REQUEST FOR ADDITIONAL INFORMATION
Volume 3--Postclosure Chapter 2.2.1.3.1—Degradation of Engineered Barriers
1st Set (RAIs 1 through 5)
(DEPARTMENT OF ENERGY'S SAFETY ANALYSIS REPORT SECTION 2.3.6.8)

SER Section 2.2.1.3.1.3.7—Drip Shield Degradation

RAI #1

1. Describe the pretest specimen preparation procedure and the polished condition of the starting surfaces of the 2.5-year titanium Grade 7 and 42-day titanium Grades 7 and 29 test coupons.

2. Assess how the posttest specimen cleaning operations used in the 2.5-year and 42-day weight-loss experiments comply with the cleaning procedures given in ASTM G1-90, specifically with regard to the use of uncorroded control specimens and the uncertainly in the weight-loss data resulting from repetitive cleaning cycles as a function of the number of equal cleaning cycles. Provide the weight-loss data sets (e.g., DTN: LL030410012251.056 and MO0705SCCIGM06.000) used to calculate the corrosion rates for the general corrosion model.

3. Explain the effect of posttest sample cleaning uncertainty of the 2.5-year titanium Grade 7 coupons (uncertainty made evident by negative corrosion rates) on the positive titanium corrosion rate values used in the performance assessment. Justify the exclusion of negative corrosion rate values and the associated uncertainty of the 2.5-year titanium Grade 7 general corrosion rate values.

4. Verify that the experimental uncertainty in the 42-day data is less than the measured variability in the corrosion rates. Assess the need to propagate experimental uncertainty into the titanium Grade 29 to Grade 7 corrosion rate ratios.

Basis: DOE relies on corrosion rates for titanium Grades 7 and 29 that are derived from weight-loss measurements based on analyses conducted in accordance with ASTM G1-90 (ASTM International, 1999; BSC, 2007a, Section 6.5.3). DOE has not adequately described experimental details that could lead to uncertainties in these rates; particularly, pretest sample preparation and posttest sample cleaning. DOE did not describe the pretest sample preparation procedure and the as-polished starting surface condition of the 2.5-year titanium Grade 7 crevice and weight-loss coupons—only the posttest sample cleaning operation. For posttest sample cleaning, BSC (2007a, Addendum, p. 6-7, 1st paragraph) states that the observed zero and negative corrosion rates for titanium Grade 7 are physically impossible and were probably caused by incomplete removal of the oxide films on the sample coupon surface during the posttest sample cleaning operations. However, BSC (2007a, Addendum, p. 1-1, 2nd paragraph) indicates more complete cleaning procedures were used for the 2.5-year titanium

Grade 7 test coupons than for the 5-year titanium Grade 16; the latter corrosion rate data were used for model validation.

In constructing the titanium Grade 7 general corrosion rate distributions, DOE ignored the negative corrosion rate values. However, DOE did not explain how the posttest sample cleaning uncertainty associated with the 2.5-year titanium Grade 7 coupons, indicated by weight gain reported in some samples, would affect corrosion rate estimates for other samples (not only those exhibiting weight gain). A technical basis is needed to explain why correcting the corrosion rate distribution was not considered for treating data indicating weight gains.

SAR Section 2.3.6.8 and BSC (2007a, Section 5.1.2) state that the general corrosion rates of titanium Grade 29 are estimated as the product of the general corrosion rate distribution of titanium Grade 7 for aggressive conditions and a multiplier distribution. This multiplier distribution function was derived from general corrosion rate ratios of titanium Grade 29 to Grade 7 from 42-day weight-loss data (BSC, 2007a, Section 6.2[a]). For the 42-day weight-loss tests of titanium Grades 7 and 29, DOE did not detail the pretest sample preparation and the posttest sample cleaning steps. In addition, DOE did not assess the experimental uncertainty from 42-day weight-loss measurements and its effects on the ratio estimates and corrosion rate.

The information above is needed to assess whether these data suitably demonstrate compliance with 10 CFR 63.21(c)(15) and 63.114(b).

RAI #2

1. Provide a technical basis to support the extrapolation of general corrosion rate ratios (developed from 42-day weight-loss test data) of titanium Grade 29 to Grade 7 to the repository performance period, given the metallurgical differences between the two metals.

2. Explain how uncertainty resulting from different metallurgical compositions in titanium Grades 7 and 29 is propagated through the performance assessment.

Basis: DOE modeled the corrosion behavior of titanium Grade 29 in terms of the comparative behavior of titanium Grade 29 vs. Grade 7 (BSC, 2007a, Section 6.2[a]). This approach assumes the passive film characteristics of these materials remain unchanged with time and are independent of the allotropic content of the parent metal. However, titanium Grade 7 is a palladium-containing single α-phase material and titanium Grade 29 is an aluminum-, vanadium-, ruthenium-containing $\alpha+\beta$ phase material. DOE did not provide a technical basis to determine whether these differences in chemical composition and phase structure could result in long-term changes in passive film characteristics; these changes could affect the general corrosion rate ratio of titanium Grade 29 to Grade 7 over long periods of time (i.e., representative of the repository performance period). This information is needed to assess whether titanium Grade

29 general corrosion rate data, derived from 42-day experiments and used in the performance assessment, suitably demonstrate compliance with 10 CFR 63.21(c)(15) and 63.114(b).

RAI #3

Assess the significance of available information that indicates a potential temperature dependence of general corrosion rates for titanium Grades 7 and 29, including welds.

The drip shield general corrosion rate, as described in SAR Section 2.3.6.8, is assumed to be independent of temperature. However, Hua and Gordon (2004) indicated that, between 50 and 110 °C, the general corrosion rate for titanium Grade 7 was a function of temperature and the general corrosion rate increased faster at temperatures greater than 80 °C. Hua and Gordon (2004) also found that the oxide films formed around 80 °C are different from the oxide films formed at lower and higher temperatures. He, et al. (2007) showed that for temperatures greater than 70 °C, titanium oxide film fracture and repair events could be relatively frequent for titanium Grade 7, which would lead to corrosion at the grain boundaries of the alloy. Zhu, et al. (2007) demonstrated that thermal effects on titanium corrosion processes are associated with the formation of iron-stabilized phases in the grain boundaries of the alloy. Information in these investigations appears to contradict the DOE modeling assumption of temperature independence for titanium corrosion rates. Potential temperature effects on titanium corrosion must be resolved to support the performance assessment used to demonstrate compliance with 10 CFR 63.114(f).

RAI #4

Provide a technical basis to assess the passivity behavior and the subsequent effect on general corrosion rates of titanium Grades 7 and 29 and the weldments during the performance assessment period for the following potential repository environmental conditions:

1. Dust deliquescence brines
2. Seepage water dripping vs. immersion condition

Basis: SAR Section 2.3.6.8 and BSC (2007a) state that the general corrosion rate of titanium Grade 7 is based on immersion tests at 60 °C and 90 °C. DOE modeled the corrosion behavior of titanium Grade 29 in terms of the comparative behavior of titanium Grade 29 vs. Grade 7 (BSC, 2007a, Section 6.2[a]). The rates in the general corrosion model abstraction are constant with time, implying that the drip shield material maintains passivity over the repository period. However, at some point under the potential repository conditions, the drip shield likely will be exposed to environmental conditions that are more aggressive than those used in the immersion experiments. Solutions with more aggressive compositions than simulated concentrated water such as dust deliquescence brines also appear credible for the range of potential repository conditions (BSC, 2007b). Drip shields also could be exposed to dripping seepage water (SAR Section 2.1.2.24, p. 2.1-66), which can lead to different corrosion processes than those that occur during constant immersion (He, et al., 2007; Lee and Solomon, 2006). DOE has not assessed the potential effects of these environmental conditions on the passivity, nor has DOE provided a technical basis to demonstrate that these effects would not significantly affect general corrosion rates of titanium Grades 7 and 29 and their weldments during the performance assessment period. This information is needed to assess assumptions in the drip shield general corrosion model for titanium Grades 7 and 29 used to demonstrate compliance with 10 CFR 63.114(f).

RAI #5

Demonstrate that using conservative assumptions for assessing drip shield corrosion performance in the nominal scenario does not underestimate the effects of drip shield stability on enhancing waste package damage in the seismic scenario.

Basis: SAR Section 2.3.6.8 and BSC (2007a) state that the drip shield outer surface general corrosion rate is modeled based on test data from simulated concentrated water at 90 °C. DOE states that it is conservative to use the most aggressive solution of the three test solutions to model outer surface corrosion rates, which leads to higher corrosion rates and earlier drip shield failure times. However, drip shield failure at earlier times might not be a conservative assumption with respect to the seismic scenario. In the seismic scenario, waste packages fail because of free motion impacts during the earthquake; these impacts result in stress corrosion cracking. Drip shield failure at earlier times will allow rock rubble to restrict waste package movement in a seismic event, thus reducing the potential for stress corrosion cracking and subsequent radionuclide release. A technical basis is needed to determine whether introducing conservatism in titanium general corrosion rates leads to nonconservative conditions for the seismic scenario. This information is needed to support the models used to demonstrate compliance with 10 CFR 63.114(g).

References:

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BSC. 2007a. “General Corrosion and Localized Corrosion of the Drip Shield.” ANL–EBS–MD–000004. Rev. 02 AD 01. Las Vegas, Nevada: Bechtel SAIC Company, LLC.

BSC. 2007b. “Analysis of Dust Deliquescence for FEP Screening.” ANL–EBS–MD–000074. Rev. 01 AD 01. Las Vegas, Nevada: Bechtel SAIC Company, LLC.

He, X., J.J. Noël, and D.W. Shoesmith. 2007. “Temperature Effects on Oxide Film Properties of Grade-7 Titanium.” *Corrosion*. Vol. 63. pp. 781–792.

Hua, F. and G. Gordon. 2004. “Corrosion Behavior of Alloy 22 and Ti Grade 7 in a Nuclear Waste Repository Environment.” *Corrosion*. Vol. 60. pp. 764–777.

Lee, S.G. and A.A. Solomon. 2006. “Localized Corrosion of Alloy C22 Nuclear Waste Canister Material Under Limiting Conditions.” *Materials Science and Engineering*. Vol. A 434. pp. 114–123.

Zhu, R., C. Nowierski, Z. Ding, J.J. Noël, and D.W. Shoesmith. 2007. “Insights into Grain Structure and Their Reactivity on Grade-2 Ti Alloy Surfaces by Scanning Electrochemical Microscopy.” *Chemistry of Materials*. Vol. 19. pp. 2533–2543.