REQUEST FOR ADDITIONAL INFORMATION (RAI)
Volume 3—Postclosure Chapter 2.2.1.2.1 (Scenario Analysis)
5th Set (RAIs 1 through 8)
(DEPARTMENT OF ENERGY'S SAFETY ANALYSIS REPORT SECTION 2.2.1.2)

RAI #1: Changes in Final Part 63 with Respect to Proposed Part 63

10 CFR Part 63 (NRC, 2009) was recently codified. Address compliance with the updates to the Final Rule requirements. In particular:

1. Demonstrate that the information available in the safety analysis report (SAR) is in conformance with the final rule, or provide the information necessary to demonstrate compliance based on the arithmetic mean of the projected doses from the performance assessment evaluation during the period within 1 million years after disposal (10 CFR 63.303).
2. Address compliance with the water table rise requirement due to seismic activity beyond the 10,000-year post-disposal period through the period of geologic stability [10 CFR 63.342(c)(1)(i)].
3. Address the impact of changes to the range of deep percolation rates to assess the effects of climate change [10 CFR 63.342(c)(2)] on compliance with the postclosure performance objectives (10 CFR 63.113).

Basis:

1. Most of the dose estimates reported in the SAR show confidence bands including median and mean doses. Clarification is needed on whether the safety analysis report conforms with10 CFR 63.303 regarding the use of the arithmetic mean of projected doses beyond 10,000 years.
2. The applicant addressed water table rise as part of the screening argument for FEP 1.2.10.01.0A Hydrological Response to Seismic Activity (SNL, 2008). However, the FEP screening argument (SNL, 2008) focused on the first 10,000 years, while 10 CFR 63.342(c)(1)(i) requires consideration of water table rise past 10,000 years.
3. 10 CFR 63.342 (c)(2) (NRC, 2009) requires consideration of deep percolation rates to assess the effects of climate change based on a lognormal distribution with arithmetic mean of 41 mm/yr and a standard deviation of 33 mm/yr, but truncated to range from 10 to 100 mm/yr. The effects of these changes on the performance assessment results and the demonstration of compliance with postclosure performance objectives (10 CFR 63.113) have not been addressed.

References:

Nuclear Regulatory Commission (U.S.) (NRC), Washington D.C. "Implementation of a Dose Standard after 10,000 Years." Federal Register. Vol. 70, No. 173. pp. 53313—53320. September 8, 2005.

NRC, Washington D.C. "Implementation of a Dose Standard after 10,000 Years." Federal Register. Vol. 74, No. 48. pp. 10811—10830. March 13, 2009.

SNL. 2008. "Features, Events, and Processes for the Total System Performance Assessment: Analyses." ANL-WIS-MD-000027. Rev. 00. ACN 01, ERD 01, ERD 02. Las Vegas, Nevada: Sandia National Laboratories.

Exclusion of FEPs on the Basis of Probability

RAI #2: For the FEPs listed below; clarify the rationale to exclude the FEP on the basis of low probability.

2.1.03.04.0A Hydride Cracking of Waste Packages
2.1.03.04.0B Hydride Cracking of Drip Shields
2.1.07.04.0A Hydrostatic Pressure on Waste Package
2.1.07.04.0B Hydrostatic Pressure on Drip Shield
2.1.09.28.0B Localized Corrosion on Drip Shield Surfaces Due to Deliquescence
2.1.11.06.0B Thermal Sensitization of Drip Shields
2.1.12.08.0A Gas explosions in EBS

This information is needed to verify compliance with 10 CFR 63.114 and 10 CFR 63.342.

Basis: The referred FEPs were excluded on the basis of low probability; however, there is no explicit reference to a probability value in the screening rationale in SNL (2008). A probability value (i.e., probability less than 10^{-4} of occurring within 10,000 years) is needed to exclude a FEP on the basis of probability, or an argument is needed to show that the FEP is of low consequence.

Reference:
SNL. 2008. "Features, Events, and Processes for the Total System Performance Assessment: Analyses." ANL-WIS-MD-000027. Rev. 00. ACN 01, ERD 01, ERD 02. Las Vegas, Nevada: Sandia National Laboratories.

Exclusion of FEP 1.1.01.01.0B Influx through Holes Drilled in Drift Wall or Crown and FEP 2.1.06.04.0A Flow through Rock Reinforcement Materials in EBS

RAI #3: In light of observations, related to temperature fluctuations recorded by sensors in boreholes of the Drift-Scale Heater Test, provide the technical basis for exclusion of FEP 1.1.01.01.0B and FEP 2.1.06.04A. These FEPs address flow in boreholes and rock reinforcement components. This information is needed to assess compliance with 10 CFR 63.114.

Basis: Analysis of several heater tests suggests that observations of temperature fluctuations could be explained by the occurrence of heat pipes in boreholes (Green, et al., 2008). Refluxing water associated with the heat pipes in the boreholes may lead to pulses of water preferentially breaching the dryout zone and possibly reaching the drift ceiling when the average drift wall rock temperatures are above 100 °C. These observations occurred in ungrouted MPBX boreholes in the Drift Scale Heater Test.

DOE has not clearly addressed how the three arguments presented as the basis for exclusion of FEPs 1.1.01.01.0B and 2.1.06.04A in SNL (2008) account for observations in the dryout zone of the Drift-Scale Heater Test of apparent refluxing within MPBX boreholes, and consequently, the possibility of liquid water reaching the drift. For the current design (SAR, Section 1.3.4.4.1), there will be approximately 26 rock bolts in the seepage area for a typical waste package that could act as pathways for refluxing water.

References:

Green, R., C. Manepally, R.W. Fedors, and M.M. Roberts. 2008. "Examination of Thermal Refluxing in In-Situ Heater Tests." Center for Nuclear Waste Regulatory Analyses, San Antonio, Texas. LSN No. NRC000029847, or ADAMS No. ML083030097.

SNL. 2008. "Features, Events, and Processes for the Total System Performance Assessment: Analyses." ANL-WIS-MD-000027 REV 00. Las Vegas, Nevada: Sandia National Laboratories.

RAI #4: In light of observations and interpretations of the presence of liquid water in the Passive Test in the Enhance Characterization of the Repository Block (ECRB) drift, provide a technical basis for exclusion of FEP 1.1.01.01.0B and FEP 2.1.06.04A which addresses vapor migration into drifts and subsequent condensation. This information is needed to verify compliance with 10 CFR 63.114.

Basis: Salve and Kneafsey (2005) describe how observations of liquid water in the Passive Test (BSC, 2004, Section 6.10.2.2) of the ECRB drift can be explained using a conceptual model of vapor migration through the fracture network and into the drift. They describe three models for vapor flux into the drift, and the degree to which each model appears to best fit the observations of hydrologic conditions and liquid water in the drift.

Observations in the Passive Test consistent with water dripping into the drift (seepage per the DOE definition) are said to be lacking (SAR Section 2.3.3.2.2.2). The distribution of water in the drift of the Passive Test is qualitatively explained by condensation after redistribution of moisture driven by small temperature and relative humidity variations (SAR Section 2.3.3.2.2.2.5). Similar variations of temperature and relative humidity would be expected to occur after the thermal perturbation period in emplacement drifts.

Influx through holes drilled in the drift wall (FEP 1.1.01.01.0B) and flow through rock reinforcement materials (FEP 2.1.06.04.0A) are currently excluded FEPs due to low

consequence. Boreholes, however, would facilitate the exchange of vapor from within the host rock to locations in the drift. As per the current design (SAR, Section 1.3.4.4.1), several tens of rock bolts will be installed around the drift periphery over the length of a waste package. In the design, rock bolts will be ungrouted (installed using pressure), and are assumed by DOE to corrode at the start of post-closure period. Regardless of the extent of corrosion, open vapor air pathways will be present.

References:

BSC. 2004. "In-Situ Testing of Field Processes." ANL-NBS-HS-000005 Rev03. Bechtel-SAIC Company, LLC., Las Vegas, Nevada. LSN# DN2001977697.

Salve, R. and T.J. Kneafsey. 2005. "Vapor-phase transport in the near-drift environment at Yucca Mountain." Water Resources Research, Volume 41, W01012, doi:10.1029/2004WR003373

Exclusion of FEP 2.2.07.05.0A Flow in the UZ from Episodic Infiltration

RAI #5: Provide a technical basis for exclusion of FEP 2.2.07.05.0A that addresses: (1) the observation that temporally varying percolation fluxes may induce time-averaged seepage that is larger than would occur with the same average flux applied at a steady rate; (2) temperature and tritium field observations that suggest episodic flow may be prevalent at Yucca Mountain, at least in scattered locations; and (3) why multi-decadal climate fluctuations necessarily have a negligible effect on performance when percolation fluctuations demonstrably may result in a systematic increase in seepage. This information is needed to evaluate compliance with 10 CFR 63.114.

Basis: Depending on the timing of the fluctuations, temporally varying percolation fluxes may induce time-averaged seepage that is larger than would occur with the same average flux applied at a steady rate. For example, DOE (2009, RAI 3.2.2.1.1-002, Figure 1-1) provides an illustrative example with mean seepage 50 percent larger under variable percolation fluxes than under the equivalent steady percolation flux.

The screening argument for excluding FEP 2.2.07.05.0A relies on numerical modeling to demonstrate that the porous matrix of the PTn imbibes wetting pulses. The screening argument uses a numerical model to explain observations of chlorine-36 in the ESF as a result of fast pathways from approximately 1 percent of infiltration. However, the screening argument does not address temperature and tritium field observations that suggest episodic flow may be prevalent at Yucca Mountain, at least in scattered locations.

References:

DOE. 2009. "Yucca Mountain – Request for Additional Information Re: License Application (Safety Analysis Report Section 2.1), Safety Evaluation Report Volume 3 – Postclosure Chapter

2.2.1.1 – System Description and Demonstration of Multiple Barriers." Letter and enclosure from J.R. Williams (DOE) to J. Sulima (NRC) February 6, 2009. ML090400455.

Exclusion of FEP 2.1.14.15.0A In-Package Criticality (Intact Configuration), FEP 2.1.14.16.0A In-Package Criticality (Degraded Configuration), and 2.1.14.19.0A In-Package Criticality Resulting from a Seismic Event (Degraded Configuration)

RAI #6: In light of SAR Section 2.2.1.4.1.1.1, Figure 2.2-4, and the description provided in SNL (2008b, Section 1), provide the justification, including the ranges of parameters, used to determine that the two sequences of events [i.e., (1) improper manufacturing, resulting in the absence and/or loss of efficacy of the neutron absorber material, and (2) improper loading of fuel assemblies] are the dominant event sequences, and the bases for screening the other event sequences. This information is needed to assess compliance with 10 CFR 63.114.

Basis: SAR Section 2.2.1.4.1.1.1 states that the criticality potential evaluation begins with the identification of applicable configuration classes and describes how configuration classes are used for this evaluation. SAR Figure 2.2-4 and the information used to screen out the individual feature, event, and process (SNL, 2008a) appear to be inconsistent. SAR Section 2.2.1.4.1.1.1 and Figure 2.2-4, which describe the disposal criticality analysis methodology approach, seem to indicate that quantification is to be used in waste form configuration class evaluations yet SNL (2008a), and references cited therein (SNL, 2008b and BSC, 2004), only discuss qualitative analyses.

References:

BSC, 2004. "Configuration Generator Model." CAL-DS0-NU-000002 REV 00B. Las Vegas, Nevada: Bechtel SAIC Company

SNL. 2008a. "Features, Events, and Processes for the Total System Performance Assessment: Analyses." ANL-WIS-MD-000027, REV 00. Las Vegas, Nevada: Sandia National Laboratories.

SNL. 2008b. "Screening Analysis of Criticality Features, Events, and Processes for License Application." ANL-DS0-NU-000001 REV 00. Las Vegas, Nevada: Sandia National Laboratories.

RAI #7: Clarify how the FEPs associated with criticality were identified. This information is needed to assess compliance with 10 CFR 63.114.

Basis: SAR Section 2.2.1.1.1 describes the process used to identify FEPs. However, SAR Section 2.2.1.4.1.1.1 implies that the Disposal Criticality Analysis Methodology Topical Report (CRWMS M&O, 2003) was the method used to identify criticality related FEPs. The SAR states that the configuration classes cover the criticality related FEPs. This implies that the probability of criticality calculated based on configuration classes will be conservative with respect to the

criticality FEPs. SAR Section 2.2.1.4.1.1.1 also states that the configuration classes are grouped according to their corresponding FEPs and that the probability estimates are made for each class, not for each FEP.

Reference:
CRWMS M&O. 2003. "Disposal Criticality Analysis Methodology Topical Report." YMP/TR-004Q, Rev. 02. Las Vegas, Nevada: Yucca Mountain Site Characterization Office.

RAI #8: Justify performance of neutron absorber shot used in DOE5 and DOE8 waste forms calculations and its impact on the calculation of the probability of criticality. This information is needed to assess compliance with 10 CFR 63.114.

Basis: SNL (2008a) states that the fuel types other than DOE1, 2, and 7, do not rely on neutron absorber plates for criticality control. SNL (2008b) states, however, that absorber material for the DOE5 and DOE8 SNF waste forms consists of a combination of both plates and shot and, thus, the absorber misload probability is considered insignificant. No justification was provided for the shot performance in presence of water flow during first 10,000 years of postclosure period. The arguments did not address the number of DOE5 and DOE8 CDSP waste packages in the screening calculation in SNL (2008a).

References:
SNL. 2008a. "Features, Events, and Processes for the Total System Performance Assessment: Analyses." ANL–WIS–MD–000027. Rev. 00. Las Vegas, Nevada: Sandia National Laboratories.

SNL. 2008b. "Screening Analysis of Criticality Features, Events, and Processes for License Application." ANL–DS0-NU–000001. Rev. 00. Las Vegas, Nevada: Sandia National Laboratories.