REQUEST FOR ADDITIONAL INFORMATION (RAI)
Volume 3—Postclosure Chapter 2.2.1.3.2 (Mechanical Disruption of Engineered Barriers)
2nd Set (RAIs 1 through 8)
(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: Estimation of Waste Package Damage Due to Seismic Ground Motions (Kinematic Analyses with Multiple Waste Packages)

RAI #1

Reconcile the assumption that the waste package pallet is intact in the kinematic analyses (SAR Section 2.3.4.5.2) with the information indicating that the stainless steel connector tubes lose structural integrity (SAR Section 2.3.4.1). Or, demonstrate that the intact waste package pallet assumption does not underestimate significantly the potential for waste package damage in the kinematic analyses.

Basis: Although the kinematic analyses use an intact waste package emplacement pallet, DOE concludes that the stainless steel connector tubes in the pallet lose their structural integrity (SAR Section 2.3.4.1). This loss of connector integrity could result in a range of pallet pedestal orientations, potential impact locations, and impact frequencies that exceed the range of parameters considered by DOE. Larger uncertainty in pedestal orientation has the potential to affect calculations of impact locations and time of impact, relative velocity of the impact bodies, relative angle of impact of the impacting bodies, and forces between the impacting bodies. Information presented in SAR 2.3.4.5.2 and 2.3.4.5.4 is insufficient to determine if such uncertainties in pedestal orientation, impact location, and frequency would affect significantly the characteristics of waste package damage calculated in kinematic analyses.

RAI #2

Describe the engineering parameters, such as stress or strain, that were used in the expert judgment process to determine the rupture probability for multiple impacts to waste packages.

Basis: DOE relies on engineering judgment to determine if multiple impacts to the waste package result in tensile rupture (SAR 2.3.4.5.1.4.2). If the degree of deformation from a single impact is judged significant, a second impact of equal or greater magnitude is judged sufficient to cause tensile rupture. Although DOE describes incipient damage to the waste package in SAR 2.3.4.5.2.1.3.2, DOE does not describe the magnitude of stress or strain on the outer corrosion barrier, the impact velocities that caused this damage, or the threshold in which such damage occurs. Information in the SAR does not explain how variations in these or other indicators of damage have been considered in the expert judgment process, such that the uncertainty in waste package damage potential has been considered in the analyses.

RAI #3
Explain why waste package rupture was excluded in the kinematic analyses for realizations where the computed maximum effective strain exceeded the effective strain limits and how this exclusion does not underestimate waste package damage. Provide triaxiality factors and deformation state (i.e., tension or compression) for realizations in which the maximum effective strain exceeded the effective strain criterion.

Basis: The applicant defined the maximum effective strain limit for the waste package rupture condition as 0.57 for uniaxial tension and 0.285 for biaxial tension (SNL, 2007, Section 6.3.2.2.5). For realizations where the maximum effective strain is less than 0.285, rupture was not considered credible. If the maximum effective strain exceeded 0.285, the strain limit was multiplied by the triaxiality factor, resulting in an effective strain limit between 0.285 and 0.57. Subsequently, the rupture condition was evaluated based on the newly computed strain limit. For some realizations the computed maximum effective strains exceed the effective strain limit (e.g., SNL, 2007, Table 6-92), however, no waste package rupture was determined for these realizations.

Subject: Estimation of Waste Package Damage under Collapsed Drip Shield Conditions

RAI #4
Demonstrate that uncertainties in the angle of impact for drip shield components onto the waste package outer corrosion barrier would not affect significantly the calculation of waste package damage fraction or rupture probability.

Basis: Kinematic analyses in SAR 2.3.4.5.4 assume that drip shield components have zero contact angles (i.e., lie flat) on the waste package outer corrosion barrier when vertical loads are applied. However, the SAR does not provide a basis to conclude that drip shield components will have a zero contact angle with the waste package if the drip shield framework collapses. Information in the SAR does not address how uncertainties in contact angle resulting from, for example, differential deformation of the drip shield (e.g., partial framework collapse) or tilting of the waste package (e.g., due to the waste package emplacement pallet degradation), could affect the kinematic analyses for waste package damage. Additionally, localization of stress from angular impacts may affect the localization of tensile strain on the outer corrosion barrier, and increase the likelihood of puncture or rupture (e.g., SAR 2.3.4.5.4.4.2).

RAI #5
Explain how the potential for tensile tearing of the waste package under a collapsed drip shield is bounded by the strain analyses for intact or fully degraded drip shields, such that the potential for tensile tearing is not underestimated.

Basis: For intact waste package internals and a collapsed drip shield, DOE considers tensile strain calculations from dynamic rock rubble loads after drip shield plate failure as bounding. For degraded internals and a collapsed drip shield, DOE considers the kinematic analyses for TAD-bearing waste packages as bounding. Thus, DOE did not present the results of models for tensile strain of the waste package after collapse of the drip shield (SAR section 2.3.4.5.4.4.1). However, DOE has not discussed how free interactions between the waste package and drip shield, or dynamic interactions with rock rubble, appropriately bound localized tensile strains that could occur between a collapsed drip shield and the waste package.

Subject: Damage Estimation of Waste Package Surrounded by Rubble Subjected to Seismic Ground Motions

RAI #6

Demonstrate that two-dimensional representations of the waste package in dynamic load calculations do not underestimate significantly the potential for tensile tearing from seismic events.

Basis: DOE uses a two-dimensional plane strain representation of the waste package and its components for dynamic analyses under rubble loads (SNL, 2007, p. 6-216). This simplification assumes that the waste package extends infinitely in the direction normal to the calculation plane and that the structural response of the waste package is not affected by its boundaries. DOE compared results of two-dimensional and three-dimensional stress analyses (SNL 2007ap, Appendix D), using uniform static loadings that are not representative of the dynamic loads associated with seismic events. Because of the dynamic loading associated with seismic events and the higher rigidity of the lid area, the area of the waste package lid potentially could be more susceptible to tensile tearing than an open cylinder.

RAI #7

Demonstrate that the stresses and strains assessed at the end of dynamic analyses do not underestimate the stresses and strains experienced by the waste package during the time history of seismic events.

Basis: In the dynamic analyses for seismic events, DOE assesses the effective plastic stresses and strains of the final waste-package configuration after re-establishing equilibrium (SNL, 2007ap, section 6.5.1.2.2). DOE has not explained if effective stresses and strains are assessed at intermediate steps during the dynamic loading simulations. Because of the transient accelerations during modeled seismic events, the effective plastic stresses and strains of final waste package configurations after re-establishment of equilibrium may not be representative of the maximum effective plastic stresses and strains that occur during dynamic simulations.

RAI #8

Clarify apparent inconsistencies in the information reported in the SAR Section 2.3.4.5.4.3.1.2 and the SAR Figure 2.3.4-89 regarding waste package damage area as a function of yield stress.

Basis: In SAR Section 2.3.4.5.4.3.1.2 the applicant stated that for a residual stress threshold of 90 percent of the yield stress, the damage area resulted in 0.2 percent of the total waste package outer corrosion barrier surface area and a residual stress threshold of 105 percent of the yield stress resulted in a 3 percent damage area. In contrast, SAR Figure 2.3.4-89 shows a damage area of 3 percent corresponds to a residual stress threshold of 90 percent of the yield stress, whereas a reported damaged area of 0.2 percent corresponds to a residual stress threshold of 105 percent of the yield stress.