems ventilate and cool the emergency switchgear rooms, there appears to be no discussion pertaining to those systems maintaining the emergency diesel generator starting batteries temperatures within their design requirements nor limiting hydrogen accumulation. Also there appears to be no discussion of the HVAC systems and their capabilities for specifically maintaining temperatures and limiting hydrogen accumulation in rooms containing other batteries such as the emergency dc system batteries. Additionally, some of these ventilation systems may operate intermittently (such as when the diesel generator is running) and some battery rooms may not have hydrogen or loss of ventilation alarms. NFPA 801 requires detection of hydrogen accumulation "in enclosed spaces" where combustible gases could accumulate. The applicant does not consider electrical equipment rooms to be enclosed because they are ventilated. The applicant should address the capabilities of the HVAC systems related to maintaining appropriate temperatures for MFFF batteries and limiting hydrogen accumulations. The applicant should identify which of those HVAC systems, as well as any other systems or components related to hydrogen control, are PSSCs. Further, the applicant

ELECTRICAL

should justify not treating electrical equipment rooms as enclosed spaces especially when no or intermittent ventilation systems are used. {28 February 2002, item 7D}

Response:

The emergency diesel generator starting batteries are provided with the engine generator package. For the current emergency diesels for the MFFF, these batteries would be sealed, “maintenance free” type batteries, typically mounted on a side rail attached to the engine skid. These batteries are similar to automotive batteries and have minimal hydrogen generation, if any. Hydrogen accumulation in the diesel rooms is not a concern because the diesel batteries are not subjected to rapid charging or discharging which generates hydrogen. The batteries are designed to operate at a 60^0F minimum temperature. A room heater and low temperature alarm are provided in each emergency diesel room. These heaters are energized at approximately 65^0 F. If the temperature in the rooms falls below 65^0F, the alarm will alert operators to take action to heat the room. Once started the diesel engine heat will maintain the room temperature and the batteries will have completed their starting function. The diesel generator rooms are large spaces with intermittent ventilation when the machine is not operating. These rooms are not underground nor air tight. The diesel and switchgear rooms have multiple openings for entry and exit, the rooms are designed for continuous worker occupancy and the rooms do not have unfavorable natural ventilation. Therefore DCS believes that the diesel rooms, the switchgear rooms, and the battery rooms are appropriately not characterized as enclosed spaces as those addressed by NFPA 801 and H_2 would not accumulate in the area.

The emergency and normal battery rooms are located in the Shipping and Receiving Area. Each of these rooms is provided with battery room ventilation to limit the hydrogen accumulation to less than 2% in accordance with IEEE 484. The CAR sections 11.4 describing ventilation will be revised to more fully discuss the battery room ventilation systems. Additional specific design detail will be provided as part of the license application.

The uninterruptible power supply (UPS) systems for the VHD system fans are located within the emergency switchgear rooms in the emergency diesel generator building. These UPS systems are packaged units that contain a set of sealed maintenance free batteries within a cabinet. All electrical equipment within the switchgear rooms is separated by National Electric Code (NEC) minimum clearances sufficient to provide for equipment removal and maintenance. The batteries associated with the UPS sets are not exposed to arcing contacts. As stated previously, DCS’s position is that the requirements for hydrogen accumulation in NFPA 801 apply to enclosed spaces where, for example, hydrogen could accumulate in a tank. The electrical equipment rooms with a HVAC system in them are not characterized as an enclosed space.

ELECTRICAL

Clarification Requested:

Section 5.1 of IEEE Std 484-1996 states that in battery areas, nearby equipment with arcing contacts shall be located in such a manner as to avoid those areas where hydrogen pockets could form. Section 6.1.7 of Regulatory Guide 1.189, "Fire Protection for Operating Nuclear Power Plants," states that switchgear and inverters should not be located in battery rooms. Also NFPA 801 recommends separation of major concentrations of electrical equipment from adjacent areas. Review of the CAR indicates that switchgear, diesel generators, and other arcing equipment may be located in the same room or in close proximity to batteries. The applicant should address this issue.

Response:

DCS is not committed to Regulatory Guide 1.189. The preceding response above discusses the type of batteries in the diesel rooms and the type of batteries in the switchgear rooms. Note that the diesels are standard packaged units with a history of many hours of reliable and safe service throughout industry. For the UPS packages located in the switchgear rooms, the sealed batteries are in an enclosed vendor supplied cabinet. The switchgear cabinets and motor control centers are closed units separated by safe minimum clearances. The rooms are well ventilated and climate controlled. DCS believes that the proposed design does meet the requirements of IEEE 484.

Enclosure A
Responses to NRC Clarification Requests

NUCLEAR CRITICALITY SAFETY

Clarification requested:

Provide justification for the experience levels (i.e., required years of nuclear industry experience) for Nuclear Criticality Safety (NCS) staff during the design phase. In addition, add the requirement that individuals in the NCS Function Manager, Senior NCS Engineer, and NCS Engineer positions must have a specified amount of technical experience in uranium/plutonium (or MOX) processing. Provide a criterion on how much experience directing an NCS Function is required for the NCS Function Manager. Guidance on accepted experience levels at other fuel facilities was provided to you by letter dated November 9, 2001 (RAI 68) {03 Nov 2001 item 3F, 28 February 2002, Item 6B}.

Response:

By letter, dated November 9, 2001, NRC provided experience requirements for NCS Managers, Level II NCS Engineers and Level I NCS Engineers at 9 facilities and 3 guidance documents. DCS has compared these accepted experience statements against the previous response to RAI 68 dated August 31, 2001 for NCS staff during the design phase. As a result of this review, DCS provides the following changes (highlighted in bold) to experience requirements.

NCS Function Manager requirements for the design phase are:

Draft 10 CFR Part 70 SRP	**August 31, 2001 Response**	**Changes as a result of information provided in NRC November 9, 2001 letter**
BS/BA or equivalent; and	BS/BA degree in science or engineering	BS/BA degree in **nuclear** science or engineering
	At least 2 years nuclear industry experience in criticality safety	**3 years** nuclear industry experience in criticality safety
Technical experience in NCS at a similar facility	An understanding and experience in nuclear criticality safety.	**Have experience in the understanding, application, and direction of NCS programs.**
		Have a familiarity with NCS programs at similar facilities
		.
The typical NCS Manager in NRC's November 9, 2001 letter had an experience base that ranged from a BS/BA degree in engineering or the physical sciences or equivalent technical experience and 4 years general nuclear experience (PGDP-PDKY) to BA/BS degree in nuclear science or engineering and 3 years of experience in NCS (NFS-ERW).		

NUCLEAR CRITICALITY SAFETY

NCS Senior Engineer requirements for the design phase are:

Draft 10 CFR Part 70 SRP	**August 31, 2001 Response**	**Changes as a result of information provided in NRC November 9, 2001 letter**
BS in science or engineering and	BS or BA degree in science or engineering with	No Change required
3 years experience in NCS	2 years or more of nuclear industry experience in criticality safety	**3 years of experience in NCS work**
The typical Level II NCS engineer identified in NRC's November 9, 2001 letter had an experience base that ranged from a BA/BS degree or equivalent in science or engineering and 2 years of nuclear industry experience in NCS (FRAM-LYN) to a BA/BS degree in science or engineering and 3 years experience in NCS work (NFS-ERW).		

NCS Engineer requirements for the design phase are:

Draft 10 CFR Part 70 SRP	**August 31, 2001 Response**	**Changes as a result of information provided in NRC November 9, 2001 letter**
BS in science or engineering; and	BS or BA degree in science or engineering with	No change required
1 year experience in nuclear criticality safety	1 year of nuclear industry experience in criticality safety.	No change required
The typical Level I NCS engineer identified in NRC's November 9, 2001 letter had an experience base that ranges from a BS/BA degree in science or engineer and no experience to a BS/BA degree in science or engineering and 1 year experience in NCS work (fuel fabrication facilities) and additional internal and external training with oversight by a senior NCS engineer (at enrichment facilities).		

NUCLEAR CRITICALITY SAFETY

Clarification requested:

For each Criticality Control Unit (CCU) in Tables 6-1 and 6-2 for which numerical parameter limits are given but the associated parameter is not identified as a controlled parameter, provide justification for the limiting values stated. In particular, justify not controlling the physiochemical form of the process material where $Pu(NO_3)_3$ is assumed, and justify the use of densities when less than theoretical densities are used (RAI 83) {28 February 2002, Item 6C}.

Response:

In response to NRC's clarification on Table 6-1 and $Pu(NO_3)_3$, the absence of a more reactive material is ensured by two upstream independent filters, between the electrolyzer and the dilution tank. Therefore, two independent filters are credited for controlling the fissile medium in the dilution tank. There are no further controls necessary for downstream tanks since there is no credible way of introducing a more reactive fissile medium.

In response to NRC's RAI 83, DCS indicated in Table 6-1 for most downstream units that credit is taken for the upstream control (by the filters) in preventing a fissile medium more reactive than $Pu(NO_3)_3$, pointing out via footnote [6] that it is controlled by an upstream unit.

However, in two rows in Table 6-1, for the Pu Rework tank and the Rafinates, Reception, and Recycling, Control Tanks, an oversight was made. In these two cases, upon the next issuance of Table 6-1, DCS will revise these two rows from "NO" to "YES" and add footnote [6] as was done for the other units.

The justification for use of densities less than theoretical densities will be provided in a later response.

NUCLEAR CRITICALITY SAFETY

Clarification requested:

The February 11, 2002, clarification for RAI Question 80/81 states that systems that rely on passive geometry control automatically meet the double contingency principle, because there are no credible changes in process conditions that can occur causing a criticality. This is not necessarily correct, because in some cases the geometry can be altered by bulging, corrosion, or other mechanisms, and in other cases, geometry can fail and result in material accumulating in unfavorable geometry areas. Commit to evaluate on a case-by-case basis the potential for the system geometry to be altered. Clarify that passive geometry control is sufficient to ensure compliance with double contingency only if there are no credible means of changing the system geometry, and that if credible means of changing the system geometry exist, sufficient controls will be established to ensure that at least two independent, unlikely, and concurrent, changes in process geometry are needed before criticality is possible (RAI 80/81) {28 February 2002, Item 6D}.

Response:

DCS agrees with the above clarification that geometry control is sufficient to ensure compliance with double contingency only if there are no credible means of changing the system geometry. And that if credible means of changing the system geometry exist, sufficient controls will be established to ensure that at least two independent unlikely and concurrent changes in process geometry are needed before criticality is possible. DCS also agrees that the standard practice will be to evaluate on a case-by-case basis the potential for system geometry to be altered.

Clarification requested:

ANSI/American Nuclear Society (ANS) –8.1-1983 (R1998): In your December 5, 2001, clarification letter you add the words "...or other justifications..." to your discussion of how extensions for the area(s) of applicability for validated calculational methods will be treated. Clarify what specific methods will be used to provide this additional justification (also, ANSI/ANS-8-17-1984) {28 February 2002, item 6D}.

Response:

DCS uses detailed calculations to demonstrate subcriticality of MFFF units under normal and credible abnormal conditions. DCS references these calculations, among other information and arguments, to show that criticality events under normal and credible abnormal conditions are highly unlikely.

The specific methods that DCS will employ to provide the additional justifications will be to include in the specific calculations and NCSEs used to demonstrate criticality safety in the MFFF the necessary arguments. These arguments will be based upon engineering logic and justification and will be quality assured including being design verified.

NUCLEAR CRITICALITY SAFETY

Clarification requested:

ANSI/ANS-8.1-1983 (R1998): In your August 31, 2001, RAI Response, you defined "unlikely" for meeting the double contingency principle as "not expected to occur during the facility lifetime." Clarify what is meant by this phrase-e.g., whether the facility lifetime is assumed to be on the order of 10 or 100 years and how you assured that "not expected to occur during the facility lifetime" was determined for the lifetime assumed {28 February 2002, item 6D}.

Response:

DCS uses a systematic approach to demonstrating that criticality events under normal and credible abnormal conditions are highly unlikely using a qualitative argument. Using that approach, the failure of certain relevant controls (IROFS) is considered to be "unlikely." This context is consistent with a failure that not expected during the facility lifetime. Since this is a qualitative approach, it is not possible to assign any particular failure probability. However, this qualitative approach is consistent with a failure probability on the order of once in 100 years.

Clarification requested:

ANSI/ANS-8.15-1981: In your December 5, 2001, clarification letter, you state that criticality control involving special actinide elements may be demonstrated by reference to the limits specified in ANSI/ANS-8.1. In your August 31, 2001, RAI response, it is mentioned that special actinide elements will be present "in relatively low concentrations in mixtures with ^{235}U and ^{239}Pu." Quantify when the concentration of special actinide elements is sufficiently low that the limits of ANSI/ANS-8.1 may be used conservatively (RAI 90) {28 February 2002, item 6D}.

Response:

As stated in the August 31, 2001, ANSI/ANS-8.15-1981 will not be referenced as a basis of design for the MFFF and DCS will use the guidance of ANSI/ANS-8.1-1983 (R1998) instead. DCS is committed to the guidance of ANS-8.1 and has to date, and intends to explicitly evaluate the criticality safety of the MFFF using validated NCS analysis methodology. However, ANS-8.1 does allow the appropriate use of single parameter limits of multi-parameter limits (sections 5 and 6).

At this time, DCS has not quantified the circumstances, including levels of special actinide elements, under which the use of single parameter limits of multi-parameter limits would be appropriate. Should such limits be used, they will be justified in the NCS calculations and NCSEs.

CONFINEMENT/VENTILATION

Clarification Requested:

Is the discharge stack a PSSC? If so, what is its design basis for seismic and other natural phenomena events and accidents {28 February 2002, item 4}?

Response:

In the CAR, the stack was considered as a component of the very high depressurization (VHD) system and high depressurization exhaust (HDE) system and these systems are identified as Principal SSCs. Specific components of these systems that are IROFS will be identified in the ISA. However, the stack is a principal SSC component whose function is to provide an adequate flowpath to allow the ventilation systems to function properly. The stack is designed in accordance with the requirements for SC-I structures described in CAR Section 11.1.7, "Design Basis for Principal SSCs."

Enclosure A
Responses to NRC Clarification Requests

FIRE PROTECTION

Clarification Requested:

Discuss how the FHA interfaces with the Safety Analysis {28 February 2002, item 1A}.

Response:

The Fire Hazards Analysis (FHA) is part of the ISA and is an ongoing process during design. During the initial phase of the ISA (Safety Assessment [SA] of the design basis), a fire safety strategy was formulated for each respective fire area of the facility. This safety strategy was based on a consequence analysis for each of the respective fire areas and an assessment of the feasibility of implementing the selected fire safety strategy. In this consequence analysis, the total quantity of (nuclear) material at risk was assumed to be involved in a fire. The SA led to the following general assumptions regarding the fire safety strategy:

- Fires within the process cells are prevented (i.e., demonstrated to be highly unlikely).
- Fires involving material within gloveboxes are required to be effectively mitigated to meet the performance requirements of 10 CFR 70.61.
- Fires involve no more than one fire area.
- Combustible loading within rooms is controlled such that the HDE system filters will effectively mitigate releases.
- Fires in Medium Depressurization Exhaust (MDE) (C2) areas are small and do not impact radioactive material.

To support these assumptions, a number of calculations are performed as part of the ISA. For the first assumption, hazard analyses are performed to demonstrate that sufficient controls are present such that process upsets that could lead to a fire are highly unlikely. In conjunction with this analysis, the FHA verifies that no ignition sources are present in the process cells and that fires external to process cells, should they occur, will not affect a given process cell.

To support the remainder of the assumptions, the FHA examines both the combustible loading and possible ignition sources. This information is then utilized to demonstrate that the fire barriers are not compromised, fires will not affect radioactive material within the C2 confinement areas, and that the effects of a given fire will not affect the ability of the high efficiency particulate air (HEPA) filters to mitigate a release that may accompany a glovebox fire.

Finally, the ISA process determines both the effectiveness and likelihood of failure of identified IROFS. With respect to fire, an assessment determines that those IROFS that are required to remain operable and effective during a fire do so. The assessments of the respective process units are summarized and documented as part of the Nuclear Safety Evaluations.

FIRE PROTECTION

Clarification Requested:

The FHA states that "Fires involving material within the gloveboxes are required to be effectively mitigated to meet the performance requirements of 10 CFR 70.61." Wording in the FHA implies that the nitrogen system is being relied on to perform this mitigation. Further, DCS response to RAI 207 states that the rear bearing of the calcination furnace is scavenged with nitrogen for containment purposes. Since it appears that the nitrogen system is relied on to mitigate fires and for containment, is the nitrogen system a PSSC {28 February 2002, item 1B}?

Response:

The FHA statement in question, which is reiterated in the response to the question above, was not meant to imply that the nitrogen system is being relied on to mitigate fires involving material within gloveboxes. Rather, the intent of this statement is to rely on the C3 exhaust ventilation system and the fire barriers in areas containing gloveboxes, which are PSSCs. The nitrogen system is not a PSSC.

Clarification Requested:

Is there a soot loading analysis for the C4 final filter {28 February 2002, item 1C}?

Response:

The soot loading analysis for the C4 final filter is being prepared as part of the ISA.

Clarification Requested:

Exhaust dampers in rooms with gloveboxes are manually operated. How is the operation of dampers guaranteed to ensure C4 confinement {28 February 2002, item 1D}?

Response:

The design basis is not to maintain the C4 confinement in case of fire in the associated C3 room. The following provides additional detailed design information.

The isolation valves on the gloveboxes are located in separate fire areas away from the gloveboxes. Manual operation of the valves will be demonstrated through administrative controls such as training and written procedures.

FIRE PROTECTION

Clarification Requested:

Explain DCS criteria for the fire protection of redundant IROFS {28 February 2002, item 1E}.

Response:

Redundant IROFS systems and components that are required to function during or after a fire are separated by fire barriers that are sufficient to ensure that a fire in one train of IROFS equipment will not affect the operation of the redundant train, even if fire suppression systems fail to operate. The fire protection IROFS separation criterion is used in the evaluation of each fire area in the FHA. Configurations where fire barriers do not separate redundant IROFS will be identified and justified.

Clarification Requested:

The FHA states nuclear materials within the gloveboxes pose "an insignificant combustible hazard and are not considered in the fire loading calculation." What amount of nuclear material is considered "insignificant" {28 February 2002, item 1F}?

Response:

The quantity of nuclear material is insignificant in relation to the other combustible materials in a given fire area and is conservatively bounded by the transient combustible load of the fire area.

Clarification Requested:

Explain how the glovebox boundary high efficiency particulate air (HEPA) filter can be relied on to prevent the soot from reaching the C4 final filter. Is this function an IROFS? Can the C3 confinement be relied upon if the intermediate C3 filter is plugged? Is the manual bypass on the C3 an IROFS/PSSC {28 February 2002, item 1H}?

Response

The glovebox boundary HEPA filter is not relied on to prevent soot from reaching the C4 final filters in the event of a fire. Analyses are in progress for the ISA to demonstrate that the C4 final filters will not clog in the event of a fire. As defense in depth, isolation valves may be closed to protect the C4 final filters.

As described in the CAR, the HDE system is a principal SSC whose design bases is to effectively mitigate the dispersions from the C3 areas. The specific components in the system that are IROFS will be identified as part of detailed design and described in the ISA summary. Effective mitigation during a fire may require the intermediate filter to be bypassed. If bypassing the intermediate filter is necessary, it will be an IROFS function. The requirement to bypass the intermediate filter, and if necessary the method to bypass the filter, will be determined as part of final design and described in the ISA.

Clarification Requested:

Discuss reliability and redundancy of the clean agent supply for suppression to a level that is comparable to what was done for water-based suppression {28 February 2002, item 1I}.

Response:

The clean agent suppression systems at the MFFF will be comprised of IROFS and non-IROFS systems. The IROFS clean agent suppression systems are provided for those fire areas that contain dispersible radioactive material in order to provide defense in depth to the IROFS fire barriers. The non-IROFS clean agent suppression systems are provided for the other fire areas where clean agent is the designated suppression agent.

The IROFS clean agent suppression systems will be installed as Seismic Category I. As Seismic Category I, these systems will be operable after an earthquake. Therefore, if a post-seismic fire were to occur in a fire area containing radioactive materials, post-seismic fire fighting capability will be available. For the non-IROFS clean agent suppression systems, the system could be degraded following a seismic event due to the impact on the system piping.

The clean agent supply for each clean agent suppression system will be provided with a 100% reserve.

Clarification Requested:

What is the basis for classifying the Reagents building as Ordinary Hazard Group 1 per National Fire Protection Agency (NFPA) codes {28 February 2002, item 1J}?

Response:

In spite of the flammable nature of some of the combustibles in the Reagents Processing Building (BRP), and after accounting for all the combustibles, it was determined that the most appropriate classification for the BRP is Ordinary Hazard (Group 1). This conclusion is consistent with the guidance provided in NFPA 13 and the Automatic Sprinkler System Handbook. Additionally, since the overall combustible loading of the BRP is low at approximately 45,000 BTU/ft^2, a designation of Ordinary Hazard (Group 2) was considered to be inappropriate since the intent of this hazard classification is for those occupancies where the quantity and combustibility of the contents is moderate to high. Finally, an Extra Hazard classification is also inappropriate since the intent of this hazard classification is for occupancies where the quantity and combustibility of the contents is very high, which is not the case for the BRP.

FIRE PROTECTION

Clarification Requested:

Who comprises the "facility fire brigade"? How is that different from "facility-trained personnel" {28 February 2002, item 1K}?

Response:

Although not part of the design basis, the following additional information is provided.

MFFF facility personnel are trained to respond to and combat incipient fires, and a facility fire brigade is available to handle major fire emergencies. The facility fire brigade is comprised of onsite facility personnel trained to react to fire emergencies. These personnel are trained in the use of fire fighting equipment, the approach to fighting fires, and how to properly operate the MFFF standpipes and hose stations. Therefore, in the Manual Fire Fighting discussion of the FHA that utilizes the phrase "facility-trained personnel" with respect to their potential use of the standpipe system, "facility-trained personnel" is synonymous with "facility fire brigade."

Clarification Requested:

The Preliminary Hazard Analysis concluded that an earthquake does not induce any risk of fire. What is the basis for this statement {28 February 2002, item 1M}?

Response:

The statement that resulted in this question appeared in the draft Revision A of the FHA that was reviewed by the NRC staff in late January 2002. In the interim, it was determined that the PHA was misinterpreted, therefore, this statement was removed from Revision A of the FHA.

Clarification Requested:

Provide specific reasons for the lack of suppression in specific areas such as some airlocks, PuO_2 buffer storage, and rod handling areas {28 February 2002, item 1N}.

Response

The PuO_2 Buffer Storage Room, Room B-152, does not lack automatic suppression; it is provided with automatic clean agent suppression. The specific reasons for the lack of suppression in specific areas of the MFFF are delineated in the discussion of the fire area of interest within Appendix A of the FHA. In general, the reasons that apply to the remaining areas of interest (i.e., airlocks and rod handling areas) are as follows:

FIRE PROTECTION

Airlocks – Automatic suppression not installed due to low fire loading.

Rod handling areas – Automatic suppression is not installed in these areas due to low fire loading, limited quantity of combustible materials.

Clarification Requested:

Some gloveboxes do not use a nitrogen blanket (i.e., they have an air atmosphere). For these gloveboxes, are process temperature conditions used only for process reasons or do they perform a safety function and therefore, should they be IROFSs/PSSCs?

DCS stated that the temperature conditions are to ensure a superior product and are not IROFSs/PSSCs. However, DCS will provide additional information to support this statement. {28 February 2002, item 1G}

Response:

As described in CAR section 5.5.2.1.6.1, over temperature events that could result in breaching a glovebox are prevented. The CAR identifies the process safety I&C system as the principal SSC whose safety function is to shut down the equipment prior to exceeding temperature safety limits. Specific temperature controls that are required to perform this function will be identified during detailed design and designated as IROFS. These items will be described in the ISA summary.

Clarification Requested:

Describe the effects of potential accidents on personnel in safe havens {28 February 2002, item 1L.

Response:

DCS has not identified any accident scenarios which would lead to an effect on personnel in the safe havens.

INSTRUMENTATION AND CONTROLS

Clarification Requested:

The CAR states that the associated AP or MP control rooms are not required when the functional unit is not operating. The CAR also states that the AP systems control room provides control of the normal and safety utilities systems, the fire detection systems, and the health physics systems. Does the first sentence imply that crucial systems, such as the fire detection systems, are not controlled when certain control rooms are not required {28 February 2002, item 8C}.

Response:

The AP control room is the only control room that is always manned. For that reason, the utilities, fire detection and health physics monitoring is located in that control room. The intent of the statement in the CAR is to indicate for example that when a receiving operation is not taking place; no one is in the receiving control room or if no waste operations are taking place no one is in the waste control room. Fire detection, health physics monitoring and utilities monitoring are continuous and the systems are in continuous operation unless down for maintenance or testing.

Clarification Requested:

DCS will clarify design basis information related to seismic qualification of mechanical equipment that was in its January 7, 2002, response, including identifying the design basis seismic event that will activate the seismic isolation system (partially answered in DCS February 11, 2002, letter) {28 February 2002, item 5M}.

Response:

As noted, DCS has already addressed the seismic qualification of mechanical equipment in previous responses. With respect to activation of the seismic isolation system, DCS plans to use the criteria within 10CFR50, Appendix S, Section IV(a)(2)(i)(A). That is, one-third of the design earthquake. Use of this criteria does not require an explicit response or design analysis as stated in the subject regulation.

PHYSICAL SECURITY

Clarification Requested:

NRC provided the design basis threat to DCS by letter dated March 13, 2000 (letter attachment is classified). Does DCS intend to meet that design basis for the MFFF?

Response:

DCS has reviewed NRC's letter of 13 March 2000 and intends to meet the design basis threat as identified therein.

SAFETY ANALYSIS AND CHEMICAL SAFETY

Clarification Requested:

Verify the accident scenario labeled "fire" in AP/MP C3 glovebox area is the same used for bounding mitigated fire/loss of confinement consequence assessment - appears to be some minor differences {verbal information request}.

Response:

The fire in the PuO2 buffer storage area was used as the bounding fire in the bounding consequence assessment.

Clarification Requested:

Verify that pressure sensors will detect a hydrogen leak in the sintering furnace and will terminate hydrogen flow {18 Dec 2001 item CC5, 28 February 2002, Item 12H}.

Response:

Pressure sensors are not use to detect a hydrogen leak and to terminate the hydrogen flow. The design basis is described in the response to RAI 124 (31 August 2002).

MECHANICAL

Clarification Requested:

Provide most recent design basis for truck shipping bay. Specifically, clarify whether fresh fuel casks will be stored in racks or frames, one above the other. If so, what is the design basis for the frames {28 February 2002, item 5N}?

Response:

CAR Figure 11.1-16 shows the current conceptual configuration of the shipping and receiving bays. Space is provided for storing three shipping casks on the loading platform. As indicated in the figure, space to store an additional three shipping casks is envisioned on retractable frames that would be secured to the structural wall when not in use. These storage frames will be designed as Seismic Category II (SC-II) to preclude any potential interaction with IROFS. Criteria for the design of SC-II items is discussed in Section 11.1 of the CAR.

Empty shipping casks will be stored in these locations in preparation for fuel assembly loading. Assuming security constraints do not preclude it (constraints to be verified as part of detailed design), shipping casks loaded with new fuel may occasionally be stored in the shipping bay in preparation for transportation to the mission reactors. To accommodate this scenario, the storage racks will be designed for the full weight of the loaded shipping package in this configuration, including seismic effects. MOX fresh fuel packages will be certified by the NRC as a Type B(U)F-85 package (in a separate licensing action), and as such will be qualified to criteria that bound a variety of handling and transportation incidents.

Clarification Requested:

The discussion of the decontamination systems doesn't mention its interface with the demineralized water and nitric acid systems. Clarify the list of interfaces for the decontamination system.{28 February 2002, item 5E}.

Response:

These upstream interfaces for decontamination system will be added to the CAR in a subsequent revision.

Clarification Requested:

Clarify the point of delineation between PSSC and non-PSSC in the instrument air system . A drawing or diagram at the equipment level would be acceptable{28 February 2002, item 5F}.

Response:

MECHANICAL

The configuration of the Emergency Scavenging Air System described in the CAR was to have a non-PSSC to PSSC interface with the Instrument Air System and supply emergency scavenging air through the normal bubbling air level instrumentation. The Emergency Scavenging Air System design has been revised and the current design provides a system that is completely independent of the Instrument Bubbling Air System and is supplied by redundant bottle cylinder banks.

Each vessel requiring emergency scavenging air includes separate penetrations for emergency scavenging air. The Emergency Scavenging Air System will utilize these penetrations instead of the normal bubbling air level instrumentation. The Emergency Scavenging Air configuration consists of redundant and independent trains, each supplied by separate air cylinder banks.

Clarification Requested:

RAI 201/CAR 11.9.1.9: Clarify the compatibility of references to two standards for instrument air. Both American National Standards Institute (ANSI)/Instrument Society of America (ISA) ISA S7.0.01-1996, "Quality Standard for Instrument Air and ISA S7.3, "Quality Standard for Instrument Air," are referenced in the CAR Section 11.9 text and non-PSSC design basis, respectively {28 February 2002, item 5G}?

Response:

CAR section 11.9.1.9, "Service Air System" states that Service Air will meet the requirements of ISA S7.3, "Quality Standard for Instrument Air". The reference to ISA 7.0.01 (1996) appears in CAR 11.9.4, Design Basis for Non-Principle SSCs, gases section.

DCS is using ANSI/ISA-S7.0.01-1996, "Quality Standard for Instrument Air" as the basis standard for service and instrument air quality. The correct reference is ANSI/ISA-S7.0.01-1996, "Quality Standard for Instrument Air" for both sections. The CAR will be updated accordingly.

Clarification Requested:

Clarify why the design bases of the instrument air and station air systems include HEPA on their penetrations of the MFFF confinement (CAR 11.9.1.10.2), while the bulk gas systems do not. Discuss the provision for HEPAs on penetrations {28 February 2002, item 5H}.

Response:

The statement in CAR Section 11.9.1.10.2 (Instrument Air System) regarding the use of HEPA filters in lines penetrating confinements refers to locations where Instrument Air is used for

MECHANICAL

glovebox ventilation. The HEPA filter discussed in this section is located downstream of the Instrument Air -to- Very High Depressurization Exhaust System (VHD) interface and is part of the VHD System rather than the Instrument Air System.

In CAR section 11.9.2 (Bulk Gas), Nitrogen is used in some gloveboxes for glovebox ventilation. In those cases, as with Instrument Air, a HEPA filter is used at the glovebox boundary for Nitrogen entering and leaving the glovebox. The HEPA filter is located downstream of the Nitrogen-to-VHD interface and is part of the VHD System rather than the Nitrogen System. HEPA filter usage is not discussed in CAR section 11.9.2 (Bulk Gas) because the HEPA filter is not part of the Nitrogen System but rather a part of the VHD System.

Refer to CAR section 11.4.2.2 (Very High Depressurization Exhaust System) for additional information on the use of HEPA filters in lines penetrating confinements.

Clarification Requested:

Clarify the basis for not including the seismic isolation system and isolation valves and seismic detectors in the hydrazine system design basis {28 February 2002, item 5I}.

Response:

Seismic isolation is used only where systems enter into the BMP or BAP areas. Hydrazine is fully within the BRP and thus does not require isolation.

Clarification Requested:

In the chemical process discussion, DCS mentions in the CAR, pages 8-8, 8-27, 8-28 a "P10" gas further described as "methane + argon 7%). Research indicates that P10 is a 10% methane 90% argon. Provide a description of the "P10" equipment and provide any design basis information. No other information can be found in Section 8 or 11. Clarify whether industrial P10 or "methane + argon 7%" is correct. If the latter, also describe what additional precautions will be taken for handling the potentially explosive mixture (RAI 113) {28 February 2002, item 5J}.

Response:

On CAR page 8-8, under section 8.1.2.1, Reagent Chemicals Process, third bullet - Gases, "Site - nitrogen, oxygen, hydrogen, argon and P-10 (methane+Argon-7%)." The mix is designated incorrectly. It should read "Site - nitrogen, oxygen, hydrogen, argon and P-10 (10% Methane+90% Argon)."

MECHANICAL

Page 8-27, Table 8-2. Chemicals Used at the MFFF, under Concentration, "Receipt CH4 (93%) + Ar, Distribution CH4 (93%) + Ar (7%)" This should be listed as "Receipt CH4 (10%) + Ar, Distribution CH4 (10%) + Ar (90%)"

Page 8-28, Table 8-2. Anticipated Onsite Inventory, under Argon-Methane (P-10), "Inventory TBD during final design." This was answered under question/responses, 31 August 2001, question #113, page 9 (113-9): "One Tube Trailer - 45,000 scf - 6 week supply."

The tube storage trailer is located in the Gas Storage Area (east of the MFFF manufacturing building). Provisions are included in the design for connecting a second tube trailer if usage demands it.

Clarification Requested:

Clarify the operating temperature for N_2O_4 system. CAR page 11.9-48 mentions gas mixture is electrically heated and the system heat traced to 122 °F or 50 °C to avoid condensation of NOx from the boiler; however, CAR response 128 (August 2001) states that the system is designed for an operating temperature of 55 °C. If the later temperature is correct, identify how the system will be maintained at this temperature and the range of allowable gas temperatures for the entire system {28 February 2002, item 5L}.

Response:

The temperatures are at two different locations. Unless the transfer line is heated, the NOx product may recombine and condense to form N_2O_4 before it can be diluted with air. A tracing temperature of 50°C is required. After dilution with air, condensation of the NOx is not a concern at the ambient conditions of the oxidation column.

Clarification Requested:

Identify service air interface with N_2O_4 system. The CAR page 11.9-48 and Figure 11.9-29 identifies the service air system, while the drawing GNO/RMN-14735 sheet 1 identifies the instrument air system supplying both the N_2O_4 evacuation and pumping the N_2O_4 system boiler {28 February 2002, item 5K}

Response:

Instrument air (dry -40°F DP) is mixed with the NOx to for a 50:50 mixture of NOx in air. The CAR will be revised to reflect the instrument air interface rather than service air interface.

MECHANICAL

Clarification Requested:

Clarify whether the maximum qualified lift height for a fresh fuel cask could be exceeded in the shipping truck bay (from maximum withdrawn position of the crane to the lowest point of the truck bay floor) {28 February 2002, item 5O}

Response:

As noted in the clarification provided in DCS letter to NRC (DCS-NRC-000083, February 11, 2002), the maximum lifting height of a MOX Fresh Fuel Package in the current design is about 16 ft above the floor elevation. This is the maximum height to the lowest floor elevation. If a truck were in place under a package, the drop height would be less. In either case, the drop height is below the 30-ft qualification height of the MOX Fresh Fuel Package.

Clarification Requested:

The CAR indicates that DCS will be using the 1977 version of American Society of Mechanical Engineers AG-1, Code on Nuclear Air and Gas Treatment, however, the latest version of the code is 1991. Please clarify which version of the code DCS using. If it is the 1977 version, please describe why the latest version is not being used {28 February 2002, item 5Q}.

Response:

DCS is committed to the 1997 version of AG-1 which is the latest version. The typographical error in CAR section 11.4.11.1 will be corrected.

Clarification requested:

Regarding the manual isolation valve mentioned in CAR Section 11.4.7.1.5, clarify if they are the only type of isolation valves on gloveboxes. Describe the design basis if other types of isolation valves are used on gloveboxes {28 February 2002, item 5D}.

Response:

Only manual isolation valves are located outside the glove box and used for isolation of mechanical systems.

MECHANICAL

Clarification requested:

If the Material maintenance and surveillance program will not be used in the process cells, what is the design basis for the corrosion allowances in the system design. DCS states that in the design process corrosion resistance of the materials with the process fluids will be addressed. However, DCS does not mention that the corrosive or galvanic effects of dissimilar metals will be considered in the design {28 February 2002, item 5C}.

Response:

Design basis applied to FTS components (equipment and piping components) take into consideration the galvanic corrosion phenomena. The considerations applied to eliminate occurrences of galvanic corrosion with the MFFF plant systems are as follows:

- Mechanical design to avoid use of dissimilar metal joints that are known galvanic carrier.
- The use of joints with dissimilar metals known for galvanic corrosion are warranted only with insulating gaskets and insulating sleeves to prevent propagation of galvanic current. Design of such a sleeve fitting or flanged joint requires periodic inspection maintenance, and surveillance. An FTS component using such an application and part of radiological process units are located in a glove box.
- FTS components are designed to have proper grounding connectors.
- FTS components are connected to the grounding network to mitigate the risk from and effect of galvanic and static current propagation.

Clarification requested:

DCS agreed to provide additional clarification with regard to quality levels and fluid transport system categories as they relate to welding and welding procedures {28 February 2002, item 5A}.

Response:

Welding procedures and qualifications etc. are not IROFS but are quality procedures in accordance with MOX Quality Assurance Plan (MPQAP). These procedures are used in development of technical and design specification for FTS components identified as IROFS. The design and technical specifications define requirements for IROFS components in terms of MPQAP quality requirements that manufacturing processes (such as welding) and contractor (such as welded equipment suppliers) must meet and qualify.

The design and technical specifications implement procedures from applicable national code practices and enhanced qualification, identification, inspection and test requirements from

COGEMA's operation and process design experience. Some of the national code practices invoked to define the general design and technical specifications for welding processes are as follows:

ASME Section II	ASME, B & PV code, Materials
ASME Section V	ASME B & PV code, Nondestructive Examination
ASME Section VIII, Div 1 & 2	ASME B & PV code, Rules for Construction of Pressure Vessels
ASME IX	ASME B & PV code, Welding and Brazing Qualifications
ASTM	American Society for Testing Materials
ANSI / AWS D-10.4	Recommended Practices for Welding Austenitic Chromium Nickel Stainless Steel Piping and Tubing
ANSI / AWS B-3.0	Welding Procedures and Performance Qualifications

Clarification requested:

Clarify the design basis for the seismic isolation valves. RAI Response 191 only discusses the response time and selection criteria for check valves {28 February 2002, item 5P}.

Response:

Seismic isolation valves are part of the monitoring system that is designed to prevent uncontrolled flooding of the BMF building (where AP and MP process units are located) as a result of a seismic event. Service fluids are brought from systems (such as utilities, reagents, and support services) located outside the BMF building. These valves are provided at the perimeter wall of BMF building (Tertiary Confinement SSCs) where pipelines carrying the service fluids enter. These valves have no direct functional dependencies to the primary and secondary confinement SSCs that are responsible for the radiological process fluids, and safety associated with the radiological processes.

The provision of these valves serves the following purposes:

- Automatic isolation of service fluids as a result of an earthquake to prevent uncontrollable flooding or release of service fluid inside BMF building.
- Ensures that service fluids that enter BMF building remain contained within the building following a seismic event. It also facilitates the operators to quickly and automatically isolate particular service fluid should a localized leakage situation arises or be identified.
- These valves in principle maintain safe isolation between controlled areas (normally free of radioactive materials) and uncontrolled areas (where no radiological materials are permitted and radiological controls are not necessary).

MECHANICAL

Functional Requirements for Seismic Isolation Valves

1. Service fluid isolation in the pipeline. Types of valves can be used are butterfly, gate, plug or ball valves.

2. The construction design for the isolation valve to be determined on the basis of chemical characteristics of the fluid, piping material of construction, and operating conditions. The valve construction design to satisfy good engineering practices used in process and service industries, and in accordance with applicable code practices. (ASME-B16.10, ASME-B36.34, API-598, API-600/602/603/608/609).

3. Automatic valve (fail safe to close) operation through pneumatically operated actuator will be designed to isolate fluid within seconds of sensing earthquake.

4. Integrity of structural supports used for the valves and monitoring system will ensure that the monitoring service remain operational in conditions such as an earthquake.

SITE DESCRIPTION

Clarification Requested:

Regarding site hydrology, CAR section 1.3.4.6 indicates no radiological contamination in Upper Three Runs or Gordon aquifers. Is this no detectable contamination or no contamination above EPA drinking water limits {28 February 2002, item 1A}?

Response:

CAR Section 1.3.4.6 indicates that radiological testing was performed for drill cuttings and all (soil) samples obtained. No radioactive contamination was detected in the soil samples obtained from the Upper Three Runs Aquifer or Gordon aquifer. During conduct of the geotechnical exploration program, no groundwater quality tests were made, and therefore no comparisons were made to drinking water standards.

Radiological screening of the soil material removed from the borings was performed at the drilling site to ensure safety of workers, and no levels were detected that would require any protective measures. On-site (SRS) laboratory radiological testing of the soil samples obtained was performed to ensure that the material met all requirements for unrestricted transportation off-site. The positive outcome of these two types of tests of soil material removed from borings at the MFFF site is what is reflected in the CAR text.

Clarification Requested:

NRC and DCS staff to decide how to release information from seismic calculation justifying unlikely events {30 January 2002 letter}

Response:

The attached (Enclosure B) topical paper "Natural Phenomena for MFFF Design" summarizes the DCS selection of NPH design bases, and presents a confirmatory evaluation demonstrating that designing for the selected Design Earthquake will ensure that the likelihood of unacceptable performance of representative SSCs will be very low.

SITE DESCRIPTION

Clarification Requested:

Will there be further studies of seepage basin plume on proposed MFFF site versus statement plumes are well defined as to extent and flow direction {28 February 2002, item 1A}?

Response:

In letter DCS-NRC-000072 (dated 13 November 2001), DCS provided a copy of the Corrective Action Plan for the Old F-Area Seepage Basin (OFASB) submitted by the Savannah River Site to the South Carolina Department of Health and Environmental Control and the United States Environmental Protection Agency. This plan outlines the scope of the problem identified, and additional characterization measures planned by the Department of Energy to increase the understanding of contamination sources and contaminant movement near the OFASB. DCS continues to maintain an interest in the outcome of these characterization efforts since the MFFF site is just east of the OFASB, and will provide NRC with any results of this testing that are received. Since the detected contamination is in the groundwater, approximately 70' below the natural ground surface, and since grading and excavation for MFFF site and facility development will remain well above that level, the MFFF is not affected by the noted contamination.

In letter DCS-NRC-000067 (dated 26 October 2001), DCS provided responses to requests for clarifications on the responses to questions on the MFFF Environmental Report. The response to question number 13 in that letter provides significant additional information on the direction and flow of groundwater near the OFASB and the MFFF site. DCS currently has no plans to perform additional studies of groundwater movement near the MFFF site.

Clarification Requested:

Provide a discussion of hospitals located in the vicinity of the Savannah River Site (SRS). Such a discussion was omitted from Section 1.3 in the Construction Authorization Request {28 February 2002, item 1B}.

Response:

Section 1.3 of the CAR did not specifically address hospitals since none are located within six miles of the MFFF site. Section 1.3.2.2 of WSRC-TR-2000-00454 (submitted to NRC with letter DCS-NRC-000065, 22 October 2001) provides additional clarifying information about the location of hospitals and nursing homes near the Savannah River Site. Appropriate portions of that document are provided below for convenience. At the next update of the CAR, the text of section 1.3.2.3.2 will be updated to state that there are no hospitals within a 6-mile radius of the MFFF.

SITE DESCRIPTION

Extract from Section 1.3.2.2 of WSRC-TR-2000-00454

Health Care Populations

One hospital and three nursing homes are located within 5 miles (8 km) of the SRS boundary. Table 1.3-11 shows the facilities by type, location, and the number of licensed beds at each facility. Total licensed bed space was 163 in 1997. In addition to the above mentioned facilities, there are two facilities that provide community residential care with a population of 15 residents and four facilities that provide intermediate care for the mentally retarded with a population of 32 residents in 1997.

Table 1.3-11 Health Care Population Within a 5-Mile Vicinity of SRS, 1998

Name of Facility	Location	Facility Type	Licensed Beds
Barnwell County Hospital	Barnwell	Acute care hospital	53
Barnwell County Nursing Home	Barnwell	Skilled care and intermediate nursing home	40
Southern Manor	Barnwell	Community Residential Care	5
Triple E Residential Care	Barnwell	Community Residential Care	10
Academy Street Community Residence	Williston	Intermediate Care for Mentally Retarded	8
Black's Drive Community Residence	Williston	Intermediate Care for Mentally Retarded	8
Harley Road Community Residence	Williston	Intermediate Care for Mentally Retarded	8
Lemon Park Community Residence	Williston	Intermediate Care for Mentally Retarded	8
Silver Springs Long Term Care	Williston	Skilled and intermediate care facility	44
New Ellenton Nursing Center	New Ellenton	Skilled and intermediate care	26

Sources: Aiken County Health Care Facilities, Health Care Facility Information, published by South Carolina Department of Health and Environmental Control, April, 10 1998.

Barnwell County Health Care Facilities, Health Care Facility Information, published by South Carolina Department of Health and Environmental Control, April 10, 1998.

FINANCIAL

Clarification Requested:

Do design costs include licensing costs (RAI 30)? Are escalation and contingency costs included in design costs (RAI 30) {28 February 2002, item 2B, 2C}

Response:

The design cost information includes licensing, escalating and contingency costs for design.

Clarification Requested:

Provide updated organization charts and descriptions (Chapter 4 and the Quality Assurance Plan).

Provide updated financial qualifications (Chapter 2).

Provide updated institutional information (Chapter 1.2) as a result of the recent purchase of Duke Engineering & Services by Framatome. Does the recent purchase affect the foreign ownership, control, or influence (FOCI) determination made by the DOE? Provide a copy of the FOCI review performed by DOE. {28 February 2002, item 3A, B, C}

Response:

The purchase of Duke Engineering and Services by Framatome ANP is currently in the process of being negotiated. It may take a month or more to be completed.

It is currently anticipated that the only financial change for the MOX Project is that Duke Energy will assume the 40 % ownership in DCS that Duke Engineering and Services currently holds. The current plan is for Framatome ANP to provide MOX engineering services under an existing contract with DCS. The DOE FOCI determination will not be complete until after the DE&S sale to Framatome ANP is completed.

The CAR will be updated to reflect financial and organizational changes following completion of those changes.

FINANCIAL

Clarification Requested:

Will project design costs under review by DOE be submitted (RAI 30) {28 February 2002, item 2A}?

Response:

Detailed information on project costs was submitted in DCS letter, DCS-NRC-000059, dated 31 August 2001, "Proprietary DCS Financial Information". Revised proprietary design cost information will be submitted at a later date when available.

STRUCTURAL

Clarification Requested:

Correct the temperature extreme values reported in Section 1.3.3 of the Construction Authorization Request {28 February 2002, item 2A}.

Response:

The temperature range reported in CAR Section 5.5.2.6.5.7 (-3F to +107F) is based upon observed temperature extremes at SRS over the period 1961 – 1996. The values are defined in WSRC-TR-2000-00454, Natural Phenomena Hazards (NPH) Design Criteria and Other Characterization Information for the Mixed Oxide (MOX) Fuel Fabrication Facility at Savannah River Site, Rev. 0, November 2000. A copy of WSRC-TR-2000-00454 was provided by DCS letter to NRC, DCS-NRC-000070, dated 12 November 2001.

A new text subsection will be added to CAR Section 1.3.3 to address temperature ranges. This new text will provide information similar to the following:

1.3.3.5 Temperature

Monthly and annual average temperatures for SRS for the 30-year period 1967-1996 are included in Table 1.3.3-12. At SRS, the annual average temperature is 64.7°F. July is the warmest month with an average daily high temperature of 92.1°F and an average daily low temperature of 71.5°F. January is the coldest month with an average daily high temperature of 55.9°F and an average daily low temperature of 36.0°F. Observed temperature extremes for SRS over the period 1961-1996 ranged from 107°F to -3°F.

Data for Augusta, GA indicate that prolonged periods of cold weather seldom occur. Daytime high temperatures during the winter months are rarely below 32°F. Conversely, high temperatures in the summer months are above 90°F on more than half of all days. The average dates of the first and last freeze are November 12 and March 16, respectively.

STRUCTURAL

Table 1.3.3-12 Monthly Average and Extreme Temperatures for SRS

	Average Daily Temperature, °F [a]			Extreme Temperature, °F [b]	
Month (Yr)	Maximum	Minimum	Month	Max(Yr)	Min
January	55.9	36.0	45.8	86 (1975)	-3 (1985)
February	60.0	38.3	49.1	86 (1989)	10 (1996)
March	68.6	45.4	57.0	91 (1974)	11 (1980)
April	77.1	52.5	64.8	99 (1986)	29 (1983)
May	83.5	60.7	72.1	102 (1963)	38 (1989)
June	89.6	68.0	78.8	105 (1985)	48 (1984)
July	92.1	71.5	81.7	107 (1986)	56 (1963)
August	90.1	69.6	80.3	107 (1983)	56 (1986)
September	85.4	65.6	75.4	104 (1990)	41 (1967)
October	76.6	54.6	65.6	96 (1986)	28 (1976)
November	67.0	45.2	56.2	89 (1974)	18 (1970)
December	59.3	39.1	49.1	82 (1984)	5 (1962)
Annual	75.5	54.0	64.7	107 (1986)	-3 (1985)

[a] Period of record: 1967-1996.
[b] Period of record: 1961-1996.

STRUCTURAL

Clarification Requested:

Submit the Aircraft Hazard safety assessment, including the hazard analysis for a helicopter.

DCS will provide either the analysis or a summary of the analysis in sufficient detail for the staff to reach a safety conclusion. DCS will also check for more recent test data on aircraft penetration into reinforced concrete walls (reference currently cited is dated 1972) and will discuss or include this more recent data into its response {28 February 2002, item 2B}.

Response:

An aircraft screening analyses was performed according to NUREG-0800, *Standard Review Plan*, SRP 3.5.1.6, "Aircraft Hazards," (SRP 3.5.1.6) to determine the frequency of an aircraft crash for the MOX Fuel Fabrication Facility (MFFF) and Emergency Diesel Generator Building (BEG). All of the inputs, assumptions, and results are summarized below. This analysis is concerned only with the probability of an aircraft crash striking the MFFF or BEG. This analyses does not consider aircraft crashes as a result of sabotage.

Assumptions and Inputs Used in the Aircraft Analysis

Public Airports and Commercial/Military/General Aircraft

Bush Field in Augusta, GA, and the Columbia Metropolitan Airport in Lexington County, SC, are the only two airports within 60 miles of SRS that provide scheduled air passenger services. Bush Field is located approximately 20 miles from SRS. Columbia is the nearest air traffic hub and is approximately 60 miles from SRS.

Barnwell County Airport, a small general aviation facility, is approximately 16 miles away and is the closest airport to the SRS boundary. Private aircraft, including corporate jets, use the Barnwell County Airport.

Other small nearby airports include Aiken Municipal Airport (28 miles away), Allendale County Airport (27 miles away), Bamberg County Airport (30 miles away, Burke County Airport in Waynesboro (26 mi away), and Daniel Field (28 miles away) in Augusta.

There are no low-altitude military training routes, pilot areas, or approach and departure paths to airports or military facilities in the vicinity of SRS.

STRUCTURAL

The Federal Aviation Administration (FAA) performed a representative count of the number of total flights a day that pass over SRS. The FAA reported that a total of 38 flights per day passed over SRS: 20 commercial, 8 military and 10 civil aircraft. Thus, the maximum number of flights over SRS a year is approximately 13,870: 7300 per year for commercial, 2920 per year for military aviation, and 3650 per year for general aviation.

Recent air traffic statistical information supplied by the FAA was obtained from the FAA website. For 1999, the FAA reported that Columbia Metropolitan Airport had 110,638 total arrivals and departures for the year and Bush Field Municipal Airport had 44,816 arrivals and departures for the year. No recent information was available from the FAA for Aiken Municipal Airport, Allendale County Airport, Bamberg County Airport, Barnwell County Airport, Burke County Airport, and Daniel Field.

SRS Helicopter and Heliport

Wackenhut Services, Inc (WSI) operates a heliport in B Area about 2.9 miles from MFFF. WSI operates two lightweight multipurpose helicopters providing support to the security services at SRS. These helicopters are both Model BK117A3 manufactured by the MBB Helicopter Corporation of Westchester, PA. They have twin engines with a maximum gross flying weight of approximately 7000 lbs. Both have wingspans of 36 feet.

WSI procedures require that security helicopters do not fly over buildings at SRS, which will include the MFFF and BEG. No turning, hovering, or maneuvering will take place near the MFFF or BEG. It is not anticipated that WSI will provide escort services or will deliver shipments to the MFFF Area. It is not anticipated that the SRS helicopters would land or takeoff at the MFFF Area.

The WSI helicopters fly missions at various altitudes and flight paths. The exact flight paths and flight schedules are sensitive information and not disseminated by WSI. Since the exact number of helicopter over flights is not known, an approximation of the number of over flights was made based on total flight hours. Over a five-year period, WSI averaged approximately 696 flight hours per year. For conservatism, it is assumed that all the flight hours are spent flying over SRS. There are 17 areas at SRS, assuming that WSI spends an equal amount of time in each area, approximately 40 hours are spent in each area. Assuming that each hour of flight time includes one overflight, the number of overflights per year over the MFFF area is estimated to be 40.

The helicopters flight path is assumed to be 14 miles. A circle with a radius of approximately 12 miles encompasses nearly all of SRS. The longest flight over the site would be 24 miles, which encompass nearly all the site, while the shortest would be approximately 5 miles (leaving the heliport, flying directly to the MFFF Area and

STRUCTURAL

returning directly back to the heliport). If all paths were considered to have equal probability, the average would be approximately 14 miles.

MFFF and BEG Information

The overall height of the multi-story MFFF building above grade is approximately 73 ft and has a footprint of approximately 300-ft by 425 ft.

The BEG is a single-story building approximately 32 ft above grade with a footprint of approximately 44-ft by 143 ft.

Analysis

According to NUREG-0800 SRP 3.5.1.6, the probability of aircraft accidents resulting in unacceptable radiological consequences is less that 1.0E-07 if all of the following requirements are met:

- The plant-to-airport distance *D* is between 5 and 10 statute miles and the projected annual number of operations is less than 500 * D^2, or the plant-to-airport distance *D* is greater than 10 statute miles and the projected annual number of operations is less than 1,000 * D^2.
- The plant is at least 5 statute miles from the edge of military training routes, including low-level training routes, except for those associated with a usage greater than 100 flights per year, or where activities (i.e., bombing) may create an unusual stress situation.
- The plant is at least 2 statute miles beyond the nearest edge of a federal airway, holding pattern, or approach pattern.

Since all of the airports are greater than 10 miles from the MFFF and BEG, using the guidance from NUREG-0800 SRP 3.5.1.6 and using the formula 1,000 D^2, where *D* is the plant-to-airport distance:

> 1000 * 16^2 = 256,000, which is 1.5 times greater than the total arrivals and departures for both Columbia and Augusta's airports and is therefore considered conservative for Barnwell County Airport, Aiken Municipal Airport, Allendale County Airport, Bamberg County Airport, Burke County Airport, and Daniel Field Airport.
>
> 1,000 * 20^2 = 400,000, which is 8 times greater than 44,816 operations for 1999 for Augusta, GA
>
> 1,000 * 60^2 = 3,600,000, which is 32 times greater than 110,638 operations for 1999 for Columbia, SC

STRUCTURAL

Therefore, based on NUREG-0800 SRP 3.5.1.6, the likelihood of an aircraft crash at the MFFF or BEG is less than 1.0E-07 per year.

In addition, since, the MFFF is greater than 5 miles from the edge of a military training route; based on NUREG-0800 SRP 3.5.1.6, the likelihood of an aircraft crash is less than 1.0E-07 per year.

Since one federal airway and the edge of a second cross the SRS, the crash frequency from the federal airway was analyzed for the MFFF and BEG. The formula given for airway crash frequencies in NUREG-0800 SRP 3.5.1.6 is:

$$P_{FA} = C \times N \times \frac{A}{W} \qquad (1)$$

The following table contains a description of each of these parameters, the input used for each parameter and the results.

Parameter	Description	Unit	Type of Aircraft		
			Commercial	Military	General
C*	In-flight crash rate for aircraft using the airway	Per mile	4.0E-10	4.0E-10	1.2E-08
W	Width of airway (plus twice the distance from the airway edge to the site when the site is outside the airway)	miles	8	8	8
N	Number of flights along the airway	Per year	7300	2920	3650
A	Effective area of MFFF (425 ft * 300 ft)	Sq mile	.00457	0.00457	.00457
	Effective area of BEG (143 ft * 44 ft)	Sq mile	.00023	0.00023	.00023
$P_{FA\ MFFF}$	Calculated	Per year	1.67E-09	6.67E-10	2.50E-08
$P_{FA\ BEG}$	Calculated	Per year	8.40E-11	3.36E-11	1.26E-09

* NUREG-0800 SRP 3.5.1.6 suggests a value of 4.0E-10 for commercial aircraft which is considered reasonable for military since military fight training and maintenance procedures meet or exceed those required for a commercial airline, so it can be reasonably assumed that the crash rate on a per mile basis would be equal to or less than that for commercial. For General Aviation, the crash rate for takeoffs from DOE-STD-3014-96 was used which is considered conservative for in-flight crashes.

STRUCTURAL

It can be determined from the above table, that the total likelihood of an aircraft crash into the MFFF or BEG resulting from the federal airway is 2.74E-08 (1.67E-09 + 6.67E-10 + 2.50E-08) and 1.38E-09 (8.40E-11 + 3.36E-11 + 1.26 E -09), respectively, per year.

In addition, a helicopter analysis was performed for the SRS security helicopters. The helicopter crash frequency can be calculated using the Equations 2 & 3 below, which were taken from DOE-STD-3014-96, which references the methodology used in NUREG-0800 SRP 3.5.1.6.

$$F_H = N_H \times P_H \times \frac{2}{L_H} \times A_H \quad (2)$$

$$A_H = (WS+R) \times H\cot\phi + \frac{2 \bullet L \bullet W \bullet WS}{R} + L \cdot W + A_S \quad (3)$$

The following table contains the parameters and the inputs used in Equations 2 and 3.

STRUCTURAL

Parameter	Description	Units	Input
N_H	Number of helicopter flights over a facility	Per year	40
P_H	Probability of a helicopter crash (DOE-STD-3014-96, Table B-1)	per flight	2.5E-05
L_H =	Average length of a helicopter flight	miles	14
$A_{H\ MFFF}$	Effective target for a facility (Calculated with Eq. 3)	Mi^2	0.006
$A_{H\ BEG}$	Effective target for a facility (Calculated with Eq. 3)	Mi^2	0.0004
WS	Helicopter wingspan	feet	36
R_{MFFF}	Length of the diagonal of MFFF area – $(L^2 + W^2)^{0.5}$	feet	520.22
R_{BEG}	Length of the diagonal of BEG area – $(L^2 + W^2)^{0.5}$	feet	149.62
H_{MFFF}	Height of facility	feet	73
H_{BEG}	Height of facility	feet	32
$\cot\phi$	Mean of the cotangent of the helicopter impact angle (DOE-STD-3014-96, Table B-17)	N/A	0.58
L_{MFFF}	Length of the MFFF (length of building for rectangular facility)	feet	425
L_{BEG}	Length of the BEG (length of building for rectangular facility)	feet	143
W_{MFFF}	Width of the MFFF (width of building for rectangular facility)	feet	300
W_{BEG}	Width of the BEG (width of building for rectangular facility)	feet	44
A_S	Helicopter skid distance (DOE-STD-3014-96, Table B-18)	feet	0

For the MFFF analysis, forty overflights per year are considered reasonable and conservative. This value takes no credit for WSI procedures that prohibit SRS helicopters from flying over SRS buildings. It assumes that all flight hours are spent at SRS, even though WSI does fly missions off the SRS. It assumes that flight time is only spent on missions supporting the individual processing areas, when most of the flight time is spent in non-processing areas, practicing drills and in training. It assumes that all flight time is equally divided among all SRS processing areas, when the helicopter has some missions that require frequent trips to some areas and rare trips to other areas.

Utilizing the 40 overflights and substituting the information from the above table into equations 2 and 3, resulted in a helicopter crash frequency of 8.64E-7 per year for the MFFF and 6.54E-08 per year for the BEG. Therefore, in the case of the BEG, the frequency of a helicopter accident resulting in unacceptable radiological consequences is

STRUCTURAL

less than 1.0E-07 per year, thereby meeting our highly unlikely criteria and the acceptance criteria of NUREG-0800 SRP 3.5.1.6 and needs no additional evaluation.

In the case of the MFFF, applying the assumption that WSI typically only spends about 25 % of their flight time doing routine patrols and performing responses at SRS processing areas and assuming that 10 % of the time, WSI does not follow its procedures and flies over the facilities, the number of overflights would be reduced to one (40*25%*10%) per year. The resulting frequency is 2.16E-08 per year, demonstrating that the frequency of a helicopter crash is highly unlikely, thereby meeting the highly unlikely criteria and the criteria of NUREG-0800 SRP 3.5.1.6.

Even though both overflights cases, resulted in a highly unlikely frequency, one additional analysis was performed to determine the probability of a helicopter crash penetrating the MFFF. As seen from the following table, the estimated probability of a small aircraft penetrating a 1-ft concrete wall is 0.003. (DCS is aware of no more recent concrete penetration estimates than those presented in this table.) Since, the MFFF is enclosed within a hardened exterior, which consists of a 5-ft thick layer of engineered fill and a 2-ft thick retaining wall, if a helicopter did crash into the MFFF, the probability of a helicopter accident resulting in unacceptable radiological consequences is 2.6E-09 (8.64E-07 * .003), which is bounding for both overflight values. Therefore, the frequency of a helicopter accident resulting in unacceptable radiological consequences is less than 1.0E-07 per year for the MFFF and meets the criteria of NUREG-0800 SRP 3.5.1.6.

Probability of an Aircraft Penetrating Reinforced Concrete

Plant Location	Aircraft Type	Thickness of reinforced concrete			
		1 foot	1.5 feet	2 feet	6 feet
<= 5 miles from airport	Small <= 12,500 lbs.	0.003	0.0	0.0	0.0
	Large >= 12,500 lbs.	0.96	0.52	0.28	0.0
>= 5 miles from airport	Small <= 12,500 lbs.	0.28	0.06	0.01	0.0
	Large >= 12,500 lbs.	1.0	1.0	0.84	0.32

(Ref. Chelapati, C. V., Kennedy, R. P., "Probabilistic Assessment of Aircraft Hazard for Nuclear Power Plants," Nuclear Engineering and Design, 1972.)

It should be noted that the Security Secondary Alarm Station (SAS) is located on the roof of the MFFF and provides a security function to the MFFF Area. The SAS is a bullet resistant enclosure that surrounds three sides of the MFFF stack. The SAS design allows observation of the roof of the MFFF and access around the MFFF stack. The SAS is approximately 27 ft by 56 ft and has a top elevation of approximately 85-ft with exterior walls approximately 1 ft thick. The SAS/stack's effective target area is approximately 5% of the effective target area of the MFFF. Therefore, the probability of

STRUCTURAL

hitting the SAS/stack is approximately 4.2 E-8 (8.64 E-7 * 5%) without taking credit for the wall thickness.

Results of the Aircraft Frequency Screening

The total aircraft frequency is summarized in the following table.

Criteria	**Aircraft Crash Frequency for the MFFF (per year)**		**Aircraft Crash Frequency for the BEG (per year)**
	Probability of Impact	**Probability of Penetrating Structure**	**Probability of Impact**
Federal Airway	2.74E-08	2.74E-08	1.38E-09
SRS Helicopter	8.64E-7	2.59E-09	6.54E-08
Total aircraft crash frequency (per year)	8.91E-07	2.99E-08	6.67E-08

The BEG was analyzed since it contains the emergency diesel generators. As seen in the above table, the total frequency of analyzed aircraft accidents for the BEG is less than 6.67E-08 per year. In addition, the acceptance criteria of NUREG-0800 SRP 3.5.1.6 paragraph A and B were determined to be less than 1.0E-7 per year, thereby meeting the frequency criteria of highly unlikely.

As seen in the above table, the total likelihood of analyzed aircraft accidents for the MFFF is less than 8.91E-07 per year, thereby meeting the frequency of highly unlikely. To meet the acceptance criteria of NUREG-0800 SRP 3.5.1.6, an additional analyses was performed, taking credit for the probability that the MFFF structure would be penetrated allowing the release of radiological materials. As seen in the above table, the total frequency of the helicopter crashing into the MFFF and penetrating the MFFF, was determined to be 2.99 E-08 per year, thereby meeting the acceptance criteria of NUREG-0800 SRP 3.5.1.6.

STRUCTURAL

Airport Traffic Count Information from Internet Site

Bush Field*

Airport	City	State	Air Carrier	Air Taxi	General Aviation	Military	Total Traffic
Bush Field	Augusta	GA	5156	7384	28155	4121	44816

* http://www.faa.gov/ats/ars/arw/states/1999%20IND%20Report%20GA.htm) downloaded on 5/9/00

Columbia County**

City	City	State	Air Carrier	Air Taxi	General Aviation	Military	Total Traffic
Columbia	Columbia	SC	21299	23419	60477	5443	110638
Columbia	Columbia	SC					0

** http://www.faa.gov/ats/ars/arw/states/1999%20IND%20Report%20SC.htm downloaded on 5/9/0000.

STRUCTURAL

Clarification Requested:

Submit the soil bearing capacity value for Structural Category I structures, and explain how it was obtained, and discuss why the foundation design will be adequate when considering this value {28 February 2002, item 2C}.

Response:

With the use of an engineered fill immediately under the MFFF reinforced concrete mat, the allowable static bearing pressure to prevent bearing capacity failure at the edge of the foundation mat, is conservatively estimated to exceed 60 ksf in the below grade areas and 30 ksf for the portion of the structure at grade. The respective allowable dynamic bearing pressures will conservatively exceed these static values. These values will be confirmed during final design.

The first sentence in Section 11.1.7.2.2.3 will be replaced as follows:

> The minimum factor of safety against bearing capacity failure due to static loads (dead loads + normal live loads, such as equipment loads) is 3.0. The minimum factor of safety for static loads + severe environmental loads, such as design wind, is 1.5, and for static loads + extreme environmental loads, such as seismic loads due to the design earthquake or wind loads due to the design tornado, is 1.1. In addition, the SC-I structures will be designed for differential settlement, as applicable.

Table 11.1-2, Foundation Design Bearing Pressure, will be revised to read, "(See Section 11.1.7.2.2.3)".

Clarification Requested:

In response to RAI 56, DCS stated that it selected a 100 year recurrence interval for snow loading. Chapter 1 in the CAR states that a 100 year recurrence interval snow load corresponds to 5 pounds per square foot (psf). NRC staff requested that DCS consider a snow load recurrence interval for more than 100 years (i.e., on the order of 10,000 years). Since the larger snow load is an extrapolation of snow loads having a lower recurrence interval, NRC staff also questioned whether the appropriate 100 year snow load should be 5 psf or 10 psf, since the MOX site lies on a boundary in the map included in the American Society of Civil Engineers (ASCE) Standard 7-98 Figure 7-1, "Ground Snow Load for the United States."

DCS stated that it had considered a larger recurrence interval and that the snow load associated with this larger interval is bounded by the roof load chosen for design. DCS will provide information to support this statement. DCS provided a more accurate map showing that the MOX site lies in the 5 psf snow load zone in ASCE 7-98. NRC staff acknowledges that for the MOX site, the ASCE 7-98 Figure 7-1, "Ground Snow Load for the United States," shows that the snow load to be considered is 5 psf. {28 February 2002, item 2D}

Response:

As stated in Section 1.3.3.3 of the CAR, the maximum ground snow load for the SRS area for a 100 year recurrence period is estimated to be 5 psf. The source of this information is ANSI A58.1-1982, *Building Code Requirements for Minimum Design Loads in Building and Other Structures*, the predecessor to the current ASCE-7-98, *Minimum Design Loads for Building and Other Structures*. A review of Figure 7-1 in ASCE-7-98 shows that the ground snow load for the SRS is 5 psf for a 50-year mean recurrence interval. Converting this value to a 100-year mean recurrence interval using the factors shown in Table C7-2 results in an estimated ground snow load of about 6 psf. When this is combined with the estimated 3 psf ice loading described in CAR Section 1.3.3, the specified 10 psf combined ice and snow design basis loading for a 100 year recurrence period is still appropriate.

The last paragraph of CAR Section 1.3.3.3 also describes an estimation of the magnitude of ice and snow loads for greater return intervals. The methodology used in this estimate is described below, and has been updated to reflect the slightly higher ASCE-7-98 estimate of snow load described above.

Evaluation Of Less Likely Snow And Ice Loads

The purpose of this evaluation is to describe the basis for selection of snow and ice loadings selected for MFFF design, and to demonstrate that credible, but less likely snow and ice events will not control facility design. The MOX project-specific Standard Review Plan, NUREG-1718, does not specify a recurrence interval for natural phenomena, but suggests that guidance for nuclear power plants (Division 1 Regulatory Guides and NUREG-0800) could be used as a starting point. NUREG-0800, Section 2.3.1 (Regional Climatology) and Section 2.3.2 (Local Meteorology) refer to ANSI 58.1-72, the predecessor document to ASCE 7-98, *Minimum Design Loads for Buildings and Other Structures*. ASCE 7-98 directs one toward a building code basis for selecting design snow and ice effects, with a 50-year to 100-year recurrence interval. NUREG-0800, Section 3.8.4, (Other Category I Structures) seems to include snow and ice in the category of general live loads, and does not show snow or ice in the categories of severe (e.g. hurricane, OBE) or extreme (e.g. tornado, SSE) loads. Nearby nuclear plants (e.g. McGuire, Catawba, Vogtle) have selected snow and ice loadings consistent with approximately a 100-year return period. Consistent with DOE-STD-1020, SRS also directs selection of snow and ice effects in accordance with ASCE-7-98 (Engineering

STRUCTURAL

Guideline 1060). All available licensing precedent therefore supports selection of a design basis snow and ice event consistent with approximately a 100-year return period.

For the MFFF, a 100-year recurrence snow event results in approximately a 6 psf surface load. Similarly, a 100-year recurrence ice accumulation is estimated to be 0.67", equivalent to approximately 3 psf surface load. These values for snow and ice are combined to result in a 10 psf design load. This load is bounded by the allowance (50 psf) specified in Section 11.1 of the CAR for general live loading effects, and therefore does not control the design of the MFFF buildings and structures.

To evaluate the potential impact of less likely snow and ice events, it is necessary to extrapolate available information to higher return periods. CAR Table 1.3.3-5 shows estimated ice accumulations for return periods between 2 and 100 years. By normalizing this information to the value expected for 100 years, it is possible to estimate how much the accumulation will increase compared to the 100-year value as the return period changes. This information is summarized in the table below.

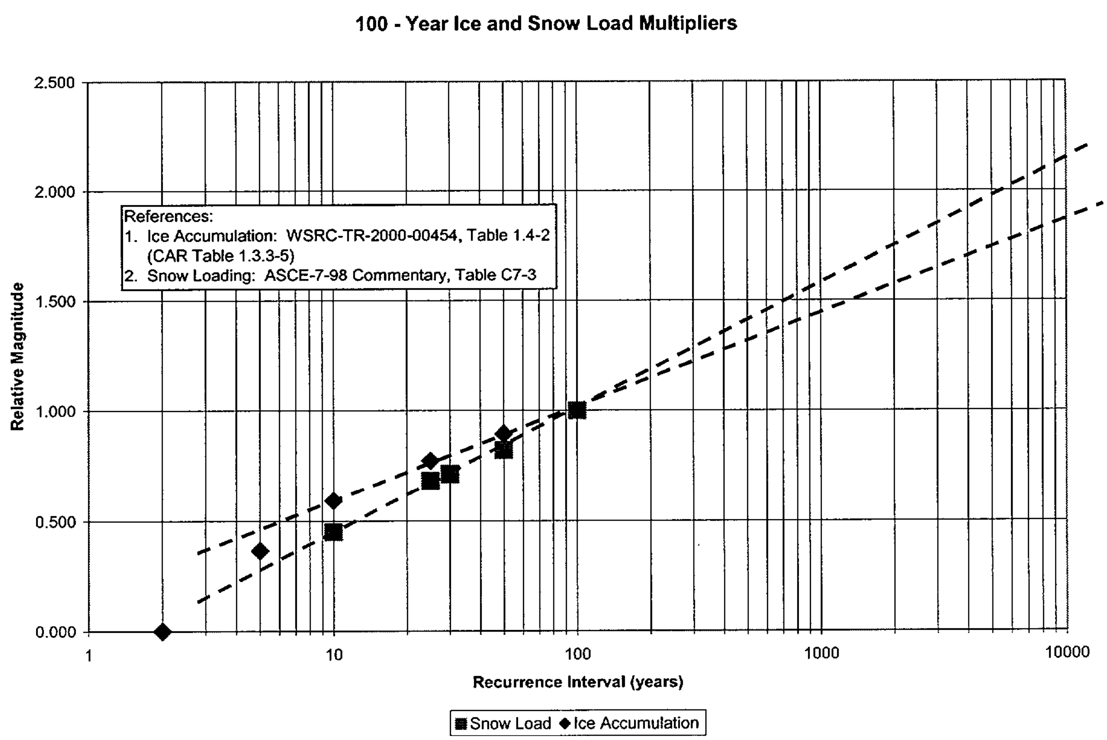
Ice Accumulation		
Recurrence Interval (Years)	Inches(1)	Magnitude Relative to 100-year
2	0.000	0.000
5	0.240	0.364
10	0.390	0.591
25	0.510	0.773
50	0.590	0.894
100	0.660	1.000
(1) From CAR Table 1.3.3-5		

Similarly, the Commentary to ASCE-7-98 (Table C-7-3) provides factors for converting snow loads with different recurrence periods to the period (50 years) used in that standard. These figures can also be directly used to convert to a 100-year recurrence period. By normalizing this information to the value expected for 100 years, it is possible to estimate how much the accumulation will increase compared to the 100-year value as the return period changes. This information is summarized in the table below.

STRUCTURAL

Snow Loading			
Recurrence Interval (Years)	Multipler to convert to 50-year[(2)]	Multipler to convert to 100-year	Magnitude Relative to 100-year
10	1.820	2.220	0.451
25	1.200	1.463	0.683
30	1.150	1.402	0.713
50	1.000	1.220	0.820
100	0.820	1.000	1.000
[(2)] ASCE-7-98, Table C-7-3			

The information about relative magnitudes shown in the tables above is presented graphically in the figure below, showing the change in magnitude as recurrence interval changes. Extrapolations far out of the data range are likely to be extremely conservative. Global climate changes that would result in trends different than those shown will also take longer than the service life of the MFFF. These figures suggest that a 10,000-year event would be on the order of 1.8 (ice) to 2.2 (snow) times the 100-year event specified for MFFF design. Even if the 10 psf snow and ice design load were increased by this factor to represent a highly unlikely (extreme) snow and ice loads, its magnitude would still be bounded by the allowance (50 psf) for general live loadings, and would not control the MFFF design. Naturally, such extremely unlikely snow and ice loads would not be combined with general live loads from other sources.



STRUCTURAL

To reflect the more recent estimate of snow load, the last sentence in the second paragraph of CAR Section 1.3.3.3 will be revised to read "The maximum ground snow load for the SRS area for a 100-year recurrence period is estimated to be 6 psf."

The following text will be added at the end of CAR Section 1.3.3.3: "Such highly unlikely snow and ice roof loads are not combined with roof live loads from other sources in the structural evaluations described in Section 11.1 of the CAR."

The following clarifications will be made to CAR Section 11.1.7.4.1.1, Live Loads:

Floor Live Loads – Change live load for the Roof from "25 psf" to "50 psf".

Rain Loads – At the end of the paragraph add, "Parapets or other structures, which could potentially contribute to significant ponding, are not used on the roofs of SC-I structures. The rain load is not applied concurrently with the roof live load specified in the above table."

Snow and Ice Loads - Revise this section to read, "The combined snow (S) and ice (L) design load is 10 psf, as defined in Section 1.3.3.3. This load is applied concurrently with the roof live load specified in the above table."

Clarification Requested:

NRC staff questioned why site proximity missiles did not include those that may be potentially generated by external explosions.

DCS will review site proximity missiles with regard to information the presented in Regulatory Guide 1.91, "Evaluations of Explosives Postulated to Occur On Transportation Routes Near Nuclear Power Plants."

Related to this issue, NRC understands that the analysis for effects of potential explosions at the Reagents Process Building and the Gas Storage Area is ongoing and will be submitted to NRC in the future. {28 February 2002, item 2E}

Response:

The MOX project-specific Standard Review Plan, NUREG-1718, does not specify specific guidance in evaluating proximity missiles, including those resulting from explosions. However, it does suggest that guidance for nuclear power plants (Division 1 Regulatory Guides and NUREG-0800) could be used as a starting point. As suggested, NUREG-0800 SRP, Section 2.2.1-2.2.2, "Identification of Potential Hazards in Site Vicinity", NUREG-0800, SRP, Section 3.5.1.6, "Aircraft Hazards", and Regulatory

STRUCTURAL

Guide 1.91, "Evaluation of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants, were all reviewed for applicability.

Analyses are in process now to identify all potential missiles that could result from an explosion. Missile sources that are currently being considered with respect to the MFFF site are: train explosions (including rocket effects) truck explosions, aircraft hazards, industrial facilities, and military facilities. Shipping or pipeline explosions are not applicable to SRS since there are no shipping lanes or pipelines near SRS.

In evaluating potential explosion generated missiles, SRS hazardous inventories, transportation records, emergency preparedness records, and safety analysis reports (i.e., SARs, BIOs, PHAs (to obtain likelihood, explosion hazards, hazardous materials inventories)) were reviewed to determine maximum amount of hazardous materials transported, stored and processed at SRS. Then a minimal distance between transportation routes and SRS facilities and the MFFF and BEG was determined. Safe distances were determined based on these minimal distances and the hazardous material inventory postulated to be involved in the hypothetical explosions. A brief summary of the some of the results is presented below.

According to NUREG 800 SRP 2.2.1-2.2.2 the range of a rocketing railroad tank car is 1,148 ft, with the range for smaller pieces extending to 1,640 ft. The F-Area railroad spur terminates at 1762 feet from the BEG. The SRS site railroad is 2041 feet from the MFFF. Therefore, the MFFF/BEG is not within the range of a "rocketing tank" car, since the distance from the MFFF/BEG to the nearest railroad is 1762 feet.

Military facilities, non-SRS industries, and commercial railroad lines, are greater than 10 miles from the MFFF site and need no further evaluation with respect to explosion generated missiles since they met the criteria of Reg Guide 1.91.

For events that are not located at a safe distance, additional analyses are currently being performed. For these potential events, explosion generated missiles will be bounded by the design of the MFFF, since the MFFF structure is specifically designed to prevent intrusion by penetrating weapons. This will be demonstrated in calculations and security studies performed to support the ISA. A discussion of explosion generated missiles will be provided as part of the ISA Summary to support the license application.

Clarification Requested:

The draft Tornado Missile Barrier Analysis and Design Report was reviewed and was acceptable {28 February 2002, item 2F}.

Response:

STRUCTURAL

The CAR statement, in the first paragraph, second sentence, of Section 11.1.7.2.1.2, incorrectly implies that the analysis has been completed. The analysis will be completed in the final design.

Table 11.1-2 requires revision to define the appropriate wind intensity factors for the SC-I, SC-II, and CS structures.

The first paragraph, second sentence of CAR Section 11.1.7.2.1.2 will be revised to change "has been" to "is".

CAR Table 11.1-2 will be revised as follows:

Extreme Wind/Tornado (Wind Loads) (SC-I) – Delete the reference to Note 1.

Note 1 – Change "I = 1.0" to "I = 1.15 (SC-I and SC-II), I = 1.0 (CS)".

Clarification Requested:

Load combinations considered by DCS for design were clarified. DCS showed that one load combination in SRP Section 3.8.4 contained a typographical error for earthquake load {28 February 2002, item 2G}.

Response:

As pointed out in the question, equation (e) on page 3.8.4-10 of NUREG-0800

$$U = D + F + L + H + T_a + R_a + 1.25E'$$

contains a typographical error. The seismic term should be operating basis earthquake (E) instead of design basis earthquake (E'). Since the MFFF does not consider an operating basis earthquake, this combination $U = D + F + L + H + T_a + R_a + 1.25E$ is not applicable.

RADIOLOGICAL CONSEQUENCES

Clarification Requested:

Solvent wastes contain greater than 5000 times the Part 20, Appendix B, Table 2, limits of plutonium-239 (i.e., the 70.61(c)(3) performance requirement). Was a spill of solvent waste considered in the hazard analysis? If so, why were no PSSCs identified to prevent or mitigate this intermediate consequence event (CAR Ch. 10/RAI 143)? {28 February 2002, item 9A}

Response:

The following table presents the bounding, unmitigated, radiological consequences associated with the release of an entire year's worth of rinsing water wastes and distillate wastes and 300-gallons of excess solvent (equivalent to the total volume of a carboy used to remove this waste form from the MFFF site). Airborne releases used to calculate the TEDE to the site worker and public and the effluent concentration ratio (air) to the restricted area boundary are assumed to occur from the MFFF stack using the maximum 95th percentile χ/Q's. Liquid releases used to calculate the effluent concentration ratio (water) are assumed to occur at the restricted area boundary. The presented results are highly conservative as large quantities of materials were assumed released, no credit was taken for airborne release fractions, respirable fractions, or leak path factors, and conservative forms for the released material were assumed (i.e., all activity in waste forms were assumed to be americium-241 and unpolished PuO_2). These conservative results satisfy the performance requirements of 10 CFR §70.61. Therefore, no PSSCs are required for events involving these waste streams.

Table: Radiological Consequences for Low Level Aqueous Waste Releases

Low Level Aqueous Waste Stream	Released Quantity (mg)	Maximum TEDE to Site Worker (rem)	Maximum TEDE to Public (rem)	Maximum Effluent Concentration Ratio (Air)	Maximum Effluent Concentration Ratio (Water)
Rinsing Water (per year)	0.02 (Am-241)	4.4×10^{-3}	3.9×10^{-5}	0.007	7.1×10^{-6}
Distillate (per year)	0.84 (Am-241)	0.2	1.6×10^{-3}	0.3	4.6×10^{-4}
Excess Solvent (per 300-gal carboy)	1.72 (PuO_2(Unpol))	8.6×10^{-3}	7.7×10^{-5}	0.02	0.18

RADIOLOGICAL CONSEQUENCES

Clarification Requested:

The applicant's estimate for radionuclide release rates during normal operations (Table D-7 of the ER) fails to meet the applicant's own ALARA design goal for effluent control stated in Ch. 10 of the CAR. The ALARA design goal is 20% of the Part 20, Appendix B, Table 2, concentration limits. The applicant's estimate of effluent release rates exceeds this goal by a factor of approximately 15. In light of the footnote accompanying Table D-7 that states the applicant's estimates are probably 10 times too high, has DCS derived a more realistic source term for normal operations? Where onsite would air effluents be measured to see if the ALARA goals are met (CAR Ch 10) {28 February 2002, item 9B}.

Response:

ER normal operating release values are calculated at the restricted area boundary (RAB) and presented here. The dispersion model is the 50% annual average for a receptor at the closest point to the stack (52 meters). The X/Q value is 2.5E-4 sec/m^3. The maximum radioisotope is Pu-239 and the concentration is 7.25E-16 µCi/ml which is 0.18 of the ALARA goal of 10CFR70.

Airborne Radiological Releases (µCi/yr)		RAB Concentration (µCi/ml)	20% 10CFR20 App B Table 2 (µCi/ml)	RAB Concentration/20% 10CFR20 App B Table 2
Isotope	ER Values	ER Values		ER Values
Plutonium-236	1.30E-08	1.04E-25	1.00E-14	1.04E-11
Plutonium-238	8.5	6.77E-17	4.00E-15	1.69E-02
Plutonium-239	91	7.25E-16	4.00E-15	1.81E-01
Plutonium-240	23	1.83E-16	4.00E-15	4.58E-02
Plutonium-241	101	8.05E-16	1.60E-13	5.03E-03
Plutonium-242	6.10E-03	4.86E-20	4.00E-15	1.21E-05
Americium-241	48	3.82E-16	4.00E-15	9.56E-02
Uranium-234	5.10E-03	4.06E-20	1.00E-14	4.06E-06
Uranium-235	2.10E-04	1.67E-21	1.20E-14	1.39E-07
Uranium-238	0.012	9.56E-20	1.20E-14	7.97E-06
TOTALS	2.72E+02	2.16E-15		

RADIOLOGICAL CONSEQUENCES

Clarification Requested:

As part of the Environmental Consequences calculation, ensure that information is provided at the restricted area boundary, identify the HEPA filter efficiency used, and that a respirable fraction is not included {28 February 2002, item 9C}.

Response:

The response to RAI 42 is appended as follows:

Accidental Releases to the Environment

The calculation of the 24-hour average release concentration (environmental concentration calculation) has been revised in accordance with 10 CFR 70.61(c)(3) for the intermediate consequence event as a release outside the restricted area. The revised calculation did not credit the respirable fraction and calculated the consequences to the environment outside the restricted area (i.e., outside the Perimeter Intrusion Detection and Surveillance, PIDAS, fence). To reflect this revision to the environmental consequences, Equation 5.4-3 in Section 5.4.4.1.2 of the CAR will be corrected to:

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

where:

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

Two atmospheric dispersion factors unique to the restricted area boundary were calculated: one for releases from the MFFF and one for releases from the Secured Warehouse. These dispersion factors were established from Savannah River Site data using the ARCON96 computer code. The calculated dispersion factors were 8.39×10^{-4} s/m^3 for releases from the MFFF and 2.71×10^{-3} s/m^3 for releases from the Secured Warehouse. These values correspond to the maximum 95th percentile χ/Q to the restricted area boundary for a 24-hour ground release (ground releases are used since they are more conservative than elevated releases). These additional dispersion factors and the method used to calculate them will be included in a revision to Section 5.4.4.1.3.2 of the CAR.

As a result of the revised calculation of the 24-hour average release concentration to the environment, Tables 5.5-10b, 5.5-13b, and 5.5-16b will be added to Section 5.5 of the CAR to reflect the principal SSCs credited for protecting the environment from Loss of Confinement Events, Fire Events, and Load Handling Events. Principal SSCs listed in these tables are needed only to make the hypothesized event unlikely. However, in cases where these principal SSCs are also used to protect the facility worker, site worker, and/or public, the principal SSC

RADIOLOGICAL CONSEQUENCES

is required to assure unacceptable consequences are highly unlikely. Note that, except for one principal SSC (as discussed below), all the principal SSCs listed in these tables already existed for the protection of the facility worker, site worker, and/or public.

In addition to the principal SSC tables, the footnotes to CAR Tables 5.5-11, 5.5-17, and 5.5-19 will be revised as follows: footnote "a" of Tables 5.5-11 and 5.5-17 will be revised to be identical to footnote "b" (i.e., "Required for site worker only.") and footnote "b" of Table 5.5-19 will be revised to be identical to footnote "a" (i.e., "Required for site worker and environment only.").

CAR Table 5.6-1 will also be revised to include a new principal SSC for fire events involving gloveboxes. This new principal SSC, "Glovebox Fire Protection Features," is used to describe design features and operating controls that ensure fires in fire areas containing gloveboxes are unlikely to result in intermediate consequences to the environment. These design features and operating controls include assuring potential combustible loads and/or ignition sources in these fire areas are controlled and using administrative controls to limit activities with a potential to initiate a fire. This conclusion is currently supported by the Fire Hazards Analysis and additional demonstration will be provided in the ISA.

Additional revisions to the text in the CAR will be made as a result of the update to the environmental concentration calculation and to reflect the changes and additions made to Tables 5.5-10b, 5.5-13b, and 5.5-16b (attached).

RADIOLOGICAL CONSEQUENCES

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 I&C System	Shut down process equipment prior to exceeding temperature safety limits
Corrosion	Material Maintenance and Surveillance Programs	Detect and limit the damage resulting from corrosion.
	Fluid Transfer Systems	Limit system corrosion through the use of materials compatible with environment and system fluids.
Small breaches in a glovebox confinement boundary or backflow from a glovebox through utility lines	C4 Confinement System	Maintain a negative glovebox pressure differential between the glovebox and the interfacing systems. Maintain minimum inward flow through small glovebox breaches.
Leaks of AP process vessels or pipes within process cells	None Required	N/A
3013 canister handling operations	3013 Canister Outer Can Opening Device	Prevent the spread of radioactive material during 3013 canister outer can opening operations.
Rod handling operations	None Required	N/A
Breaches in containers outside gloveboxes due to handling operations	Material Handling Controls	Ensure proper handling of primary confinement types outside of gloveboxes.
	3013 Canister	Withstand the effects of design basis drops without breaching.
	Transfer Container	Withstand the effects of design basis drops without breaching.
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	High Depressurization Exhaust System	Ensure that temperatures in the 3013 canister storage structure are maintained within design limits.
Glovebox Dynamic Exhaust Failure	C4 Confinement System	Operate continuously to ensure that a negative pressure differential exists between the C4 glovebox and the C3 area

RADIOLOGICAL CONSEQUENCES

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 highly unlikely.
AP/MP C3 Glovebox Areas	Glovebox Fire Protection Features	Ensure that fires in fire areas containing gloveboxes are unlikely to adversely impact the contents of the glovebox.
	C3 Confinement System	Remain operable during design basis fire and effectively filter any release.
C2 - 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.
C2 - 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.
C2 - 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.
C2 - 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.
C2 - Waste Container	None Required	N/A
C2 - 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.

RADIOLOGICAL CONSEQUENCES

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

Event Group	Principal SSC	Safety Function
C2 - 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.
	C4 Confinement System	Provide design features to ensure that final C4 HEPA filters are not impacted by fire.
Outside MOX Fuel Fabrication Building	MOX Fuel Fabrication Building Structure	Maintain structural integrity and prevent damage to internal SSCs from external fires.
	Emergency Diesel Generator Building Structure	Maintain structural integrity and prevent damage to internal SSCs from fires external to the structure.
	Waste Transfer Line	Prevent damage to line from external fires.
Facility Wide Systems	Fire Barriers	Contain fires within fire area
Facility	Fire Barriers	Contain fires within fire area

RADIOLOGICAL CONSEQUENCES

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 Entry Controls	Prevent the entry of personnel into process cells during normal operations thereby preventing drops.
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
C2 - 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.
C2 - 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.
C2 - Fuel Rod	None Required	N/A
C2 - 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.
C2 - Waste Container	None Required	N/A
C2 -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.

RADIOLOGICAL CONSEQUENCES

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

C2 - 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.
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.
Facility Wide	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.

POLYCARBONATE REPORT

Clarification Requested:

Will isolation valves for the hydraulic system be located in a separate fire area {28 February 2002, item 3F}?

Response:

There are no automatic isolation valves installed in the hydraulic system for the pelletizing process.

Clarification Requested:

Were the effects of high temperature hydraulic oil leak or sprays on the windows considered {28 February 2002, item 3H}?

Response:

A casing to prevent oil dispersion protects the hydraulic system piping. This enclosure is intended to provide for the containment of oil leaks.

Clarification Requested:

Indicate the location of motors or electrical panels (in corners or near walls) to ensure that the effect of fires are not worse than accounted for in the analysis{28 February 2002, item 3I}.

Response:

Motors and electrical panels will be located away from walls as necessary.

POLYCARBONATE REPORT

Clarification Requested:

Provide basis for estimating heat release rate of motor fires {28 February 2002, item 3J}.

Response:

The combustible in motors is the insulation of the internal wiring. The insulation is conservatively assumed to be composed of polyethylene (as compared to other insulation materials). As insulation composed of polyethylene, assuming the equivalent of approximately one square foot of polyethylene is in a motor, the insulation has a worst case heat release rate of approximately 42 BTU per second per square foot of projected floor area. This heat release rate is based on the worst-case heat release rate for a cable with polyethylene insulation inside and out per Table 1E of the Fire-Induced Vulnerability Evaluation (FIVE), EPRI TR-100370, by the Electric Power Research Institute dated April 1992. From this table, Cable No. 13 with a heat release rate of 41.85 BTU/s/ft^2 was utilized.

Enclosure B
Natural Phenomena for MFFF Design

1.0 SELECTION OF NPH DESIGN BASES

Consistent with 10 CFR 70 and NUREG-1718, DCS has selected the magnitudes of the Design Earthquake (DE) and other design basis natural phenomena for adequate protection considering the most severe documented historical event for the MFFF site. These natural phenomena hazards have been selected on the order of what would be required for a reactor licensed under 10 CFR 50. The technical basis for selecting the magnitude of these natural phenomena is the same as has been used to develop design bases for DOE facilities near the MFFF site.

Regulatory Guide 1.165 provides current NRC guidance for determining the Safe Shutdown Earthquake (SSE) for new reactors, and proposes a 1×10^{-5} reference annual median probability of exceeding the SSE. For eastern United States sites, the 1×10^{-5} annual median probability of exceedance performance generally corresponds to a 1×10^{-4} annual mean probability of exceedance design value. The probabilistic methodology described in Regulatory Guide 1.165 is very similar to the DOE Standard 1020 methodology used in developing seismic criteria for the Savannah River Site (SRS), which have been developed in terms of mean probabilities of exceedance. Therefore, the DE for the MFFF is selected using existing SRS hazard information with a goal of meeting a 1×10^{-4} annual mean probability of exceedance. This equates to a recurrence interval of 10,000 years.

The soil surface DE spectrum for the MFFF has been selected to be a Regulatory Guide 1.60 spectrum shape in both horizontal and vertical directions, scaled to a 0.2g peak ground acceleration. Section 1.3.6 of the Construction Authorization Request (CAR), as well as DCS responses to requests for additional information on the CAR (see responses to CAR RAI-012 through RAI-022), describe the selection of this criterion. The 0.2g RG-1.60 spectrum is shown to lie between the criteria for DOE essential (PC-3) facilities and the criteria for DOE critical (PC-4) facilities. Development of the PC-3 and PC-4 criteria has considered the most severe historical earthquakes in the general site region. The CAR demonstrates that for frequencies of significant structural interest (greater than approximately 2 Hz), the acceleration ordinates of the DE spectrum have return periods greater than 10,000 years. DCS maintains that selection of this definition of the DE ensures that high consequence seismically-induced events will be highly unlikely, since the DE itself is highly unlikely.

Similarly, design basis straight wind loadings are selected to achieve a return period of approximately 10,000 years. The design magnitude for tornado loadings, on the other hand, has traditionally been selected at a more conservative level, with a recurrence frequency of 2×10^{-6}. Design levels selected for floods and precipitation are primarily a function of the location and elevation of the facility. Therefore, the recurrence frequency for floods and precipitation events is selected to be 1×10^{-5}.

2.0 CONFIRMATORY EVALUATION OF SEISMIC DESIGN BASIS

To illustrate the conservatism in the selection of the DE, this paper presents a confirmatory evaluation demonstrating that if the MFFF is designed for the selected DE, the expected likelihood of unacceptable performance of representative systems, structures and components (SSC) will be very low. Design practices introduce significant margin into the design of SSCs for physical natural phenomena effects, such as wind and earthquake loading. As a result, the recurrence frequency for such natural phenomena can be selected at higher than the desired performance goal, while still achieving that goal. This evaluation demonstrates that selecting the magnitude of earthquake loading for the MFFF as defined for the DE will achieve a likelihood of unacceptable performance of less than approximately 1×10^{-5}.

2.1 Approach

The definition of the DE has been selected as described in Section 1 above. The performance goal achieved using this DE for MFFF design will be determined using the following steps:

- Consider representative SSCs that are designed for the DE.
- Estimate the conditional failure probability of these SSCs (probability of unacceptable performance at a given seismic acceleration).
- For a range of credible earthquake magnitudes, perform a numerical summation of the probability of the earthquake times the probability of unacceptable performance given the earthquake.
- Compare the calculated probability of unacceptable performance to the desired goal.

The selected DE is adequate when the associated performance goal is shown to be approximately 1×10^{-5} probability of exceedance. This probability of exceedance demonstrates that failure of individual SSCs due to seismic loadings is highly unlikely, and therefore, any high consequence event initiated by a seismic event is also highly unlikely. As described in Appendix B to NUREG 1718, if desired performance were not achieved, a revised DE would be selected and the process would be iterated.

2.2 Selection of Earthquake Design Inputs

SRS has conducted a number of seismic studies to establish earthquake criteria for use in design of facilities located in various areas of the site. Report No. WSRC-TR-2000-00454, "Natural Phenomena Hazards (NPH) Design Criteria and Other Characterization Information for the Mixed Oxide (MOX) Fuel Fabrication Facility at Savannah River Site (U)," developed by Westinghouse Savannah River Company, provides information on natural phenomena hazard design criteria for SRS.

CAR Figure 1.3.6-16 presents soil surface hazard curves for SRS, expressed in terms of spectral velocity (S_v) versus annual probability of exceedance. As discussed in CAR RAI-021, the figure can be converted to an acceleration hazard curve by the relationship $S_a = 2\pi f S_v$, and appropriate conversion factors to convert accelerations to "g's." WSRC-TR-98-00263, Rev. 0, "Soil Surface Seismic Hazard and Design Basis Guidelines for Performance Category 1 & 2 SRS Facilities," by R.C. Lee, September 1998, is the source document for WSRC-TR-2000-00454. Figures 6.9 and 6.10 of WSRC-TR-98-00263 present the velocity and acceleration hazard curves. The site soil surface acceleration hazard curve is reproduced in Figure I.

For simplicity in determining the appropriate design response spectrum, only the 5.0% damping curve is investigated. The 5.0% damping curve is representative of the input spectrum that should be applied for design of reinforced concrete structures. Since the basic structure for the MFFF is a massive, heavily reinforced concrete structure, basing this evaluation on the 5.0% input response spectrum is appropriate. Figure II (CAR Figure 1.3.6-21) compares the MFFF DE Spectrum with DOE criteria for PC-3 and PC-4 facilities. Table I (CAR Table 1.3.6-7) compares the return periods for representative frequencies on these spectra. Figure III (CAR RAI Figure 017-1) compares the MFFF DE Spectrum to soil surface Uniform Hazard Spectra at four spectral frequencies. On this basis, it can be concluded that the scaled Regulatory Guide 1.60 spectrum represents approximately a 10,000-year recurrence event for frequencies of practical structural interest, since most structural elements behave in the 4 Hz and above range. This yields an annual probability of DE exceedance of 1×10^{-4}.

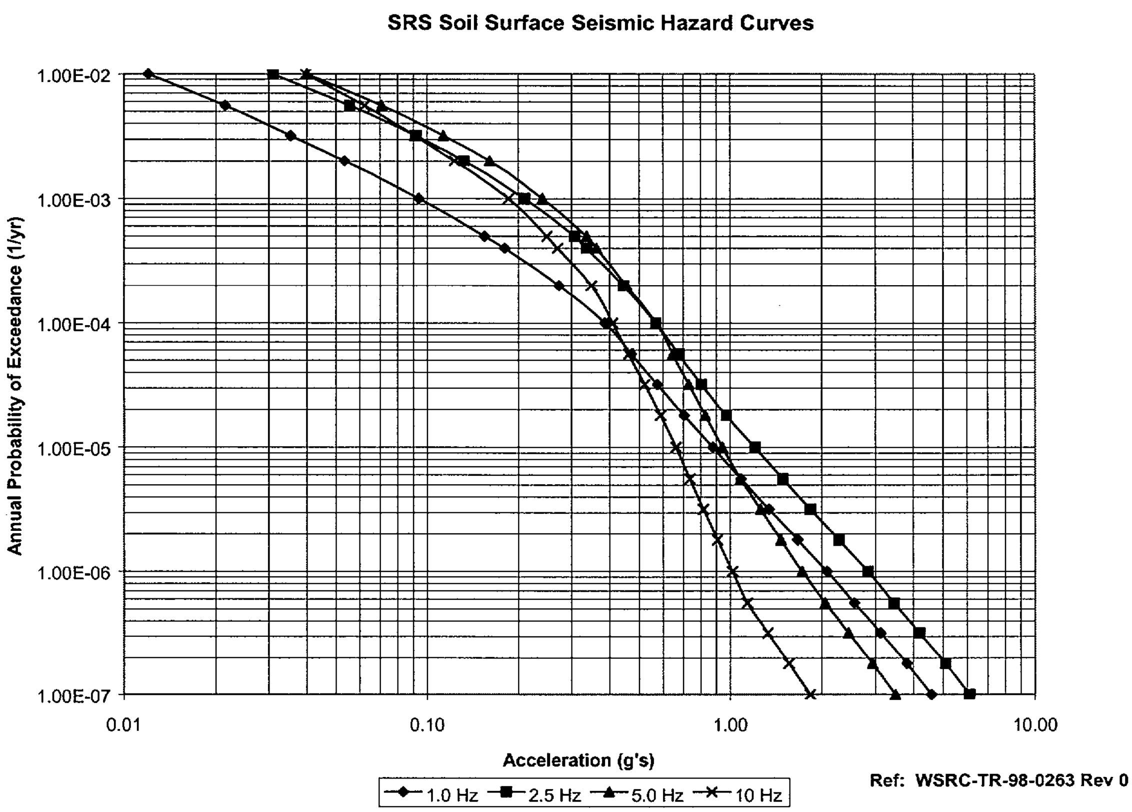


Figure I: Seismic Hazard Curves for Horizontal Design Response Spectrum.

Enclosure B
Natural Phenomena for MFFF Design

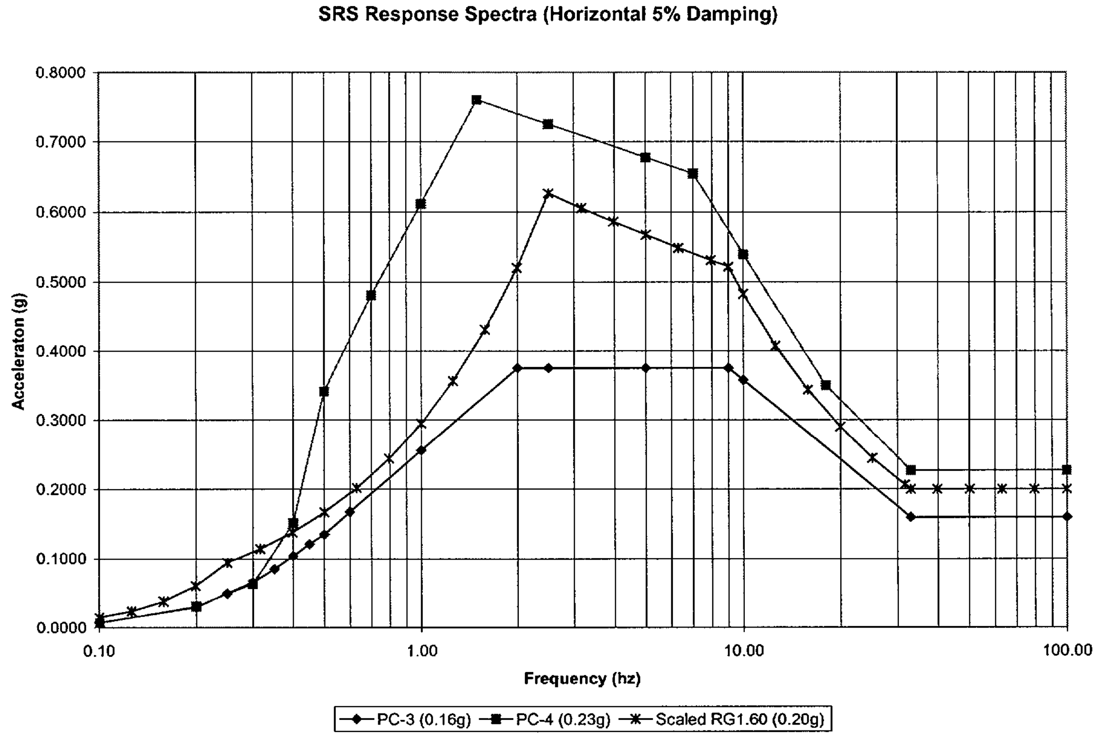


Figure II. Comparison of 0.2g RG 1.60 Spectrum to PC-3 and PC-4

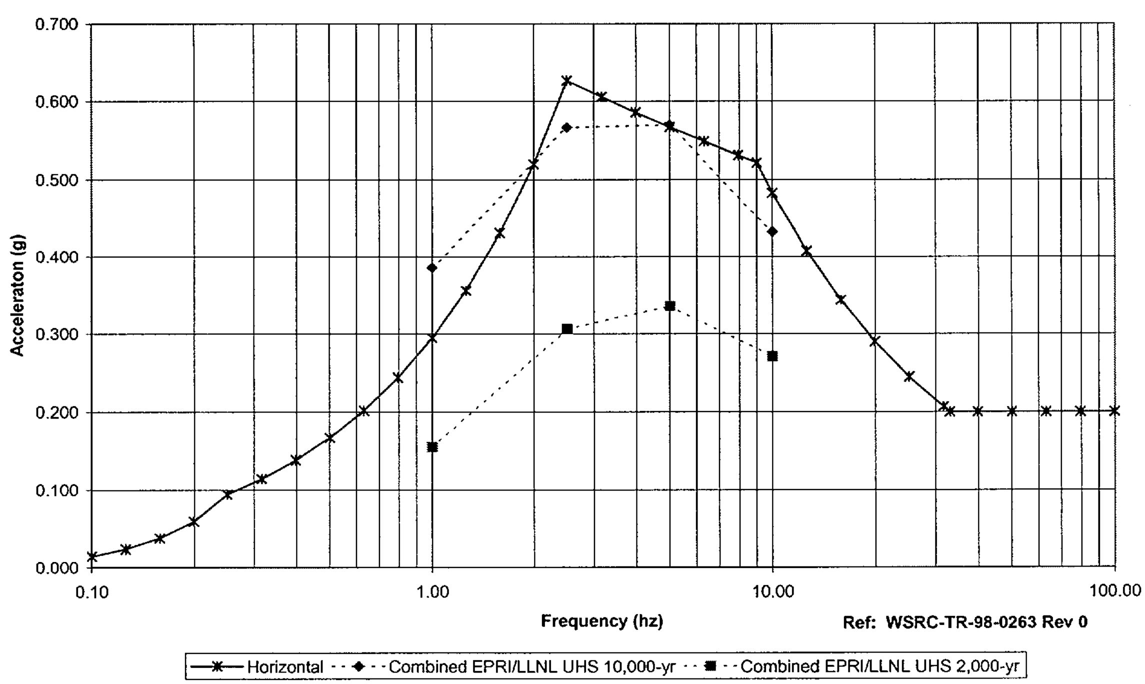


Figure III. Comparison of MFFF Horizontal DE Response Spectrum to Soil Surface UHS at Four Spectral Frequencies

Table I. Return Periods for Spectrum Ordinates

PC-3 Spectrum (0.16g)

Frequency (Hz)	Sa (g)	Return (yr)
1.00	0.250	4,000
2.50	0.375	3,300
5.00	0.375	2,700
10.00	0.360	5,600

PC-4 Spectrum (0.23g)

Frequency (Hz)	Sa (g)	Return (yr)
1.00	0.610	37,000
2.51	0.730	23,000
5.01	0.680	22,000
10.00	0.540	36,000

0.2g Regulatory Guide 1.60 Spectrum

Frequency (Hz)	Sa (g)	Return (yr)
1.00	0.300	6,300
2.51	0.620	14,000
5.01	0.570	10,000
10.00	0.480	22,000

3.0 DETERMINATION OF PERFORMANCE ACHIEVED

Determination of the performance goal is performed using methodology described in DOE-STD-1020-94. Appendix C of DOE-STD-1020 provides the background theory for determining performance goals and seismic design criteria. In addition, UCRL-CR-111478 DR provides the details for development of the seismic portion of DOE-STD-1020. The technical approach described in these documents is used to determine the seismic design performance goal specifically applicable to the MFFF.

The following subsections describe the methodology used for determining the performance goal, fragility data applicable to the MFFF, and seismic hazard curves for the MFFF.

3.1 Method for Determining Seismic Design Performance Goal

The seismic performance of SSCs is a function of the likelihood of hazard occurrence and the strength of the SSCs for resisting the earthquake. Therefore, seismic performance can be determined by evaluating the earthquake probability used to specify the design input response spectrum, and by considering the degree of conservatism used in the design process. The earthquake probability can be accounted for by using the site seismic hazard curves to evaluate the annual probability of seismic occurrence of the design input response spectrum selected for the facility. The degree of conservatism used in the design process is a function of the SSC seismic response evaluation design process and the degree of ductility included in the design. These parameters are quantified by establishing fragility curves or data for the specific types of SSCs being evaluated. This approach to determining the seismic performance is illustrated in Figure IV.

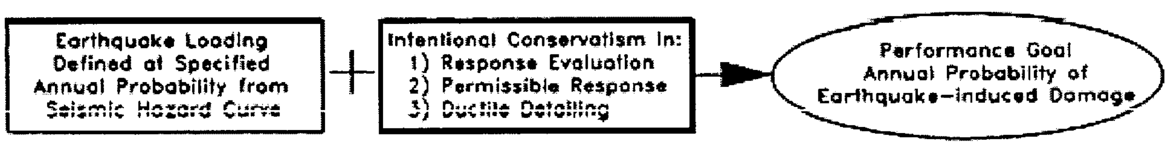


Figure IV: Approach to Determining Seismic Performance

MFFF SSCs are designed for the DE using conservative deterministic acceptance criteria. In order to be adequately conservative, the acceptance criteria must introduce an additional reduction in the risk of unacceptable performance that is below the annual risk of exceeding the DE. This reduction in risk is defined as the risk reduction ratio, R_R, which is the ratio of the seismic hazard exceedance probability, P_H, to the performance goal, P_F:

$$R_R = P_H / P_F \text{ ,or} \qquad \textit{Equation 1}$$

$$P_F = P_H / R_R \qquad \textit{Equation 2}$$

For the MFFF, it will be shown that the performance goal achieved, P_F, will be approximately 1×10^{-5} probability of exceedance. As previously shown, for frequencies of practical structural interest, the Regulatory Guide 1.60 input response spectrum anchored at 0.20g that is selected for MFFF design has a return period of approximately 10,000 years, which equates to a design earthquake with a $1x10^{-4}$ hazard probability ($P_H = 1 \times 10^{-4}$). Therefore, to obtain a performance goal of $P_F \approx 1 \times 10^{-5}$ for a specified hazard probability of $P_H = 1 \times 10^{-4}$, a risk reduction ratio, R_R, of about 10 would have to be provided:

$$P_F \approx 1x10^{-5}$$

$$R_R = P_H / P_F = 1x10^{-4} / 1x10^{-5} = 10$$

The risk reduction ratio, R_R, can be determined using estimates of the fragility of the MFFF SSCs. Fragility data can be determined by estimating the robustness of the SSCs to accommodate loads. The ductility, or inelastic energy absorption factors, $F_{\mu D}$, of the SSCs are used to perform a statistical analysis to determine the median (50% failure probability) structural capacity, C_{50}, of the SSCs at various frequency levels.

In order to compute the risk reduction ratio, R_R, corresponding to any specified seismic design/evaluation criteria, a mean seismic fragility curve must be defined for an SSC resulting from the use of the associated seismic criteria. This mean seismic fragility curve describes the probability of an unacceptable performance versus the ground motion level. This fragility curve is defined as being lognormally distributed and is expressed in terms of two parameters: a median capacity level and a composite logarithmic standard deviation β. To estimate this composite logarithmic standard deviation, it is sufficient to estimate the 50% failure probability capacity C_{50} and the capacity associated with any one of the following failure probabilities: 1%, 2.5%, 5%, or 10%. Then, the composite logarithmic standard deviation can be computed from the ratio of these two capacity estimates. The standard deviation will generally lie within the range of 0.3 to 0.5.

The median structural capacity, C_{50}, can be calculated using the following formula:

$$C_{50} = 1.5\, F_{\mu D}\, DBE\, e^{1.28\beta} \qquad \textit{Equation 3}$$

where, $F_{\mu D}$ is the inelastic energy absorption factor for the particular type SSC being evaluated (i.e., shear wall, moment frame, etc.). DBE is the earthquake level from the design response spectrum curve at the frequency being evaluated, and β is an estimate of the composite logarithmic standard deviation of the seismic fragility function.

The DE at specified hazard probability, P_H, can be defined using a seismic hazard curve that relates the probability of exceedance to various seismic accelerations along the curve. Seismic hazard curves are plotted with the vertical axis providing the annual probability of exceedance and the horizontal axis providing the peak acceleration in "g" on a logarithmic scale.

Over any ten-fold difference in exceedance probabilities, the hazard curve may be approximated by the following equation:

$$H_{(a)} = K_1\, a^{-k_H} \qquad \textit{Equation 4}$$

where $H_{(a)}$ is the annual frequency of exceedance of ground motion level "a," K_1 is an appropriate constant, and K_H is a slope parameter for the hazard curve.

The slope parameter K_H can be defined as follows for the slope of the log curve:

$$K_H = 1 / \log(A_R) \qquad \textit{Equation 5}$$

where A_R is the ratio of ground motions corresponding to a ten-fold reduction in exceedance probability. The value of A_R is not constant over probability ranges that differ by an order of magnitude.

The performance goal probability of unacceptable performances, P_F, is obtained by a convolution of the seismic hazard and fragility curves. This convolution can be expressed by either of the following formulas:

$$P_F = -\int_0^{+\infty} (dH_{(a)} / da)\, P_{F/a}\, da \qquad \textit{Equation 6}$$

$$P_F = \int_0^{+\infty} H_{(a)}\, (dP_{F/a} / da)\, da \qquad \textit{Equation 7}$$

where $P_{F/a}$ is the conditional probability of failure given the ground motion level "a," which is defined by the SSC fragility curve.

These equations are applicable as long as the fragility is lognormally distributed and the hazard curve is defined by Equation 4, which is linear on a log-log plot. However, actual hazard curves are not perfectly linear when plotted on a log-log scale. They tend to curve downward as the ground motion acceleration increases. Therefore, Equation 4 is only an approximation of the actual hazard curve. Essentially all hazard curves have reduction in A_R (i.e., increasing K_H values) as the exceedance probability is lowered.

For any shape hazard curve, the probability of unacceptable performance, P_F, may be obtained by numerically integrating Equation 6 to obtain the following equation:

$$P_F = \sum_{i=1}^{\infty} [H_{(a_i)} - H_{(a_{i+1})}]\, P_{F/a_{cg_i}} \qquad \textit{Equation 8}$$

where a_{cg_i} is the center-of-gravity ground motion level between a_i and a_{i+1} defined by:

$$a_{cg_i} = \frac{\int_{a_i}^{a_{i+1}} H_{(a)}\, a\, da}{\int_{a_i}^{a_{i+1}} H_{(a)}\, da} \qquad \textit{Equation 9}$$

Assuming a piecewise linear hazard curve defined locally by $H_{(a)} = K_1\, a^{-k_H}$, between a_i and a_{i+1}, and defining the local slope parameter K_{H_i} by:

$$K_{H_i} = \frac{\log (H_{(a_i)} / H_{(a_{i+1})})}{\log ((a_{i+1}) / (a_i))} \qquad \textit{Equation 10}$$

Then the Equation 9 for a_{cg_i} gives:

$$a_{cg_i} = \frac{(1 - K_{H_i})\,[a_{i+1}^{(2 - K_{H_i})} - a_i^{(2 - K_{H_i})}]}{(2 - K_{H_i})\,[a_{i+1}^{(1 - K_{H_i})} - a_i^{(1 - K_{H_i})}]}$$ *Equation 11*

The use of Equation 11 to define a_{cg_i} improves the accuracy of the equation for determining P_F over that obtained using the midpoint acceleration, and thus permits larger acceleration steps to be used in the calculation of P_F.

$P_{F/a_{cgi}}$ is the conditional failure probability at ground motion level a_{cg_i}, which is obtained from the fragility curve for the increment along the curve that is being assessed. $P_{F/a_{cgi}}$ can be calculated by taking the standard normal cumulative distribution probability of the normal deviate, Z, for the ground motion acceleration increment being assessed. The normal deviate, Z, can be calculated by the following formula:

$$Z = (\ln a_{cg_i} - \ln C_{50}) / \beta$$ *Equation 12*

Values for $P_{F/a_{cgi}}$ along the fragility curve can be calculated using computer spreadsheet functions for standard normal cumulative distribution, which has a mean of zero and a standard deviation of one.

Once incremental values are determined for $H_{(a_i)} - H_{(a_i + 1)}$ and $P_{F/a_{cgi}}$, the overall performance achieved for the particular type of SSCs at the specific frequency level can be calculated by simply summing their products for all of the increments over the seismic hazard curve.

The following summarize the steps that are used for determining P_F for the various types of SSCs and frequencies representative of the MFFF:

Step 1 Determine fragility data for the representative types of SSCs, at the various frequencies required (1.0 Hz, 2.5 Hz, 5.0 Hz, and 10.0 Hz). Median structural capacities (C_{50}) for the various SSCs and frequency levels are calculated for the 0.20g Regulatory Guide 1.60 response spectrum. This can be done using Equation 3:

$$C_{50} = 1.5\, F_{\mu D}\, \text{DBE}\, e^{1.28\beta}$$

In these calculations, DBE is the design earthquake level at the corresponding frequency being considered. These DBE levels can be taken from the DE curve in Figure III, where the curve intersects with the appropriate frequency value.

Step 2 Establish the seismic hazard curves for various structural frequencies for the MFFF site. These are available from a reference given in WSRC-TR-2000-00454 and is reproduced as Figure 1.

Step 3 For various increments along each seismic hazard curve, determine accelerations (a) and corresponding exceedance probabilities ($H_{(a)}$).

Step 4 For each increment along the hazard curve, calculate the local slope parameter K_{H_i} in accordance with Equation 10, using the end point accelerations and exceedance probabilities for each increment:

$$K_{H_i} = \frac{\log (H_{(a_i)} / H_{(a_{i+1})})}{\log ((a_{i+1}) / (a_i))}$$

Step 5 For each increment, calculate the center-of-gravity acceleration (a_{cg_i}) using Equation 11:

$$a_{cg_i} = \frac{(1 - K_{H_i}) [a_{i+1}^{(2 - K_{H_i})} - a_i^{(2 - K_{H_i})}]}{(2 - K_{H_i}) [a_{i+1}^{(1 - K_{H_i})} - a_i^{(1 - K_{H_i})}]}$$

Step 6 Calculate the normal deviate (Z) for each increment using Equation 12:

$$Z = (\ln a_{cg_i} - \ln C_{50}) / \beta$$

Step 7 Determine the conditional failure probability ($P_{F/a_{cgi}}$) for each increment by taking the standard normal cumulative distribution probability of the normal deviate, Z, with a mean of zero and a standard deviation of one.

Step 8 Calculate the probability hazard for the range ($H_{(a_i)} - H_{(a_i + 1)}$) of each increment by determining the change in the exceedance probability over the increments selected in Step 3.

Step 9 Calculate the performance (P_{F_i}) for each increment along the seismic hazard curve by multiplying the probability hazard within the increment by the conditional failure probability for the increment:

$$P_{F_i} = [H_{(a_i)} - H_{(a_i + 1)}] \, P_{F/a_{cgi}}$$

Step 10 Determine the overall performance goal (P_F) achieved by summing the incremental performances for all of the increments over the seismic hazard curve:

$$P_F = \sum P_{F_i}$$

3.2 Estimated Fragility Data for Representative MFFF SSCs

The MFFF is being designed in accordance with criteria that will result in robust SSCs that exhibit a high degree of ductility (strength beyond the elastic range). Conservatism will be introduced in the response evaluation, permissible response, and ductile detailing of MFFF SSCs. For example, the following criteria are being used that will introduce conservatism in the MFFF design:

- Reinforced concrete structures are being designed in accordance with ACI 349.
- Steel structures are being designed in accordance with ANSI/AISC N690.
- Piping systems, tanks, and associated components will be designed in accordance with the ASME codes.
- Seismic analysis of SSCs follows the guidelines specified in ASCE Standard 4.

The fragility of representative MFFF SSCs has been estimated considering the use of these stringent design criteria using practices of DOE standard 1020. Applicable fragility data from that assessment are shown in Table II. Values are provided for the inelastic energy absorption factor, $F_{\mu D}$, for the particular type SSC being evaluated (i.e., shear wall, moment frame, etc.) and for the logarithmic standard deviation of the seismic fragility function, β. These values are a function of the structural strength of facility SSCs and do not change as a result of a change in the design response spectrum selected.

Table II: Values for Developing Fragility Curves

SSC Type	$F_{\mu D}$	β
Gross Building Structure	2.00	0.50
Diesel Generator Power	1.62	0.52
C3/C4 Ventilation System	1.59	0.52
C3 Area Confinement	1.50	0.40
Glovebox Confinement	1.10	0.35
Piping Systems and Tanks	1.25	0.35

For the various types of MOX SSCs, the median structural capacity, C_{50}, (i.e., the 50% failure probability capacity) can be calculated using Equation 3 ($C_{50} = 1.5\ F_{\mu D}\ DBE\ e^{1.28\beta}$).

Median structural capacities are calculated at 1.0 Hz, 2.5 Hz, 5.0 Hz, and 10.0 Hz to cover the potential range of frequencies for MFFF SSCs. In these calculations, DBE is the design earthquake level at the corresponding frequency being considered. These DBE levels can be taken from the DE curve in Figure III, where the curve intersects with the appropriate frequency value.

The logarithmic standard deviation, β, given in Table II varies up to 0.52. It is not practical to use a standard deviation above 0.40, since this could result in overestimating the structural capacity of facility SSCs. Therefore, β values are conservatively limited to 0.40 maximum when calculating performance goal achievements for the MFFF.

Table III shows the calculation of fragility data, which are based on a DE equal to the 0.20g Regulatory Guide 1.60 horizontal response spectrum shown in Figure III. Figure V shows representative fragility relationships for items designed for a 0.2g seismic design basis (DBE).

Table III. Fragility Data for MFFF Based on DE (PGA) = 0.20 g

IROFS	Frequency (Hz)	DBE (g)	F_{uD}	B	C_{50} (g)
Gross Building Structure	1.0 Hz	0.30	2.00	0.40	1.50
	2.5 Hz	0.62	2.00	0.40	3.11
	5.0 Hz	0.57	2.00	0.40	2.86
	10.0 Hz	0.48	2.00	0.40	2.40
Diesel Generator Power	1.0 Hz	0.30	1.62	0.40	1.22
	2.5 Hz	0.62	1.62	0.40	2.52
	5.0 Hz	0.57	1.62	0.40	2.31
	10.0 Hz	0.48	1.62	0.40	1.95
C3/C4 Ventilation System	1.0 Hz	0.30	1.59	0.40	1.19
	2.5 Hz	0.62	1.59	0.40	2.47
	5.0 Hz	0.57	1.59	0.40	2.27
	10.0 Hz	0.48	1.59	0.40	1.91
C3 Area Confinement	1.0 Hz	0.30	1.50	0.40	1.13
	2.5 Hz	0.62	1.50	0.40	2.33
	5.0 Hz	0.57	1.50	0.40	2.14
	10.0 Hz	0.48	1.50	0.40	1.80
Glovebox Confinement	1.0 Hz	0.30	1.10	0.35	0.78
	2.5 Hz	0.62	1.10	0.35	1.60
	5.0 Hz	0.57	1.10	0.35	1.47
	10.0 Hz	0.48	1.10	0.35	1.24
Piping Systems, Tanks, & Associated Components	1.0 Hz	0.30	1.25	0.35	0.88
	2.5 Hz	0.62	1.25	0.35	1.82
	5.0 Hz	0.57	1.25	0.35	1.67
	10.0 Hz	0.48	1.25	0.35	1.41

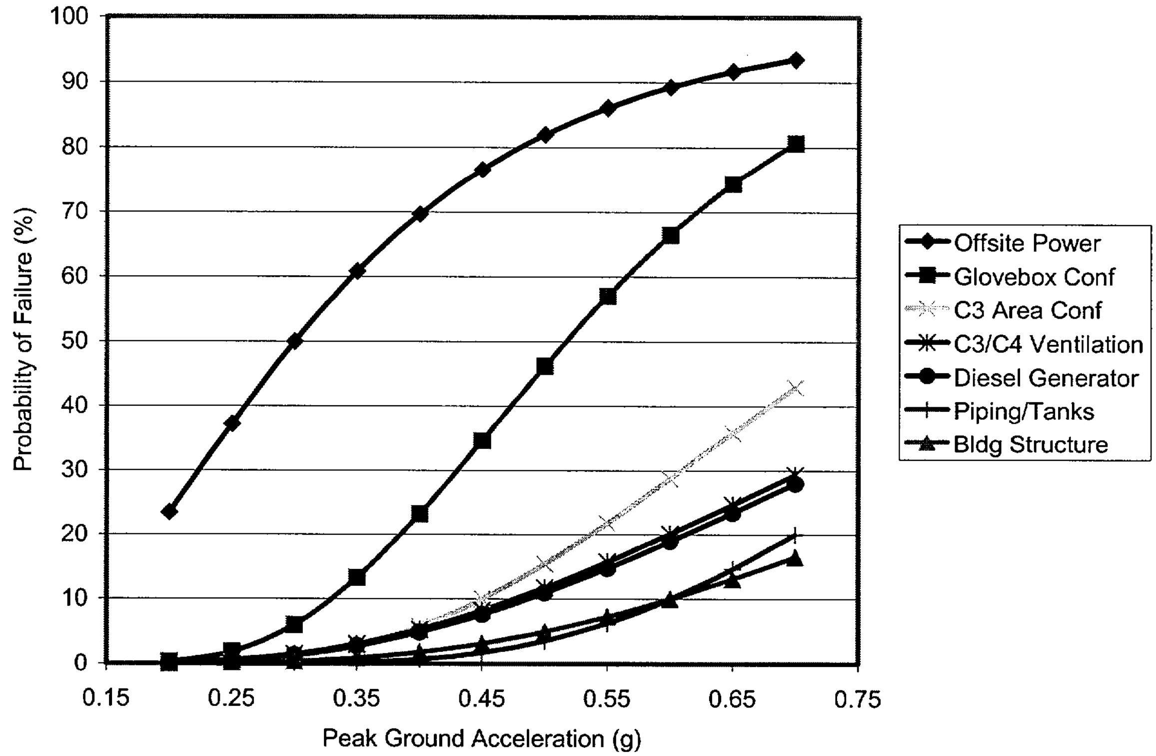


Figure V. Fragility Curves for SSCs Designed for a 0.20 g Seismic Design Basis

3.3 Seismic Hazard Relationships

Figure I shows selected seismic hazard curves for the MFFF site at SRS. Seismic hazard curves are included for 1.0 Hz, 2.5 Hz, 5.0 Hz, and 10.0 Hz. By examining this range of structural frequencies, seismic hazard curves are enveloped for the gamut of structural systems that are likely to exist at the MFFF (such as reinforced concrete and steel structures, piping systems, HVAC systems, equipment, electrical components, etc.).

Table IV provides detailed coordinate data that define the seismic hazard curves at each frequency. These coordinates are used as input for the calculations of seismic performance of the selected SSCs are the various frequencies.

Table IV. Seismic Hazard Curve Coordinate Data

Annual Probability of Exceedance	Acceleration @ 1.0 Hz (g)	Acceleration @ 2.5 Hz (g)	Acceleration @ 5.0 Hz (g)	Acceleration @ 10.0 Hz (g)
1.00E-02	0.0120	0.0309	0.0400	0.0397
5.60E-03	0.0215	0.0554	0.0708	0.0621
3.20E-03	0.0354	0.0916	0.1130	0.0909
2.00E-03	0.0534	0.1323	0.1611	0.1230
1.00E-03	0.0937	0.2093	0.2399	0.1857
5.00E-04	0.1546	0.3062	0.3359	0.2479
4.00E-04	0.1803	0.3351	0.3616	0.2690
2.00E-04	0.2721	0.4439	0.4541	0.3484
1.00E-04	0.3854	0.5667	0.5700	0.4093
5.60E-05	0.4721	0.6768	0.6466	0.4624
3.20E-05	0.5741	0.8032	0.7305	0.5214
1.80E-05	0.7051	0.9703	0.8278	0.5892
1.00E-05	0.8757	1.2032	0.9406	0.6629
5.60E-06	1.0835	1.4882	1.0802	0.7359
3.20E-06	1.3382	1.8315	1.2566	0.8153
1.80E-06	1.6642	2.2710	1.4683	0.9082
1.00E-06	2.0772	2.8281	1.7219	1.0165
5.60E-07	2.5549	3.4511	2.0515	1.1388
3.20E-07	3.1197	4.1830	2.4460	1.3277
1.80E-07	3.0858	5.0917	2.9305	1.5570
1.00E-07	4.5880	6.0992	3.4913	1.8318

3.4 Calculation of Seismic Performance Goal Achievement

The seismic performance achieved for each type of SSC at the MFFF is calculated using the steps previously outlined. The calculations are performed for 1.0 Hz, 2.5 Hz. 5.0 Hz, and 10.0 Hz frequencies for each SSC type. Fragility data from Table III and seismic hazard curve data from Table IV are used as inputs to these calculations.

These calculations are performed using Excel spreadsheets. Table V provides an example of one of these spreadsheet calculations.

Table V: Sample Calculation of Seismic Performance

Gross Building Structure Performance Goal Achieved @ 1.0 Hz

Design Basis Earthquake at Frequency Evaluated, DBE (g) = 0.30
Median Capacity, C_{50} (g) = 1.50
Logarithmic Standard Deviation, B = 0.40

Acceleration, a (g)	Exceedance Probability, H(a)	Local Slope Parameter, K_{Hi}	Center of Gravity Acceleration, a_{cgi} (g)	Normal Deviate, Z = ($\ln a_{cgi} - \ln C_{50}$)/B	Conditional Failure Probability, P_F/a_{cgi} = Normal Std. Dist. of Z	Probability Hazard Within Range, $H_{ai} - H_{(ai+1)}$	Incremental Performance, $P_{Fi} = P_F/a_{cgi} \times [H_{ai} - H_{(ai+1)}]$
0.012	0.01						
		0.994293387	0.016293558	-1.13E+01	0.00E+00	0.0044	0.00E+00
0.0215	0.0056						
		1.122241686	0.027804489	-9.97E+00	0.00E+00	0.0024	0.00E+00
0.0354	0.0032						
		1.143285958	0.043697013	-8.84E+00	0.00E+00	0.0012	0.00E+00
0.0534	0.002						
		1.232727476	0.071235015	-7.62E+00	1.30E-14	0.001	1.30E-17
0.0937	0.001						
		1.384237531	0.120649047	-6.30E+00	1.49E-10	0.0005	7.43E-14
0.1546	0.0005						
		1.451047658	0.166972327	-5.49E+00	2.03E-08	0.0001	2.03E-12
0.1803	0.0004						
		1.684245814	0.220919299	-4.79E+00	8.41E-07	0.0002	1.68E-10
0.2721	0.0002						
		1.991160779	0.322231626	-3.84E+00	6.03E-05	0.0001	6.03E-09
0.3854	0.0001						
		2.857528699	0.424573559	-3.16E+00	8.02E-04	0.000044	3.53E-08
0.4721	0.000056						
		2.860834643	0.518356758	-2.66E+00	3.95E-03	0.000024	9.48E-08
0.5741	0.000032						
		2.799334589	0.633337617	-2.16E+00	1.56E-02	0.000014	2.18E-07
0.7051	0.000018						
		2.712645398	0.782069261	-1.63E+00	5.17E-02	0.000008	4.14E-07
0.8757	0.00001						
		2.723069781	0.969589485	-1.09E+00	1.38E-01	0.0000044	6.06E-07
1.0835	0.0000056						
		2.650588464	1.199004917	-5.60E-01	2.88E-01	0.0000024	6.91E-07
1.3382	0.0000032						
		2.639053847	1.485614771	-2.41E-02	4.90E-01	0.0000014	6.87E-07
1.6642	0.0000018						
		2.651553866	1.850531887	5.25E-01	7.00E-01	0.0000008	5.60E-07
2.0772	0.000001						
		2.801160394	2.293038099	1.06E+00	8.56E-01	0.00000044	3.76E-07
2.5549	0.00000056						
		2.801949	2.811034875	1.57E+00	9.42E-01	0.00000024	2.26E-07
3.1197	0.00000032						
		-52.66057055	3.104366164	1.82E+00	9.65E-01	0.00000014	1.35E-07
3.0858	0.00000018						
		1.481939942	3.763555718	2.30E+00	9.89E-01	0.00000008	7.91E-08
4.588	0.0000001						
						Overall Performance Goal Achieved = sum P_{Fi} =	**4.13E-06**

Table VI shows the cumulative results of the spreadsheet calculations of seismic performance goals for the MFFF.

Table VI: Estimated MFFF Seismic Performance Goals Achieved

IROFS	Frequency	Performance
Gross Building Structure	1.0 Hz	4.13×10^{-6}
	2.5 Hz	1.27×10^{-6}
	5.0 Hz	4.11×10^{-7}
	10.0 Hz	8.10×10^{-8}
Diesel Generator Power	1.0 Hz	7.31×10^{-6}
	2.5 Hz	2.35×10^{-6}
	5.0 Hz	1.01×10^{-6}
	10.0 Hz	2.64×10^{-7}
C3/C4 Ventilation System	1.0 Hz	7.83×10^{-6}
	2.5 Hz	2.49×10^{-6}
	5.0 Hz	1.08×10^{-6}
	10.0 Hz	2.96×10^{-7}
C3 Area Confinement	1.0 Hz	9.02×10^{-6}
	2.5 Hz	2.94×10^{-6}
	5.0 Hz	1.38×10^{-6}
	10.0 Hz	4.08×10^{-7}
Glovebox Confinement	1.0 Hz	2.16×10^{-5}
	2.5 Hz	7.39×10^{-6}
	5.0 Hz	4.76×10^{-6}
	10.0 Hz	1.77×10^{-6}
Piping Systems, Tanks, & Associated Components	1.0 Hz	1.56×10^{-5}
	2.5 Hz	5.11×10^{-6}
	5.0 Hz	2.80×10^{-6}
	10.0 Hz	9.05×10^{-7}

As can be seen from Table IV, a performance goal of 1×10^{-5} is met for all type SSCs over the range of frequencies considered, except for Glovebox Confinement SSCs at 1.0 Hz and Piping Systems and Tanks at 1.0 Hz. Glovebox Confinement SSCs are typically structural steel elements, such as columns, beams, walls, and ceiling and floor diaphragms. These type structures typically behave in the 4 Hz to 10 Hz range; hardly any SSCs will be in the 1.0 Hz range. Steel tanks typically behave in the 2 Hz to 20 Hz range. Therefore, for all practical purposes, all SSCs for the MFFF will exhibit seismic performance above the 1×10^{-5} goal.

It should be noted that this evaluation is based on the free-field input response spectrum for the MFFF site. In reality, SSCs will experience seismic response spectra that have been amplified by soil-structure interaction and in-structure effects. Through the design process, the in-structure spectra eventually developed for performing SSC design will include increases for soil-structure interaction and in-structure response. Therefore, any effects of amplification will be accounted for in the design. As a result, designing for a Regulatory Guide 1.60 input response spectrum anchored at 0.20g will ensure seismic performance of 1×10^{-5} or better.

4.0 CONCLUSION

The 0.20g Regulatory Guide 1.60 seismic horizontal response spectrum shown in Figure II should be used for design of the MFFF. This level of seismic response is estimated to have 1×10^{-4} annual probability of exceedance (i.e., a recurrence of once in 10,000 years) for frequencies of practical structural interest. Use of this spectrum will ensure seismic performance of 1×10^{-5} or better for all types of SSCs over all frequency ranges of practical structural interest. This performance demonstrates that a high consequence seismic event is highly unlikely to occur at the MFFF as a result of a DE.

5.0 OTHER NATURAL PHENOMENA

Results from the earthquake evaluation can be extrapolated to establish the appropriate level of straight wind that should be used for MFFF design. From this correlation, it is reasonable that a straight wind design level should be used that corresponds to a 1×10^{-4} probability of exceedance. This correlation is reinforced since straight wind considerations (instead of tornado winds) control the design criteria for probabilities down to about $1\text{x}10^{-4}$. Using this level of wind will achieve a performance goal of approximately 1×10^{-5} for straight wind design. This is comparable to the recurrence interval for DOE PC-4 facilities.

The design magnitude for tornado loadings should be somewhat more conservative based on design precedents for other nuclear facilities. The traditional approach for establishing tornado criteria for nuclear facilities has been to select extremely low exceedance probabilities. For commercial reactor facilities, an annual exceedance probability of 1×10^{-7} was adopted circa 1960 when very little was known about tornado effects from an engineering perspective. Much has been learned since 1960, which suggests that larger exceedance probabilities could be adopted. Some increase over the $1\text{x}10^{-7}$ is justified, especially for facilities that pose substantially smaller risks of radioactive material dispersal than commercial nuclear plants. However, it is desirable to use relatively low tornado hazard probabilities because straight and hurricane winds control the criteria for probabilities down to about 1×10^{-4}, and because additional construction costs to achieve low tornado probabilities are relatively small when compared to earthquake design costs. On these bases, the recurrence frequency for tornado events is selected to be $2x10^{-6}$ for the MFFF. Design for this magnitude of tornado event clearly satisfies a performance goal of 10^{-5}, and the recurrence interval is comparable to that used for DOE PC-4 facilities.

Flood and precipitation events present conditions for which significant design margin cannot be provided without exceptional measures. Because of this, the recurrence frequency of the initiating flood or precipitation event is selected to be the same as the target performance goal. For the MFFF, the recurrence frequency for flood and precipitation events is selected to be $1x10^{-5}$, which clearly satisfies a performance goal of 10^{-5}. This is comparable to the recurrence interval used for DOE PC-4 facilities.

Designing the MFFF to these levels of natural phenomena will ensure that high consequence events are highly unlikely to occur and that MFFF performance will meet or exceed a 1×10^{-5} probability of exceedance.

6.0 REFERENCES

- NUREG-1718, Appendix A and B
- DOE-STD-1020-94, "DOE Standard – Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities," U.S. Department of Energy, April 1994, Change Notice #1, January 1996
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