Monte Carlo Simulations of the Degradation of the Engineered Barriers System in the Yucca Mountain Repository Using the EBSPA code

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Introduction

Yucca Mountain (Nevada, USA) is the proposed site for a geologic repository for the disposal of high-level radioactive waste.

The nuclear waste will be stored within an engineered barriers system (EBS) that combines a drip shield (DS) and a waste package (WP). The performance of the EBS is primarily controlled by the corrosion performance of the titanium Grade 7 (Ti-7) DS and the Alloy 22 (C-22) WP.

Corrosion commences once aqueous conditions are established on the DS and the WP surfaces. The degradation modes considered in the model are general passive corrosion (GC) and hydrogen induced cracking (HIC) for the DS, and GC, crevice corrosion (CC), and stress corrosion cracking (SCC) for the WP.

Failure Model

Based on a probabilistic model, a Monte Carlo code, EBSPA4 (currently in its third version), has been developed to very conservatively predict the lifetime of the EBS.

EBSPA Code

Conclusions

The simulations demonstrate that the DS will always fail due to HIC, and CC of the WP is only a remote possibility even for the worst-case scenario.

Simulation Results

Two scenarios were simulated using the EBSPA code:

a) a conservative scenario for the conditions thought likely prevail in the repository;
b) a worst-case scenario in which the impact of degradation processes is overstated.

The calculated CPF (10^-4) shows that the EBS should not fail until 255,000 years under conservative conditions, and even for the worst-case scenario, the EBS would likely survive for more than 115,000 years after emplacement.

Acknowledgements

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Responsibility ratios of various failure mechanisms and individual components to failure

<table>
<thead>
<tr>
<th>Responsibility ratio</th>
<th>Conservative</th>
<th>Worst-case</th>
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<tbody>
<tr>
<td>HIC to DS failures</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CC to WP shell failures</td>
<td>0.0057</td>
<td>8.016x10^-7</td>
</tr>
<tr>
<td>SCC to WP inner lid failures</td>
<td>0.133</td>
<td>0.133231</td>
</tr>
<tr>
<td>DS to EBS failures</td>
<td>0.199038</td>
<td>0.005747</td>
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The EBSPA4 can calculate

a) the cumulative probability of failures (CPF) of the DS, the WP (including the shell, the inner lid, and the outer lid), and the EBS;
b) the responsibility ratio of individual components to the overall EBS failure; and

c) the contributions of different degradation modes to failure.