

**REQUEST FOR ADDITIONAL INFORMATION**  
**Volume 3--Postclosure Chapter 2.2.1.3.1—Degradation of Engineered Barriers**  
**2nd Set (RAIs 1 through 11)**  
**(DEPARTMENT OF ENERGY'S SAFETY ANALYSIS REPORT SECTION 2.3.6.3 and 2.3.6.4)**

**SER Section 2.2.1.3.1.3.3—General Corrosion of the Waste Package Outer Barrier**

**RAI #1**

Provide additional technical bases to support: (1) the range of activation energy values used in TSPA, (2) the selection of the mean activation energy as 40.78 kJ/mol, and (3) an evaluation of whether the range or the estimate of the central tendency in the activation energy controls consequence estimates. These should all include a discussion of the extrapolation of activation energy for Alloy 22 passive dissolution to the range of temperatures and water chemistries expected for repository conditions during the performance period.

**Basis:** The model for passive dissolution of Alloy 22 uses a mean activation energy of 40.78 kJ/mol to represent all temperatures and water conditions analyzed in the general corrosion model (SAR Section 2.3.6.3; SNL, 2007, Section 6.4.3.4). Available information in the literature shows that mean activation energies can be roughly 50 percent lower for solution chemistries and temperatures that may occur during repository closure (e.g., Gordon, 2002; Hua and Gordon, 2004; BSC, 2004). Hua and Gordon (2004) also indicate that activation energy for Alloy 22 varied with time. DOE has not provided a technical basis to address why these apparent solution chemistry, temperature, or time-dependent effects are not considered in the selection of the mean activation energy used in the Alloy 22 corrosion model. This information suggests that the mean activation energy, which has a potentially significant effect on expected annual dose (SNL, 2008a), may be lower than used in the current model. This requested information is needed to assess the use of these activation energy data in the performance assessment used to demonstrate compliance with 10 CFR 63.21(c)(15) and 63.114(b).

**RAI #2**

Provide additional technical basis to show that the range of general corrosion rates extrapolated to low temperatures (e.g., 25 °C) in the current DOE model accounts for published experimental data at this temperature.

**Basis:** In SAR Section 2.3.6.3.4.2, the Alloy 22 general corrosion rates at 25 °C are extrapolated to be 1.13, 3.04, and 6.50 nm/yr at the 50th, 95th, and 99.99th percentiles, respectively; however, no experimental data are given to support these rates at this temperature. Literature information shows that some measured corrosion rates at ~25 °C are

relatively high, ranging from 7 to 137 nm/yr (Dunn, et al., 2005; McMillion, et al., 2005). DOE has not provided a technical basis to assess the significance of these data or explained how the current range of uncertainty in extrapolated general corrosion rates accounts for these data. This requested information is needed to assess the use of these corrosion rates in the performance assessment used to demonstrate compliance with 10 CFR 63.21(c)(15) and 63.114(b).

### **RAI #3**

1. Assess the effects of apparent experimental errors for the 5-year weight loss data for Alloy 22 (SNL, 2008b, 2008c) on the uncertainties in associated corrosion rates used to develop the general corrosion model.
2. Assess how the post-test specimen cleaning operations used for the 5-year weight loss Alloy 22 experiments are equivalent to the cleaning procedures given in ASTM G1-90, specifically with regard to the use of uncorroded control specimens and the uncertainty in the weight-loss data resulting from repetitive cleaning cycles.

**Basis:** DOE uses data from 5-year experiments to develop the general corrosion model (SAR Section 2.3.6.3.4.2). Information from SNL (2008b, Section 3.4; 2008c) indicates there may be unquantified experimental uncertainties on the corrosion rates derived from the 5-year Alloy 22 weight loss experiments due to incomplete cleaning and sample preparation errors. Proper sample preparations and complete cleaning of the 5-year coupons could result in larger weight loss, generating higher general corrosion rates than are currently used for the general corrosion model. DOE has not quantified explicitly the effects of these experimental uncertainties nor assessed how these uncertainties could affect Alloy 22 general corrosion rates. This requested information is needed to assess the use of the Alloy 22 general corrosion rates in the performance assessment used to demonstrate compliance with 10 CFR 63.21(c)(15) and 63.114(b).

### **RAI #4**

Provide additional technical basis to assess uncertainties in Alloy 22 corrosion rates associated with the long-term persistence of the passive film on Alloy 22 with regard to the structure, composition, and thickness of the passive film. Assess the potential effects of foreign deposits (e.g., silicon oxide) during the repository performance period.

**Basis:** DOE assumed a constant general corrosion rate of Alloy 22 at a given temperature (i.e., time independent) (SAR, Section 6.3.2.3). This assumption relies on the long-term stability of the thin and adherent passive oxide film formed on the alloy surface, which is mainly composed of chromium and nickel oxides. Lloyd, et al. (2003, 2004) indicated that the structure and composition of the oxide film was a function of temperature and redox condition. However,

DOE has provided limited information on oxide film characterization of Alloy 22 under simulated repository conditions (SNL 2007, Orme 2005). The data in SNL (2007, Figure 6-7) showed a decrease of chromium and nickel concentrations in the film as the immersion time in a test solution increases while silicon concentration increases. The 5 years' long-term data (Orme, 2005) did not clearly support the assumption of the long-term stability of the passive film. The data that characterizes the evolution of the thickness, composition, and structure of the passive film for a range of potential repository environmental conditions is not available, as commented in the pre-licensing evaluation of Container Life and Source Term (CLST) Key Technical Issue (KTI) Agreement CLST 1.08 and 1.09 (NRC, 2004). DOE has not assessed the potential effects changes of the oxide structure, composition, and thickness of the oxide on the long-term stability of the oxide film, nor has DOE provided a technical basis to demonstrate that these effects would not significantly affect general corrosion rates of Alloy 22 during the performance assessment period. This requested information is needed to assess the use of a constant general corrosion rate at a given temperature in the general corrosion model for Alloy 22 in the performance assessment used to demonstrate compliance with 10 CFR 63.114(f).

#### **RAI #5**

Provide a technical basis to show that the assumed role of molybdenum in Alloy 22 in eliminating the deleterious effect of sulfur on passivity is supported by available information.

**Basis:** In SNL (2007, Section 6.4.1.1.4), DOE notes that the dissolution of molybdenum sulfides is expected in the anticipated oxidic repository environment. Therefore, potentially deleterious effects of anodic sulfur segregation on Alloy 22 passivity will be avoided. However, this effect has not been demonstrated experimentally and may not be consistent with available information. Some published information shows sulfur enrichment on Alloy 22 can occur even in the presence of molybdenum in an oxidizing environment (Windisch, et al., 2007; Wong, et al., 2004, Figures 2 and 3). This information apparently was not considered by DOE, and DOE did not provide a technical basis to support the assumed role of molybdenum in mitigating the potential effects of sulfur segregation on passive film stability for Alloy 22. This requested information is needed to assess the use of Alloy 22 general corrosion rates in the performance assessment used to demonstrate compliance with 10 CFR 63.114(f).

#### **RAI #6**

Provide a technical basis to assess the potential effects of dripping and evaporation of seepage water on the long-term persistence of passive film, and subsequent effects on the general corrosion rates of Alloy 22.

**Basis:** DOE used data from immersion experiments to derive general corrosion rates for Alloy 22. Corrosion conditions in the potential repository, however, may include the dripping of seepage water in contacting the waste package surface (SAR Section 2.1.2.24, page 2.1-66).

Literature information (Lee and Solomon, 2006) showed localized corrosion (i.e., pitting) of Alloy 22 occurred under dripping and evaporation conditions, which is not observed in DOE immersion tests. This information indicates that the stability of passive film and general corrosion rates may be altered under dripping water conditions, relative to immersion conditions. DOE did not provide a technical basis to assess the potential effects of dripping water conditions on the passivity and general corrosion rates of Alloy 22. This requested information is needed to assess the use of Alloy 22 general corrosion rates in the performance assessment used to demonstrate compliance with 10 CFR 63.114(f).

#### References:

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#### **SER Section 2.2.1.3.1.3.4—Localized Corrosion of Waste Package**

##### **RAI #7**

Provide additional support to show that DOE's localized corrosion initiation model appropriately accounts for the effects of planned fabrication processes on the repassivation potential of Alloy 22, including welding, solution annealing, and surface mitigation at high temperature and high chloride concentrations.

**Basis:** In SAR Section 2.3.6.4.4.2.1, DOE indicates that it does not adjust the localized corrosion initiation model for fabrication effects. SNL (2007, Section 6.4.6.2) indicates that in high chloride conditions, the repassivation potential for as-welded material decreases with increasing temperature more rapidly than observed for mill-annealed material. At high temperatures and high chloride concentrations representative of some early in-drift conditions, this effect may lead to lower repassivation potentials for as-welded samples than calculated by the DOE repassivation potential model. SNL (2007) states that low plasticity burnishing and/or laser shock peening would mitigate the effect of welding by increasing the repassivation

potential. However, this conclusion is inconsistent with the information in SAR Section 2.3.6.4.4.2.1, which states that the repassivation potential for both welded and surface stress-mitigated samples was very similar. This requested information is needed to assess the Alloy 22 localized corrosion model in the performance assessment used to demonstrate compliance with 10CFR 63.21(c)(15) and 10CFR 63.114(f).

#### **RAI #8**

Provide additional technical basis to show that the effects of chloride or nitrate on crevice corrosion (SAR Figures 2.3.6-24 and 2.3.6-26) are supported by available experimental evidence in the literature.

**Basis:** The results of the localized corrosion repassivation potential model described in SAR Section 2.3.6.4.3.1.2 indicate that at pH 7, as chloride concentration is increased or the nitrate concentration is decreased, the localized corrosion susceptibility decreases. However, some published experimental investigations show opposite trends (Dunn, et al., 2005; King, et al., 2005). In these experiments, higher chloride concentrations increase crevice corrosion susceptibility, whereas higher concentrations of nitrate decrease crevice corrosion susceptibility of Alloy 22. This published information was not considered by DOE in developing the technical basis to support the evaluation of crevice corrosion. The requested information is needed to assess the potential effects of crevice corrosion in the performance assessment used to demonstrate compliance with 10 CFR 63.21(c)(15) and 63.114 (f).

#### **RAI #9**

Provide additional justification for the assumption that the repassivation potential is not underestimated by using the cyclic potentiodynamic polarization (CPP) method rather than an alternative method such as the Tsujikawa-Hisamatsu Electrochemical (THE) method.

**Basis:** DOE has used CPP testing to determine the localized corrosion repassivation potential, as described in SAR Section 2.3.6.4.2.2. Evans, et al. (2005) indicated that the CPP method can provide different results than the THE method, which is inconsistent with the justification in SNL (2007, Section 6.4.4.1) for using the CPP method. Additional information is needed to assess the use of the repassivation potential data in the performance assessment used to demonstrate compliance with 10 CFR 63.21(c)(15) and 63.114(b).

#### **RAI #10**

Provide additional supports for the treatment of the effects of microbially influenced corrosion (MIC) on Alloy 22 corrosion demonstrating:

- the enhancement factor used in the general corrosion model that appropriately accounts for the effects of MIC
- the technical basis for excluding microbially induced localized corrosion

**Basis:** DOE accounts for the effects of MIC on general corrosion by applying an enhancement factor of between 1 and 2 to Alloy 22 general corrosion rates for high relative humidities (SAR, Section 2.3.6.3.3.2). Results from scanning electron microscopy in SNL (2007, Section 6.4.5) show that test coupons that were exposed in nonsterile microcosm reactors for 57 months were clearly corroded (i.e., clear reduction of overall surface roughness), whereas the test coupons that were exposed to sterile microcosm reactors for 43 months showed no sign of corrosion (i.e., with clearly visible machining marks identical to that of the un-exposed coupons). These results may indicate that the effects of MIC on Alloy 22 general corrosion rates may be greater than a factor of two, as concluded in SNL (2007, Section 6.4.5) using electrochemical linear polarization resistance techniques in relatively short-term experiment (5 months). This requested information is needed to evaluate the use of Alloy 22 general corrosion rates in the performance assessment used to demonstrate compliance with 10 CFR 63.114(b).

DOE did not consider MIC effect on localized corrosion (SAR, 2.3.6.4). Alloy 22 test coupons that were incubated in nonsterile microcosm reactors developed micropits on the surface (SNL, 2007, Section 6.4.5). These micropits appear to have morphologies that are distinct from surface features associated with general corrosion. DOE did not provide a technical basis to explain why these micropits will not continue to propagate with time. This requested information is needed to evaluate the localized corrosion of Alloy 22 in the performance assessment used to demonstrate compliance with 10 CFR 63.114(f).

## **RAI #11**

Provide additional information to demonstrate the significance of salt separation effects on the timing and magnitude of radionuclide release from the proposed repository system.

**Basis:** The salt separation aspects of localized corrosion initiation were not implemented in Revision 1 of the SAR (Sections 2.3.5.5 and 2.3.6.4.4). Therefore, DOE has not adequately described the relative significance of salt separation on the timing and magnitude of radiological release from the proposed repository system. This requested information is needed to assess the effects of salt separation on localized corrosion rates used in the performance assessment for the demonstration of compliance with 10 CFR 63.114(f).

### References:

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