



# **SENSITIVITY ANALYSIS OF WASTE PACKAGE**

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**U. S. Nuclear Waste Technical Review Board  
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during the Thermal Pulse**

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# OUTLINE

- **Previous Analysis**
- **Current Analysis and Basis**
- **Long-term Passivity**
- **Conclusions**

# **PREVIOUS NRC ANALYSIS**

## **TOTAL-SYSTEM PERFORMANCE ASSESSMENT (TPA) CODE**

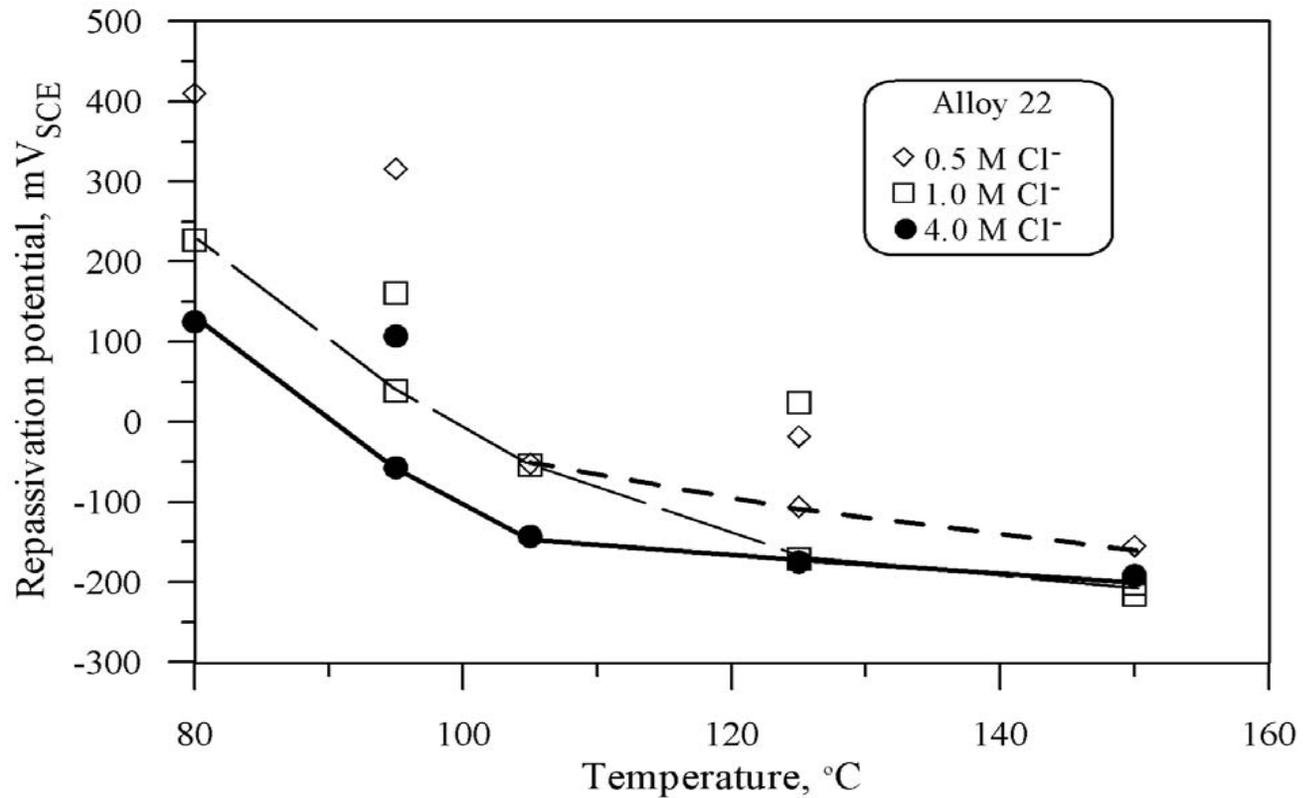
- **All corrosion parameters were from electrochemical tests in pure sodium chloride solutions.**
- **Deliquescent salt mixture or inhibitors were not considered.**
- **Drip Shield Life Time:**  
**Sampled from lognormal distribution of [3700, 27300] years**
- **No corrosion failure of waste packages in 10,000 years**
- **TPA Results: ~ 0.03 mrem/yr at 10,000 years**

# CURRENT ANALYSIS

- **Effects of Deliquescent Salts**
- **Effects of Inhibitors**
- **Effects of Perforations**

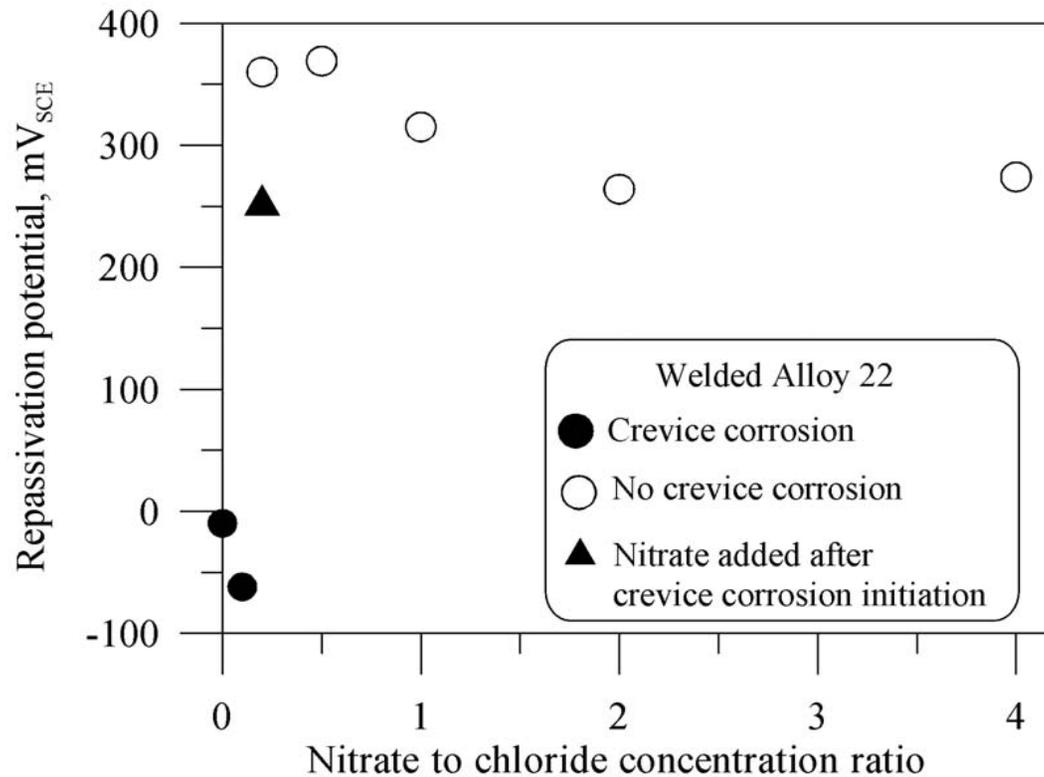
# LOCALIZED CORROSION

## Repassivation Potentials for Deliquescence at High Temperature



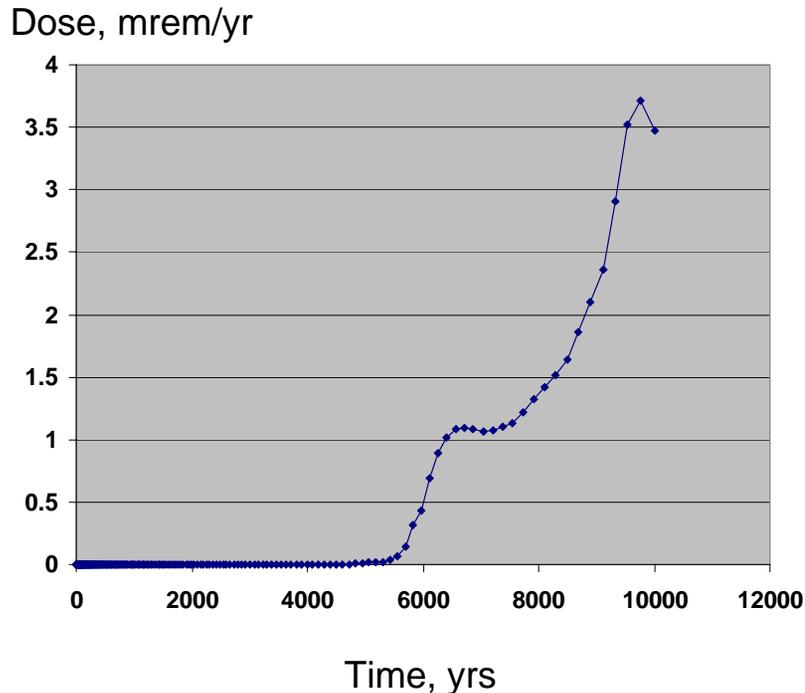
# LOCALIZED CORROSION

Inhibitors may reduce susceptibility for localized corrosion.



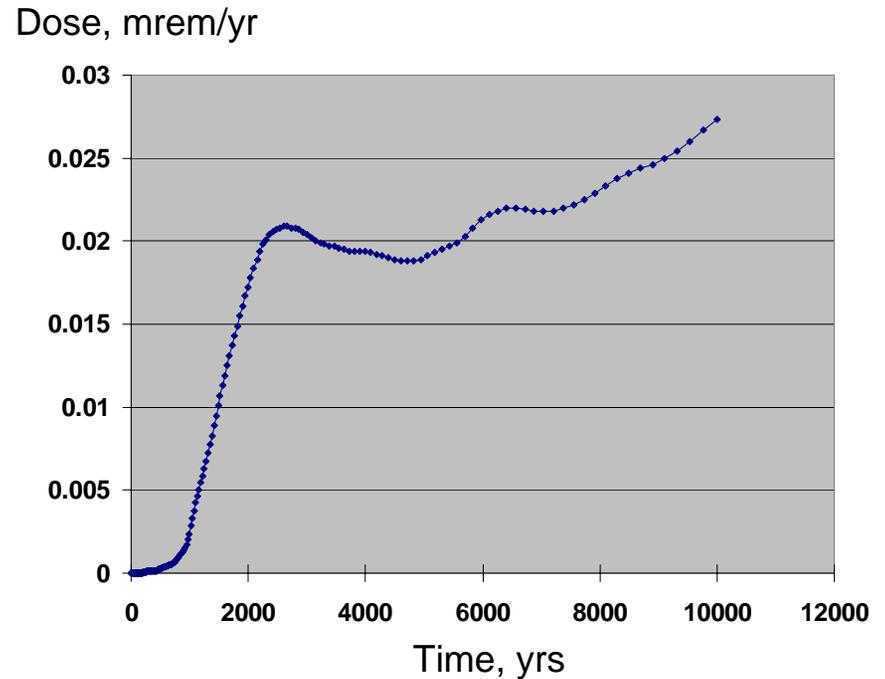
# LOCALIZED CORROSION

**Analysis using current information on repassivation potential equation**



- **About 87 % waste package failure**
- **Sodium chloride solution**

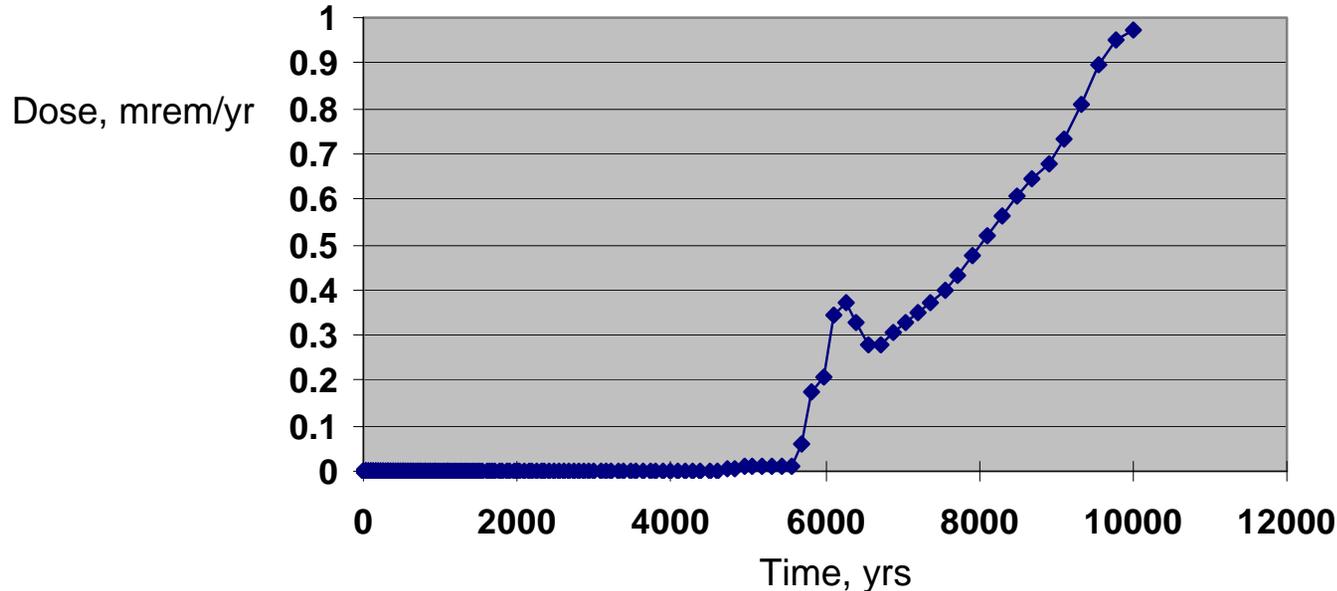
**Analysis considering inhibitors in groundwater contacting waste package**



- **No corrosion failure of waste package**
- **Sodium chloride solution with abundant nitrate; No drip shields (however, availability of fluorides can limit drip shield corrosion.)**

# LOCALIZED CORROSION

Probabilistic approach of the evaluation of high temperature deliquescence and inhibitors by sampling critical relative humidity (RH): normal distribution [0.35,0.60]

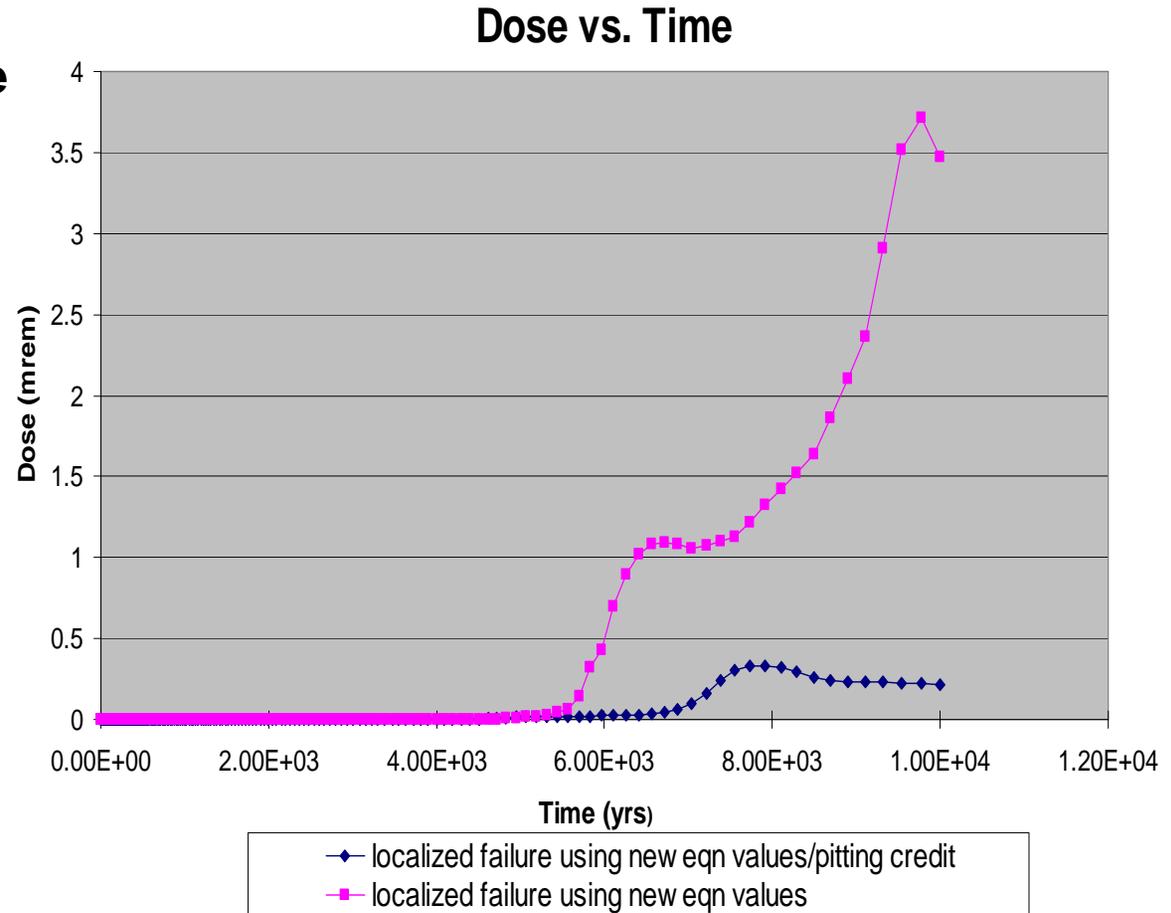


- **About 17 % waste packages were failed from the distribution.**  
- reference: no waste package failure without deliquescence in the previous NRC analysis, ~ 0.03 mrem/yr at 10,000 years)
- **Detailed distributions are under study.**

# LOCALIZED CORROSION

## Effects of Perforation Size and Frequency

- **Modified inputs to estimate the effects of the exposed surface area from size and frequency of perforations**
- **Pits could be stifled under open-circuit corrosion conditions.**
- **Crevice area is likely to be restricted.**



# UNIFORM CORROSION

## Potential Effects of High Temperature and High Acidity

- **Na-K-Cl-NO<sub>3</sub> High Temperature Deliquescence:**
  - Corrosion rates decrease with time (e.g., weight loss measurements).
- **Ca/MgCl<sub>2</sub> High Temperature Deliquescence:**
  - pH may go down leading to enhanced uniform corrosion.
  - The fraction of Ca/MgCl<sub>2</sub> is low. Also, Ca/MgCl<sub>2</sub> is likely to decompose and the resulting acids will evaporate.

# LONG-TERM PASSIVITY

- **Time and extent of waste package corrosion is important.**
- **Given no localized corrosion condition with passivity from laboratory testing, assess the stability of passive film over a geological time period.**
- **Use inference from modeling and analogue study, emphasizing potential long-term latent effects.**

# LONG-TERM PASSIVITY

- **Modeling**
  - **Void Formation: mechanical and chemical stability of passive film**
  - **Anodic Sulfur Segregation at Metal-Oxide Interface: mechanical stability and enhanced transient current on unstable passive film**
  - **Anion Selective Sorption in Crevice: latent initiation of localized corrosion**
  - **Development of Large Cathodic Surface Area of Corrosion Products: enhanced transient current on unstable passive film**
- **Analogue Study**
  - **Investigations of responsible mechanisms for the long-term survivability of analogue (e.g., josephinite, Ni<sub>3</sub>Fe)**
- **Modeling and analogue studies give better technical bases as to the long-term stability of passive film.**

# SUMMARY

- **Evaluation of corrosion of Alloy 22 needs to consider both deleterious and beneficial conditions.**
  - **The high temperature deliquescence environment could occur under specific chemical conditions such as Ca/MgCl<sub>2</sub> or mixture of Na-K-Cl-NO<sub>3</sub> salts.**
  - **Waste packages could be passivated by the effects of inhibitors.**
  - **The release could be restricted by the limited amount of deleterious Ca/MgCl<sub>2</sub> and limited exposed surface area from deleterious localized corrosion.**
- **Performance assessment provides tools to evaluate the impacts of the high temperature deliquescence on the dose and the associated uncertainties. Detailed evaluation of the uncertainties continues.**
- **Understanding of the stability of passive film over a geological period assisted by analogues and modeling**

**Disclaimer: The NRC staff views expressed herein are preliminary and do not constitute a final judgment or determination of the matters addressed or of the acceptability for a geologic repository Yucca Mountain**