REQUEST FOR ADDITIONAL INFORMATION (RAI)
Volume 3—Postclosure Chapter 2.2.1.2.1 (Scenario Analysis)
3rd Set (RAIs 1 through 11)
(DEPARTMENT OF ENERGY'S SAFETY ANALYSIS REPORT SECTION 2.2, TABLE 2.2-5)

Exclusion of FEP 1.1.03.01.0A Error in Waste Emplacement

The FEP 1.1.03.01.0A Error in Waste Emplacement is excluded from the performance assessment model on the basis of low consequence (Safety Analysis Report Section 2.2, Table 2.2-5; Sandia National Laboratories, 2008). The staff considers that the technical bases of the screening argument do not address consequences of errors in waste emplacement.

RAI #1: Provide a technical basis for exclusion of FEP 1.1.03.01.0A that is consistent with a screening decision of low consequence. This information is needed to verify compliance with 10 CFR 63.114 (e), (f).

<u>Basis</u>: In SAR Table 2.2-5 the FEP 1.1.03.01.0A is classified as excluded based on low consequence. Table 2.2-5 refers to SNL (2008) for further discussion of the technical bases for screening decision. The document SNL (2008, p. 6-39) states that FEP 1.1.03.01.0A is excluded by regulation. The version ERD 01 of the SNL (2008) corrects the screening decision as excluded on the basis of low consequence (in consistency with SAR Table 2.2-5). However, the screening argument was not updated to address consequence of errors in waste emplacement.

Reference

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.

Exclusion of FEP 1.4.07.03.0A Recycling of Accumulated Radionuclides from Soils to Groundwater

The FEP 1.4.07.03.0A Recycling of Accumulated Radionuclides from Soils to Groundwater is excluded from the performance assessment model on the basis of low consequence (Safety Analysis Report Section 2.2, Table 2.2-5; Sandia National Laboratories, 2008). The staff considers that the technical bases of the screening argument are not sufficient to support exclusion of the FEP from the performance assessment model.

RAI #2: Evaluate the effect of other credible groundwater flow lines on the capture zone geometry and well recapture fraction or justify why other likely alternatives should not be analyzed. For example, nonparallel flow lines that converge near the compliance boundary may imply a capture zone that widens with upstream distance from the well. This information is needed to verify compliance with 10 CFR 63.114 (e).

Basis: The capture zone geometry of the irrigation recycling model to support the FEP screening argument (Sandia National Laboratories, 2008) is based on an idealized system of a pumping well applied to a background of uniform, parallel groundwater flow lines. Observations in northern Amargosa Valley indicate flow lines converge near the compliance boundary and may support a different shape of the well capture zone that widens with increasing upstream distance from the well. A wider capture zone may increase the well recapture fraction compared to the assumed capture zone geometry for uniform, parallel groundwater flow lines. Increasing the well recapture fraction increases both the amount of recycling and estimated concentrations of radionuclides in groundwater.

RAI #3: Demonstrate that distributions of distances between a hypothetical well and irrigated fields are representative of actual distances of irrigation supply wells to irrigated fields, or justify the differences and assess the effect of those differences on the well recapture fraction. This information is needed to verify compliance with 10 CFR 63.114 (e).

Basis: Distributions of distances from wells to irrigated fields were developed to determine the well recapture fraction (Sandia National Laboratories, 2008). Based on current water usage in Amargosa Valley, about 90 percent of withdrawn water is used for irrigation. To quantify distances from the single hypothetical water supply well to the fields, the FEP screening analysis assumed that the well could be located anywhere within the community and calculated distributions of distances for the first, second, third, and fourth closest irrigated fields from the well for the set of random well locations. Because the placement of irrigation supply wells is not likely to be random, irrigation practices in Amargosa Valley may indicate that irrigation wells were closer to the field than modeled. In the DOE model, a reduction in the distances of fields to the well corresponds to a greater well recapture fraction and increased amount of radionuclide recycling.

RAI #4: Justify that the assumption on page 6-282 of Sandia National Laboratories (2008) that “radionuclides that reach the water table and are within the well capture zone are returned to the well volume without accounting for transport within the saturated zone” does not underestimate doses at later times. This information is needed to verify compliance with 10 CFR 63.114 (e).

Basis: Accounting for delayed arrival of radionuclides to the well volume would spread radionuclide releases in time. This spread of release could result in higher radionuclide concentrations at the pumping well than estimated using the DOE assumption that each year the recycled water that arrives at the water table makes it to the pumping well. For example, more than a single year release of radionuclides to the water table from recycled water might arrive at the pumping well in a single year at some later time due to delayed transport. It is not clear how dose estimates would be affected by accounting for transport within the saturated zone.

Reference

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

Exclusion of FEP 2.1.03.03.0B Localized Corrosion of Drip Shields

The FEP 2.1.03.03.0B Localized Corrosion of Drip Shields is excluded from the performance assessment model (Safety Analysis Report Section 2.2, Table 2.2-5). The staff considers that the technical bases of the screening argument have not considered uncertainty in the potential deformation of the drip shield.

(2/2/09: DOE is not required to respond to RAI #5)

~~**RAI #5**: Justify the assumption that localized corrosion of Titanium Grade 29 drip shield legs and potential buckling of the framework would not compromise the function of the drip shield to protect the waste package against seepage. The justification should address the uncertainty on the drip shield deformed shape in case the legs collapse. Also, potential gaps between contiguous drip shields and local failure of drip shield plates due to deformation should be considered in the response. This information is needed to verify compliance with 10 CFR 63.114 (e), (f).~~

Basis: The screening argument for exclusion of FEP 2.1.03.03.0B Localized Corrosion of Drip Shields stated that, since there is no long-term data to conclude otherwise, localized corrosion may initiate on Titanium Grade 29 on the side-support framework directly exposed to seepage (Sandia National Laboratories, 2008). Localized corrosion of the side framework would make the drip shield more susceptible to failure under rock load and subsequent buckling of the sidewall, but there would not be any increase in the snap-through failure of the drip shield crown (Sandia National Laboratories, 2007, Section 6.8.3.1). The screening argument concluded that, since the Titanium Grade 7 plates would still be intact, the drip shield would continue to function as a barrier to seepage, and localized corrosion was excluded from the performance assessment model. The screening rationale did not provide justification for the assumption that the drip shield would protect the waste package against seepage water even if the drip shield columns buckle.

References

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

Sandia National Laboratories. 2007. "Seismic Consequence Abstraction." MDL–WIS–PA–000003 Rev. 03. Las Vegas, Nevada: Sandia National Laboratories.

Exclusion of FEP 2.1.07.05.0B Creep of Metallic Materials of the Drip Shield

The FEP 2.1.07.05.0B Creep of Metallic Materials of the Drip Shield is excluded from the performance assessment model based on low consequence (Safety Analysis Report Section 2.2, Table 2.2-5; Sandia National Laboratories, 2008). The staff considers that the technical bases of the screening argument are not sufficient to support exclusion of the FEP from the performance assessment model.

The DOE analysis of creep of metallic materials of the drip shield was divided in two parts. The first part DOE developed a model to estimate the amount of creep strain of Titanium Grade 7 and Grade 29 as a function of applied stress and time, at the temperature determined to be appropriate for the FEP screening analysis. RAI #6 through 10 focus on the first part of the DOE creep analysis. In the second part of the analysis, DOE considered loading scenarios and the creep model to estimate the amount of creep strain in the Grade 7 drip shield plates and the Grade 29 support beams and bulkheads. RAI #11 focuses on this second part of the DOE creep analysis.

RAI #6: State the assumed temperature of the drip shield in the analyses that were used to exclude this FEP from the performance assessment model. Provide the rationale for the assumed temperature. Provide the creep equations (creep strain as a function of time and applied stress) used to estimate the amount of creep strain of Titanium Grades 7 and 29 at the considered temperature. This information is needed to verify compliance with 10 CFR 63.114 (e), (f).

<u>Basis</u>: The assumed temperature of the drip shield in the analyses that DOE used to exclude this FEP from the performance is not clear from the supporting documentation. In Sandia National Laboratories (2008, p. 6-565), DOE stated that “a reasonably bounding drip shield exposure temperature” of 300 °C was used in the analysis of creep of metallic materials in the drip shield. The document cited in Sandia National Laboratories (2008), Bechtel SAIC Company (2005), and Safety Analysis Report chapter 2.3.6.8.5 for the analysis of drip shield creep referred to a drip shield temperature of 150 °C.

RAI #7: Show that uncertainty regarding the extent to which the creep strains of Titanium Grade 7 and Grade 29 vary with temperature is adequately accounted for in the creep analysis. This information is needed to verify compliance with 10 CFR 63.114 (e), (f).

<u>Basis</u>: The temperature-dependence of creep is typically quantified by the activation energy for creep, which generally corresponds to the activation energy of the rate-limiting creep deformation mechanism. Literature reviews of low-temperature (less than about one-fourth of the melting temperature) creep of titanium (e.g. Dutton, 1996; Ankem and Wilt, 2006) suggest that there is significant uncertainty regarding the nature of the rate-limiting creep deformation mechanisms (e.g. dislocations thermally overcoming interstitial barriers, intrinsic lattice resistance, nucleation and growth of deformation twins) and, in turn, the activation energy for creep. A broad range of values for the activation energy of creep of titanium has been reported in the literature (e.g. Kiessel and Sinnott, 1953; Stetina, 1969; Thompson and Odegard, 1973).

RAI #8: Show that the creep analysis has adequately accounted for the effect of alloy microstructure on the extent of creep strain for Titanium Grades 7 and 29. This information is needed to verify compliance with 10 CFR 63.114 (e), (f).

Basis: The extent to which a titanium alloy creeps at a particular temperature and applied stress level depends upon the microstructure of the material. For instance, previous investigations (e.g. Drefahl et al, 1985; Ankem, Greene, and Singh, 1994; Aiyangar et al, 2005) have shown that the amount of creep deformation and the creep deformation mechanisms (e.g. dislocation slip, deformation twinning) in α-titanium alloys, such as Titanium Grade 7, depend upon the grain size of the material. The amount of creep strain may increase significantly with increasing grain size for the same alloy at the same applied stress level. Similar investigations (e.g. Thompson and Odegard, 1973; Miller, Chen, and Starke, Jr., 1987) have shown that the microstructure has a significant effect on the creep deformation in two-phase α–β titanium alloys, such as Titanium Grade 29.

RAI #9: Show that the creep analysis has adequately accounted for the potential hydrogen uptake into Titanium Grades 7 and 29. Hydrogen may be generated by corrosion reactions on the titanium alloy surfaces. This information is needed to verify compliance with 10 CFR 63.114 (e), (f).

Basis: In the screening analysis for the FEP 2.1.03.04.0B Hydride Cracking of the Drip Shields, DOE stated that hydrogen generated from corrosion reactions may be absorbed into the drip shield titanium alloys (Sandia National Laboratories, 2008, FEP 2.1.03.04.0B). Previous investigations (e.g. Gao and Dexter, 1987; Paton and Thompson, 1982) have shown that increasing the hydrogen content in Ti-6Al-4V and Ti-5Al-2.5Sn may significantly increase the amount of creep deformation. According to the DOE analysis (Sandia National Laboratories, 2008, FEP 2.1.03.04.0B), titanium alloys may absorb greater than 100 parts per million hydrogen in 10,000 years.

RAI #10: Define the creep strain/stress threshold, and explain the basis of the creep strain/stress threshold above which failure of the drip shield is assumed. This information is needed to verify compliance with 10 CFR 63.114 (e), (f).

Basis: In Sandia National Laboratories (2008), DOE stated that failure of the drip shield is assumed when the creep strain at any point in the drip shield structure reaches the strain corresponding to the onset of tertiary creep. DOE stated that, based on the literature, the onset of tertiary creep occurs at approximately 15% strain (Sandia National Laboratories, 2008, p. 6-566). In Section 2.3.6.8.5 of the SAR, DOE stated a strain of 10% is assumed to collapse the drip shield. Thus, the creep failure criterion is not clear.

RAI #11: Provide details of the drip shield creep analysis used for the assessment of creep deformation effects on drip shield performance, i.e., the strain and stress distributions in the drip shield components for 10,000 year simulations associated to the six quasi-static loading cases (SAR Section 2.3.4.5.3.3.2). In addition, for the static and dynamic analyses where the drip shield components experience permanent stresses and strains that exceed the creep failure threshold values, provide explanation why the drip shield system does not experience structural failure. This information is needed to verify compliance with 10 CFR 63.114 (e), (f).

Basis: From the information in the FEP screening document, cited references, and Ankem and Wilt (2006), creep failure of the drip shield may occur for stresses and strains that approach or exceed the stresses and strains at yielding of the titanium alloys. Earlier analysis documented in Bechtel SAIC Company (2004) show that stresses in the drip shield components may approach or exceed yield conditions when subjected to the six static loading cases in the Safety Analysis Report Section 2.3.4.5.3.3.2. However, SAR Section 2.3.4.5.3.1 indicates that the impact of creep on drip shield stability under static load of rubble is not significant.

References

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Ankem, R. and T. Wilt. “A Literature Review of Low Temperature ($<0.25^*T_m$) Creep Behavior of α, $\alpha-\beta$, and β Titanium Alloys.” San Antonio Texas: CNWRA. 2006.

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