Consideration of Uncertainty in the Near-Field Environment and Coupled Process Effects

LA Design Selection Process

Presentation to:
Nuclear Waste Technical Review Board (NWTRB)

Presentation by:
Ernest L. Hardin
M&O/LLNL

Beatty, Nevada
June 29-30, 1999

U.S. Department of Energy
Office of Civilian Radioactive
Waste Management

Yucca Mountain Project

Outline

- Selection and development process
- Review of uncertainties
- How uncertainties were addressed in EDA development

Discuss the near-field and engineered barriers, except the waste package and its contents, and drip shield corrosion.

Development and Selection Process

Postclosure Performance Uncertainty was Considered:

- For EDA Development

  Multi-pass Conceptual Process

- For EDA Evaluation:

  Licensing Probability/Safety Criterion

  (includes evaluation of differences in scientific approach to uncertainty)

Review of Uncertainties

- **Thermal-Hydrology**
  - Fracture capillarity
  - Fracture-matrix interaction
  - Hydro-property sets
  - Spatial heterogeneity of fracturing
- **Thermal-Mechanical**
  - Constitutive relationships
  - Boundary conditions
  - Ground support longevity

Review of Uncertainties

- **Thermochemistry**
  - Chemical heterogeneity
  - Intrinsic rates and reactive surface areas
- **Thermal-Hydrologic-Chemical (THC)**
  - Potential effects on fracture hydrologic properties, fracture-matrix interaction, and chemical fractionation
  - Effects on radionuclide transport in the UZ

Review of Uncertainties

- **Thermal-Hydrologic-Mechanical (THM)**
  - Unloading during cooldown
  - Relative magnitude of effects
- **Thermal-Hydrologic-Chemical-Mechanical (THCM)**
  - Sensitivity of fractures to processes, e.g. pressure solution, cementation
  - Relative magnitude of effects

Review of Uncertainties

- **Environmental Factors - Uncertainty of CRM Performance**
  - Physical environment (T, RH, liquid water, mechanical loading)
  - Bulk chemical environment (pH, availability of anions and buffer species)
  - Materials contacting CRM barriers

Review of Uncertainties

- **Stability and Predictability of In-Drift Physical and Chemical Conditions**
  - Effects of rockfall on the DS & WP
  - Properties of debris-backfill
  - Performance characteristics for water diversion barriers
  - Chemical evolution of introduced materials

Addressing Uncertainty in EDA Development

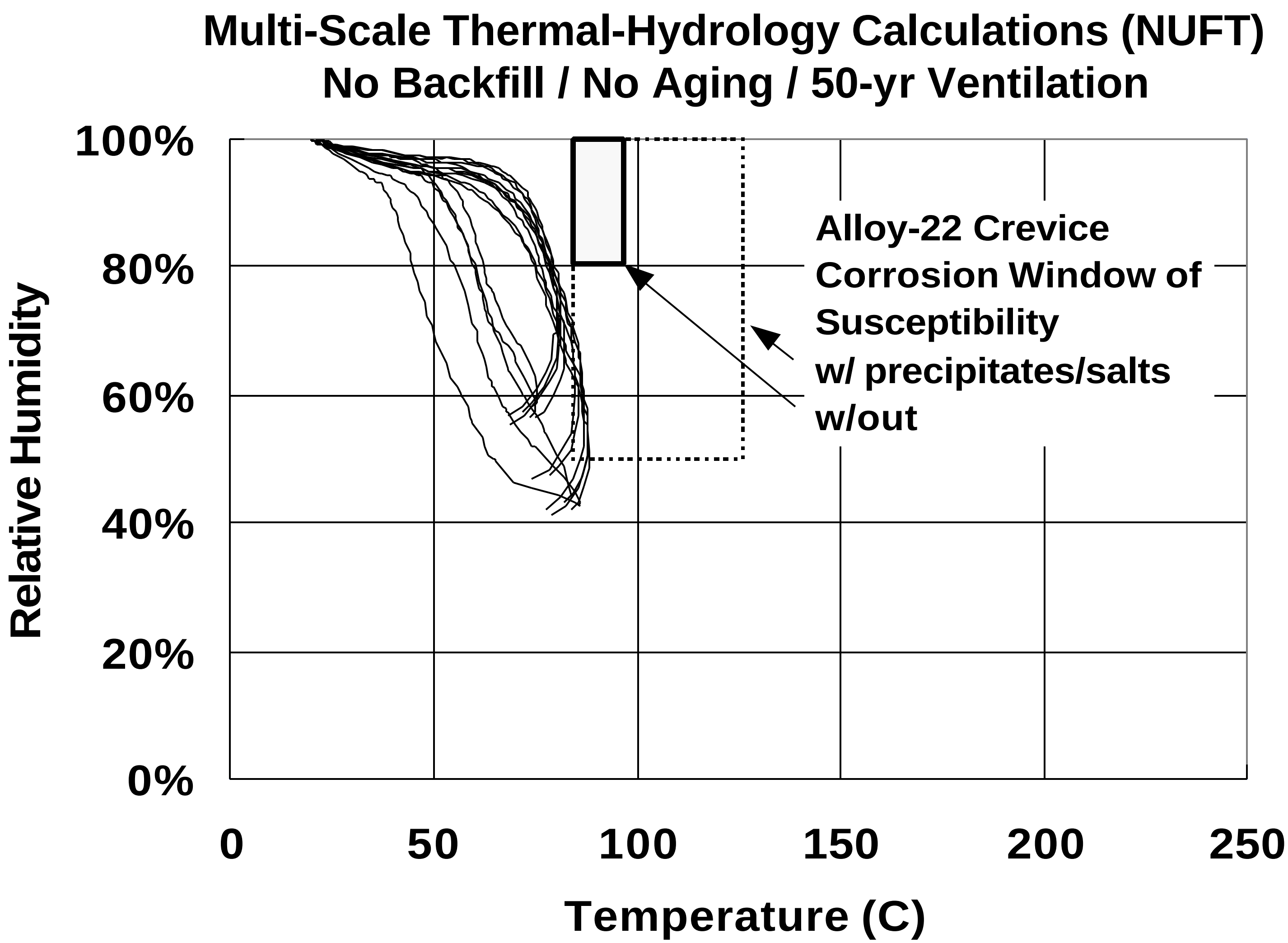
- Uncertainty of TH Conditions/Coupled Processes

  Design for lower temperature and faster cooldown

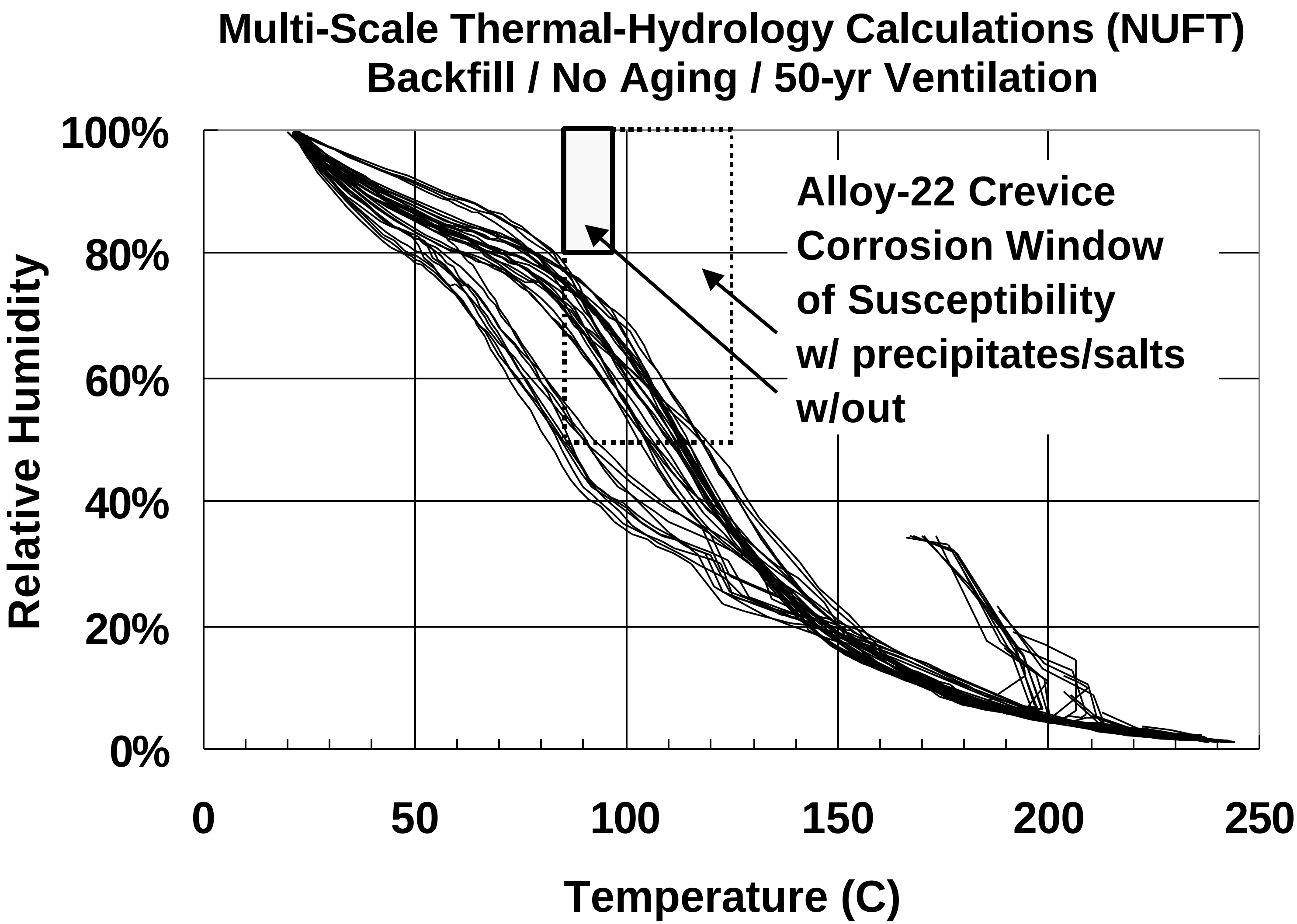
  EDA I: Drift wall T < boiling

  EDA II: Pillars mostly below boiling
  Drift wall T < boiling after 500 to 1,000 yr

EDA I - WP Temperature/Relative Humidity



EDA II - WP Temperature/Relative Humidity



Addressing Uncertainty in EDA Development

- Uncertainty of TH Conditions/Coupled Processes (cont.)

Design for higher temperature to prolong the time until return of moisture

EDAs III, IV & V:	Delay moisture return by drying host rock
EDA IV:	Also uses backfill
EDA V:	Uses high thermal loading

Addressing Uncertainty in EDA Development

- Uncertainty of TH Conditions/Coupled Processes (cont.)

  Limit reliance on prolonged low-humidity conditions in backfill

EDA I:	Low T rather than low RH
EDA II:	Limits period to ~1,000 yr
EDA V:	Uses high thermal loading without backfill

Addressing Uncertainty in EDA Development

- Uncertainty of TH Conditions/Coupled Processes (cont.)

  Design to increase reliance on local heat and mass transfer processes

EDA's I & II:	Limit multi-drift effects (can be evaluated with simplified models)
EDAs III to V:	Multi-drift TH effects

Addressing Uncertainty in EDA Development

- Uncertainty of TH Conditions/Coupled Processes (cont.)

Line Loading to Limit TH Dimensionality

EDAs II to V: Line loading

EDA I: Point loading to limit T

Blending for More Uniform Thermal Load

EDAs I, II & V: Blending to level output

EDAs III & IV: Limited blending

Addressing Uncertainty in EDA Development

- Uncertain effects from warm, moist conditions

  Use CRM outer WP barrier

  e.g. EDA I includes CRM WP outer barrier

  Limit the effects of WP energy density on duration of TH conditions

  EDA I: 12-PWR WPs
  EDAs II to V: 21-PWR WPs

  Postclosure passive ventilation not used

Addressing Uncertainty in EDA Development

- Uncertainty of coupled process chemical effects

Thermal management to limit cumulative effects

EDA I: Eliminate boiling in host rock
EDA II: Limited extent and/or duration

Drip shield to protect WP from effects of thermally driven coupled processes

All EDAs: CRM drip shield

Addressing Uncertainty in EDA Development

- Uncertainty of coupled process chemical effects (cont.)

  Design to delay onset of thermally driven coupled processes

All EDAs:	Use preclosure ventilation
EDAs III to V:	Delay effects from aqueous coupled processes on the in-drift environment

Addressing Uncertainty in EDA Development

- In-drift physical environment

  Use engineered backfill to control physical properties & effects of rockfall

  EDA's II & IV include backfill which will:

  Mitigate rockfall mechanical effects
  Stabilize EBS geometry
  Control heat and mass transport properties
  Simplify hydrologic responses (e.g. reflux)

Addressing Uncertainty in EDA Development

- In-drift physical environment (cont.)

  Use water diversion barrier to decrease potential for advective releases

  All EDAs: Include a drip shield which will strongly decrease advective releases while intact

Addressing Uncertainty in EDA Development

- In-drift chemical environment

  Limit cementitious materials, and use steel for ground support

  All EDAs: Use steel in lieu of concrete

  Use backfill to chemically isolate ground support from the WP

  EDAs II & IV: Isolate ground support materials (except mobile corrosion products)

Addressing Uncertainty in EDA Development

- In-drift chemical environment (cont.)

  Use buffer materials to control conditions at CRM contact

  Buffer materials (e.g. marble) were considered but not used in the EDAs

Summary

- **Uncertainty of postclosure performance was emphasized in EDA development & selection**
- **Review of uncertainties**
  - Coupled processes (THCM)
  - Environmental factors affecting CRM performance
  - Stability and predictability of in-drift physical and chemical environment

Summary
(continued)

- Specific Design Features Were Used to Address Important Uncertainties
  - **All EDAs:**

    CRM Drip Shield for Water Diversion and to Control WP Environment

    CRM Outer Waste Package Barrier

    Limit Cementitious Materials

Summary
(continued)

- Specific Design Features Were Used to Address Important Uncertainties (cont.)
  - **Certain EDAs:**

    Low/High Thermal Loading

    Line Loading/Blending

    Reliance on Backfill for Low Humidity

    WP Energy Density

    Backfill