**REQUEST FOR ADDITIONAL INFORMATION (RAI)**
**Volume 3—Postclosure Chapter 2.2.1.3.2 (Mechanical Disruption of Engineered Barriers)**
**3rd Set (RAIs 1 through 9)**
**(DEPARTMENT OF ENERGY'S SAFETY ANALYSIS REPORT SECTION 2.3.4)**

**The information is needed to verify compliance with 10 CFR 63.114(a).**

**Subject: Drip Shield mechanical response to seismic loading.**

**RAI #1**
Demonstrate that the drip shield retains adequate seepage barrier functionality after deformation (SAR 2.3.4.5.3).

**Basis**: DOE concludes that the drip shield continues to function as a barrier to seepage after the drip shield framework collapses (SNL 2007ay; Section 6.12.2). SAR Section 2.3.4.5.3.3.2 concludes that the drip shield plates in the crown will remain intact after the framework legs buckle because they are structurally more robust than the framework. The SAR, however, does not discuss how an appropriate level of uncertainty for framework collapse (including spatial variability) has been considered. Neither does the SAR demonstrate that failures due to high stress concentrations in the collapsed Titanium Grade 7 plates are unlikely to occur or that seepage water inflow through deformed drip shields (e.g., discontinuities) will not affect performance significantly.

Analyses also show that for an intact drip shield framework (i.e., no uniform corrosion), the bulkhead snaps through in the middle of the crown span during failure (SAR, 2.3.4.5.3.3.2). The SAR does not explain the apparent inconsistency between the analyses used to generate the drip shield abstractions for the first tens of thousands of years, and the conclusion that the crown plates are structurally more robust than the framework legs (SAR Sections 2.3.4.5, 2.3.4.5.3.3.2, and 2.3.4.4.4.1), particularly in the context of barrier functionality.

**Reference**
SNL. 2007ay "Seismic Consequence Abstraction." MDL–WIS–PA–000003. Rev. 03. ERD 01. Las Vegas, Nevada: Sandia National Laboratories.

**RAI #2**
Demonstrate that the drip shield quasi-static limit load analyses appropriately represent the potential effects on drip shield performance from horizontal accelerations during vibratory ground motion from seismic events.

**Basis**: To obtain an approximation of the peak ground acceleration that the drip shield can withstand, the applicant monotonically increased the initial static vertical load, while keeping constant the lateral rubble loading (SNL, 2007ap; Section 6.4.3.2.2.2). The approach appears to be inconsistent with the dynamic loading being represented in the quasi-static analysis, given that dynamic amplifications in the horizontal accelerations are expected to be similar to those in the vertical direction, according to applicant's results (BSC, 2004al; Appendix P).

**References**

BSC. 2004al. “Drift Degradation Analysis.” ANL–EBS–MD–000027. Rev. 03. ACN 001, ACN 002, ACN 003, ERD 01. Las Vegas, Nevada: Bechtel SAIC Company, LLC.

SNL. 2007ap. “Mechanical Assessment of Degraded Waste Packages and Drip Shields Subject to Vibratory Ground Motion.” MDL–WIS–AC–000001. Rev. 00. ERD 01. ERD 02 Las Vegas, Nevada: Sandia National Laboratories.

**RAI #3**

For the drip shield two-dimensional model subjected to acceleration time histories, demonstrate that a failure criterion based on the effective plastic strain at the end of the dynamic simulations is appropriate. In addition, demonstrate that the effective plastic strain from one event is considered in the analyses of subsequent events.

**Basis**: DOE uses the maximum effective plastic strains at the end of the time history analyses to evaluate the drip shield performance (SAR Section 2.3.4.5.3.3.3 and SAR Figure 2.3.4-85) but does not provide maximum effective strain-time and maximum effective plastic strain-time relationships.

DOE has not shown that the maximum effective plastic strains at the end of the simulation, as calculated in UDEC, appropriately represents the maximum effective plastic strains experienced by components subjected to cyclic loading, such that the tensile effective strain-failure criterion (SAR Section 2.3.4.5.1.2.2) is not underestimated.

**RAI #4**

Demonstrate that including the base of the emplacement pallet in the dynamic analyses of drip shield mechanical performance does not overestimate drip shield capacity during vibratory ground motions.

**Basis**: DOE dynamic analyses in SAR section 2.3.4.5.3.3.3 include the waste package base pallet in the two dimensional model (e.g., SAR Figure 2.3.4-84). Some of the results of these analyses show that deformation of the drip shield sidewall may be influenced by the presence of the base pallet (e.g., SAR Figure 2.3.4-85). However, the base pallet only extends across approximately one fifth of the drip shield length. DOE analyses have not discussed the potential effects of drip shield-base pallet interactions during dynamic analyses, and have not included analyses in which the drip shield framework performance is not be influenced by the base pallet.

**RAI #5**

Clarify the apparent inconsistency between SNL (2007ap, Section 6.4.4.2) and SAR Section 2.3.4.5.3.3.3 with respect to the inclusion of horizontal accelerations in the drip shield dynamic analyses. If horizontal accelerations from seismic time histories were not used in the dynamic analysis, explain how the analytical approach in SAR Section 2.3.4.5.3.3.3 does not underestimate drip shield capacity significantly.

**Basis**: DOE indicates in SNL (2007ap, Section 6.4.4.2) that the vertical and one horizontal component (H1) of the ground motion acting normal to the drift axis are used in the drip shield two-dimensional analyses. Conversely, the applicant states in SAR Section 2.3.4.5.3.3.3 that “the vertically propagating ground motion time histories are applied at the base of the entire

period of the strong ground motion (SNL 2007ap; Section 6.4.4.4). These analyses automatically generate the lateral rubble loads applied to the drip shield legs generated by rubble-drip shield interaction under the vertical seismic loading." Staff needs to clarify whether horizontal ground motions were included in the drip shield dynamic analyses, or if exclusion of these ground motions affects drip-shield performance significantly.

**References**

SNL. 2007ap. "Mechanical Assessment of Degraded Waste Packages and Drip Shields Subject to Vibratory Ground Motion." MDL–WIS–AC–000001. Rev. 00. ERD 01. ERD 02 Las Vegas, Nevada: Sandia National Laboratories.

**RAI #6**

For the computation of the drip shield cross section properties used in the two-dimensional dynamic analysis, demonstrate that Titanium Grade 7 plate stiffness contribution does not decrease across its transverse width, and therefore, an effective width of 1.071 m does not overestimate drip shield capacity.

**Basis**: The cross section properties of the two dimensional drip shield elements include the contribution of the Titanium Grade 29 framework components and the Titanium Grade 7 shell plates. Although the plate stiffness contribution is fully effective in the vicinity of the drip shield frameworks, it could decrease across the transverse width. Such decreases in plate stiffness often are represented by reducing the effective width of the plate to values less than the framework span. DOE analyses, however, assume that the plate stiffness remains constant between the framework spans and use an effective width of 1.071 m (SNL, 2007ap; Table B-1). Information in SNL (2007ap) does not explain the rationale for using an effective width that is equal to the framework span, which maximizes the plate stiffness and drip shield capacity.

**Reference**

SNL. 2007ap. "Mechanical Assessment of Degraded Waste Packages and Drip Shields Subject to Vibratory Ground Motion." MDL–WIS–AC–000001. Rev. 00. ERD 01. ERD 02 Las Vegas, Nevada: Sandia National Laboratories.

**RAI #7**

For the development of the drip shield framework abstractions, justify the exclusion of Case 13 (4.07 m/s in SAR Table 2.3.4-42) that estimates lower values for drip shield capacity than those calculated using quasi-static analyses.

**Basis**: DOE compared the drip shield capacity results of the three-dimensional quasi-static evaluation and the two-dimensional dynamic analyses, concluding that the limit loads determined from the quasi-static fragility analyses underestimate the framework capacity. However, the results from dynamic analyses for Case 13 at 4.07 m/s (i.e., SAR Table 2.3.4-42) calculate an equivalent drip shield capacity of less than 947 kPa for a drip shield with no uniform corrosion. This capacity is less than that indicated from the results of quasi-static analyses (i.e., SAR Figure 2.3.4-83). Information in SAR Section 2.3.4.5 does not explain the rationale for disregarding this information, given that a limited number of cases were compared, and that quasi-static analyses cannot account for dynamic effects such as intercomponent variability, duration and frequency content of vibratory ground motions.

**RAI #8**
Clarify whether rockfall during the early stages of a seismic event is considered in the implementation of the drip shield abstractions presented in SAR Tables 2.3.4-43 and 2.3.4-44.

**Basis**: To assess the likelihood of drip shield damage, DOE appears to evaluate a static rockfall load on the drip shield at the end of a seismic event (see SAR Tables 2.3.4-43 and 2.3.4-44). DOE indicated (SNL, 2008, Section 6.6.1.2) that only the rockfall load accumulated prior to the evaluated seismic event is accelerated due to vibratory ground motions. Analyses in BSC (2005) conclude that rockfall forms close to the onset of strong ground motions. In SAR 2.3.4.5 or SNL (2008, Section 6.6.1.2), DOE has not discussed the potential significance of accelerations applied to the rockfall that potentially forms and accumulates during the early stages of the seismic event. Thus, strong seismic events that occur in a relatively intact drift might underestimate drip shield damage because of the lesser rockfall load that can lead to amplification of permanent loading. Compare, for instance, the drip shield abstractions in SAR Tables 2.3.4-43 and 2.3.4-44 for cases with 0-10 percent rockfall load and those with 50-100 percent rockfall load.

**References**
BSC 2005. Mechanical Assessment of Waste Package Subject to Vibratory Ground Motion. CAL-WIS-AC-000001 Rev. 0B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20050823.0001.

SNL. 2008. "Total System Performance Assessment Model/Analysis for the License Application." MDL–WIS–PA–000005. Rev. 00. AD 01, ERD 01, ERD 02, ERD 03, ERD 04. Las Vegas, Nevada: Sandia National Laboratories.

**RAI #9**
Provide weld design information to demonstrate that the assumption of full composite action used in the finite element models is adequate; particularly for the internal and external Titanium Grade 7 plates. In addition, provide an evaluation of residual stresses in the titanium components, resulting from weld processes and heat treatment.

**Basis**: DOE concludes (SNL, 2007ap; Section 6.4.3.2.2.1) that drip shield structural components will be welded together in such a way that relative motion between the components will be prevented (i.e., the welds will not fail before any of the welded components). However, DOE needs to provide information on the weld design to demonstrate that full composite action should be expected for all welded plates; particularly for the internal and external Titanium Grade 7 plates. In addition, DOE needs to provide information to demonstrate that residual stresses from welding have been evaluated in the design.

**Reference**
SNL. 2007ap. "Mechanical Assessment of Degraded Waste Packages and Drip Shields Subject to Vibratory Ground Motion." MDL–WIS–AC–000001. Rev. 00. ERD 01. ERD 02 Las Vegas, Nevada: Sandia National Laboratories.