RAI Volume 2, Chapter 2.1.1.2, Second Set, Number 18:

Provide information on the location of the area radiation monitors (ARMs) that supports the applicant’s conclusion that criticality alarm systems are not required at the GROA (SAR Section 1.14.2.3.5). Specifically, address monitoring in the areas where workers could be exposed to radiation from a potential criticality accident, or exposed during maintenance activities and other changes in plant condition. Also, clarify whether or not the radiation monitoring system (RMS) can detect neutron radiation, as stated in SAR Section 1.2.5.1.1. Explain how neutron radiation and dose is monitored, and provide information on applicable standards.

In SAR Section 1.14.2.3.5, DOE states that criticality alarms are not required to meet the performance objectives of 10 CFR 63.111 because the RMS, which includes the ARMs, is designed to detect extreme radiation levels regardless of the cause, implying that the RMS might be credited for Criticality Accident Alarm System (CAAS) throughout the GROA. However, in SAR Section 1.14.3.1, DOE commits to designing the repository in accordance with ANSI/ANS-8.3-1997, American National Standard Criticality Alarm System. But, in SAR Section 1.4.2.2.1, DOE claims that “The location and design of the area radiation monitors use the methods and practices of ANSI/ANS-HPSSC-6.8.1-1981, Location and Design Criteria for Area Radiation Monitoring Systems.” It is not clear that ARMs would be installed in the areas where a CAAS would generally be installed under ANSI/ANS-8.3-197. DOE has not provided all the information needed for NRC staff to determine if the placement of ARMs is in accordance with the guidance of the two standards mentioned above.

The staff notes, that in SAR section 1.14.2.3.5 DOE relies in part upon its interpretation of the CAAS requirements of 10 CFR Parts 50, 70 and 72 in determining that CAAS are not required at the GROA. The applicant has not demonstrated that per 10 CFR 50.68, 70.24 or 72.124 that a CAAS is not required. For example 10 CFR 72.124(c) says “Underwater monitoring is not required when special nuclear material is handled or stored beneath water shielding.” It is not clear whether or not, in the WHF, the spent nuclear fuel is always either under water or in its final storage configuration. The spent fuel assemblies are considered to be in their stored configuration when they have been properly placed in a cask confinement system and the confinement system has been adequately drained, dried, inerted, and sealed. At this point, no further handling of the individual fuel assemblies takes place, and the contents and all criticality control design features are in a static state and are not purposely modified or disturbed. Thus, per 10 CFR 72.124(c), criticality monitoring would not be required after that point. The staff notes that industry standard practice is to have a CAAS even when a criticality accident is shown to be highly unlikely.

In SAR Section 1.2.5.1.1, DOE claims that ARMs measure gamma and neutron radiation levels. However, neutron detectors are not mentioned in SAR Section

1.4.2.2.1, and the scope of ANSI/ANS-HPSSC-6.8.1-1981 standard is limited to gamma radiation only. It is not clear which form of radiation will be detected and which standards would be used for neutron radiation monitoring. This information is needed to verify compliance with 10 CFR 63.112(e)(7), and 63.112(e)(10).

1. RESPONSE

The primary basis for the conclusion that a criticality accident alarm system (CAAS) is not required for geologic repository operations area (GROA) operations is that it has been quantitatively demonstrated that preclosure criticality events are not credible. DOE believes that this conclusion and its bases are consistent with current industry practice. The deployment of area radiation monitors (ARMs) in the GROA is not intended to support the conclusion that a CAAS is not required, but rather supports the conclusion that a CAAS is not needed as a defense-in-depth feature. Section 2.3.11.4 of *Preclosure Criticality Safety Analysis* (BSC 2008), titled "Defense-in-Depth Evaluation," does not form the basis for whether a CAAS is required for GROA operations, but provides a qualitative evaluation of whether a CAAS could be considered a defense-in-depth feature. This qualitative evaluation concludes that a CAAS is not needed as a defense-in-depth feature for several reasons, one of which is that ARMs are present and will detect excessive radiation levels regardless of the cause.

SAR Section 1.4.2.2.1 describes the radiation monitoring system capability in GROA facilities, which includes continuous air monitors, airborne radioactivity effluent monitors, and ARMs. ARMs are located at selected positions in the surface handling facilities and at the aging pads. The specific locations of the ARMs will be determined during detailed design based upon: (1) frequency and length of personnel occupancy, (2) potential for personnel to be exposed to high radiation levels, and (3) potential for radiation exposures to exceed radiation limits due to system failure or personnel error. ARMs are not required for the subsurface facility because of limited personnel occupancy and associated radiation protection program administrative controls. ARMs will be designed to ANSI/ANS-HPSSC-6.8.1-1981, *Location and Design Criteria for Area Radiation Monitoring Systems*, and not to ANSI/ANS-8.3-1997, *American National Standard Criticality Accident Alarm System*, and will only have gamma radiation detection capability. SAR Sections 1.2.3.1.1, 1.2.4.1.1, 1.2.5.1.1, and 1.2.6.1.1 incorrectly state that ARMs will detect both gamma and neutron radiation. Neutron radiation will be monitored using portable instruments during routine radiation surveys as required by the radiation protection program.

SAR Section 1.14.3.1 commits to performing criticality safety analyses and establishing criticality safety design criteria in accordance with ANSI/ANS-8.3-1997. This national consensus standard provides guidance for evaluating the need for deploying a CAAS, as well as guidance for the design and locations of CAAS detectors, if deemed necessary. Consistent with the guidance in Sections 2 and 4.1.1 of this standard, and the explicit quantification of event sequences important to criticality[1], which demonstrates that preclosure criticality is not credible

[1] Event sequences with end states labeled "Important to Criticality" conservatively indicate the frequency of a potential impact to a criticality control parameter, but do not indicate a postulated criticality accident or an end-state configuration whose k_{eff} exceeds the upper subcritical limit.

(i.e., limiting event sequence frequency below 1×10^{-7} per year), SAR Section 1.14.2.3.5 concludes that a CAAS is not required for GROA operations. The additional bases listed in this SAR section are conclusions based on a comparison with other regulations and a summary of the defense-in-depth evaluation.

Because there are no specific criticality monitoring requirements in 10 CFR Part 63, other regulations such as 10 CFR Parts 50, 70, and 72, which include specific requirements and specific considerations for a CAAS evaluation, were reviewed in *Preclosure Criticality Safety Analysis* (BSC 2008, Section 2.3.11.4).

Repository operations with canistered spent nuclear fuel (SNF) and high-level radioactive waste (i.e., operations in the Canister Receipt and Closure Facilities, Initial Handling Facility, Receipt Facility, subsurface facility, aging facility, and intrasite, as well as operations with sealed and inerted canisters in the Wet Handling Facility (WHF)), are similar to those conducted under 10 CFR Part 72. For these operations, SNF and high-level radioactive waste are considered to be in their stored configuration as they have been packaged in a canister and the canister has been drained, dried, inerted, and sealed. During these operations, no handling of individual fuel assemblies takes place, and the contents and the criticality control design features are in a static state and are not purposely modified or disturbed. Thus, 10 CFR 72.124(c) would not require criticality monitoring for any of these operations.

Repository operations with individual commercial SNF assemblies in the WHF pool are conducted underwater. 10 CFR 70.24(a) states that criticality monitoring for underwater operations is not required.

Operations with unsealed canisters containing commercial SNF and individual commercial SNF assemblies in the WHF are similar to those conducted in spent fuel pools under 10 CFR Part 50. 10 CFR 50.68(b) allows a licensee to forego a criticality monitoring system if the licensee complies with specific enumerated requirements that ensure that criticality events are not credible. Although 10 CFR Part 50 is not applicable to GROA operations, the WHF pool design could meet items 1 through 7 of 10 CFR 50.68(b). Current industry practice is to demonstrate the noncredibility of criticality events and not deploy a criticality monitoring system. Thus, using 10 CFR 50.68 as a guide, criticality monitoring would not be required for operations similar to those of the WHF pool.

In the evaluation of criticality monitoring for loading and handling of casks in the WHF, the project considered NRC staff correspondence (e.g., NRC 2005) indicating that criticality monitoring was not needed for the loading and handling of storage casks per 10 CFR 50.68(c) and 10 CFR 72.124(c) based on criticality safety design criteria and analysis bases similar to those for the WHF, including:

- WHF pool design includes physical measures to prevent criticality including geometric controls, and fixed and soluble neutron absorber controls.

- Criticality analyses used bounding SNF characteristics, including fresh fuel loading with maximum enrichment (5.0 wt % ^{235}U), and no burnup credit.

- Canisters are filled with borated water (2,500 mg/L of boron enriched to 90 atom % ^{10}B, which results in a significant margin of subcriticality) when moved in and out of the pool. Lids are emplaced on the canisters/casks during such movements which inhibits any potential boron dilution inside the canisters.

- Drying and inerting of canisters during closure operations further reduces criticality concerns.

- Area gamma radiation monitors, not specifically designed to monitor for a criticality accident, provide local audible and remote alarms if excessive gamma radiation levels are detected.

- No credible event sequences that lead to an important to criticality end-state were identified. Each important to criticality event sequence has a calculated frequency at least an order of magnitude less than the Category 2 event sequence frequency threshold (less than 1×10^{-7} per year).

DOE-STD-1136-2009, *Guide of Good Practices for Occupational Radiological Protection in Uranium Facilities*, which the NRC discussed during the clarification call on July 16, 2009, states in Section 7.4.1, *Criticality Accident Alarm System*, item c.:

> If the fissionable material mass exceeds the ANSI/ANS-8.3 limits, but a criticality accident is determined to be impossible or less than 10^{-6} per year (per a Documented Safety Analysis), then neither a criticality alarm nor nuclear accident dosimetry is needed.

The *Preclosure Criticality Safety Analysis* (BSC 2008) conclusion that CAAS deployment is not needed is consistent with this provision in DOE-STD-1136-2009, although this standard is not directly applicable to GROA operations.

The bases summarized in SAR Section 1.14.2.3.5, which include a detailed and quantitative event sequence analysis demonstrating that criticality events are not credible as well as a review of industry practices for similar operations, lead to the conclusion that a CAAS is not required nor is it needed as a defense-in-depth feature for GROA operations.

2. COMMITMENTS TO NRC

The DOE commits to update the license application as described in Section 3. The changes will be included in a future license application update.

3. DESCRIPTION OF PROPOSED LA CHANGE

The text in SAR Sections 1.2.3.1.1, 1.2.4.1.1, 1.2.5.1.1, and 1.2.6.1.1 will be corrected to describe the area radiation monitors as only having gamma detection capability.

4. REFERENCES

ANSI/ANS-HPSSC-6.8.1-1981. *Location and Design Criteria for Area Radiation Monitoring Systems for Light Water Nuclear Reactors*. La Grange Park, Illinois: American Nuclear Society. TIC: 253112.

ANSI/ANS-8.3-1997. 2003. *American National Standard Criticality Accident Alarm System*. La Grange Park, Illinois: American Nuclear Society. TIC: 258157.

BSC (Bechtel SAIC Company) 2008. *Preclosure Criticality Safety Analysis*. TDR-MGR-NU-000002 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080307.0007.

DOE-STD-1136-2009. *Guide of Good Practices for Occupational Radiological Protection in Uranium Facilities*. Washington, D.C.: U.S. Department of Energy.

NRC (U.S. Nuclear Regulatory Commission) 2005. 04/26/05 Ltr to L.M. Stinson (Southern Nuclear Operating Company, Inc.) from R. Lewis—Regarding Southern Nuclear Operating Company, Inc. Request for Exemption from 10 CFR 72.124(c)—Criticality Monitors. ML051160287.