Waste Form Process Components

Presented to:
Nuclear Waste Technical Review Board

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Outline

- Overview
- Unquantified uncertainties
  - In-Package chemistry
  - Np and Pu dissolved concentrations
  - In-package transport
  - Cladding
- Low temperature implications
- Other lines of evidence

Overview

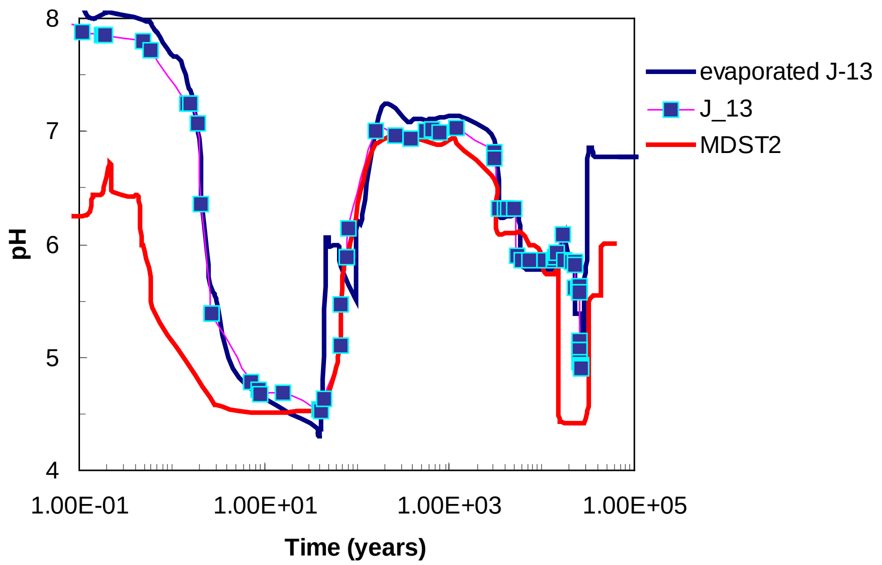
- EQ3/6 uses steel, glass, and fuel degradation rates to predict major element behavior (pH, Cl-, F-) inside the waste form as a function of time
- Solubility response surfaces for Np, Pu, U, Tc are calculated and mapped onto abstracted in-package reaction paths to predict dissolved concentrations.
- Degradation product masses and sorption of radionuclides onto degradation products is estimated
- Diffusive transport from breached no-seepage CSNF WP's is estimated (instantaneous advective release assumed for all others)
- Clad integrity is predicted as a function of time

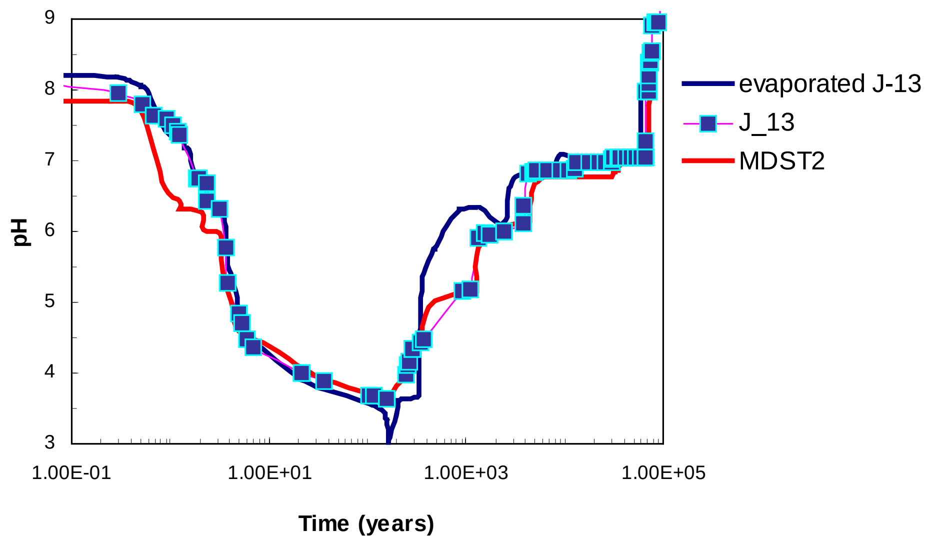
In-Package Chemistry

Non J-13 inputs

Steel degradation

Glass degradation





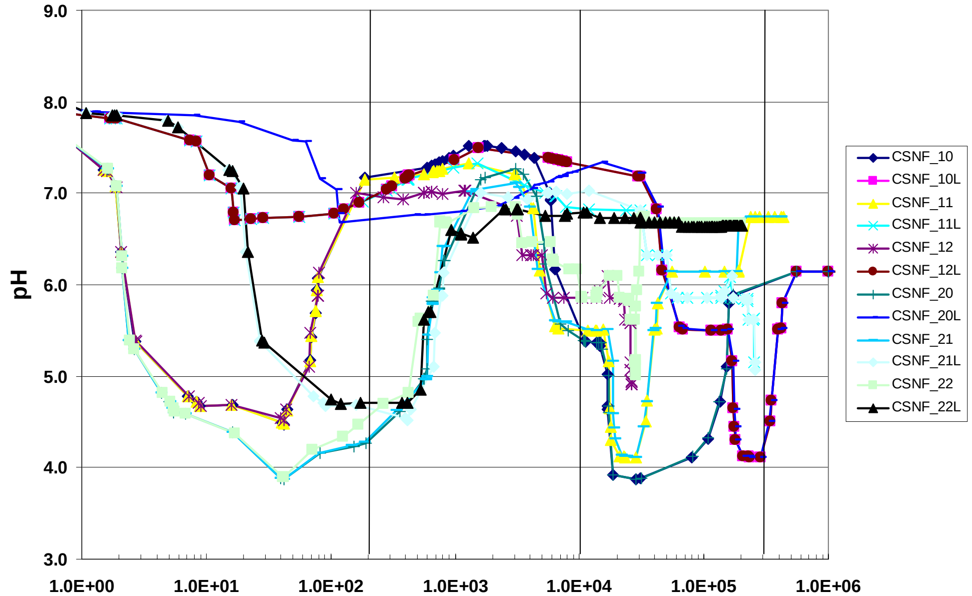
Conclusion: Input fluid made so little difference in pH trajectories that no change needed.

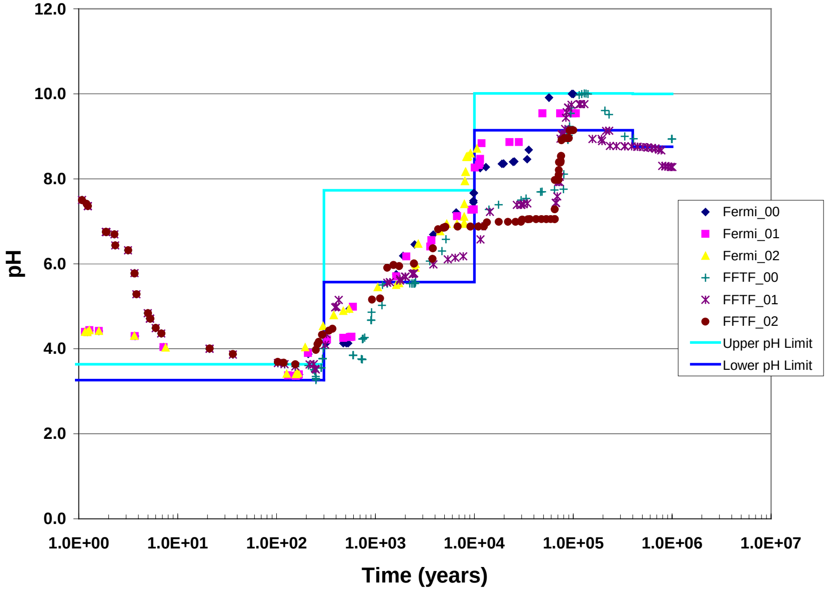
Supplemental In-Package Chemistry

Non J-13 inputs

Steel degradation

Glass degradation





Conclusion: pH trajectories resolved into more time steps; lower flow rates considered.

Supplemental In-Package Chemistry

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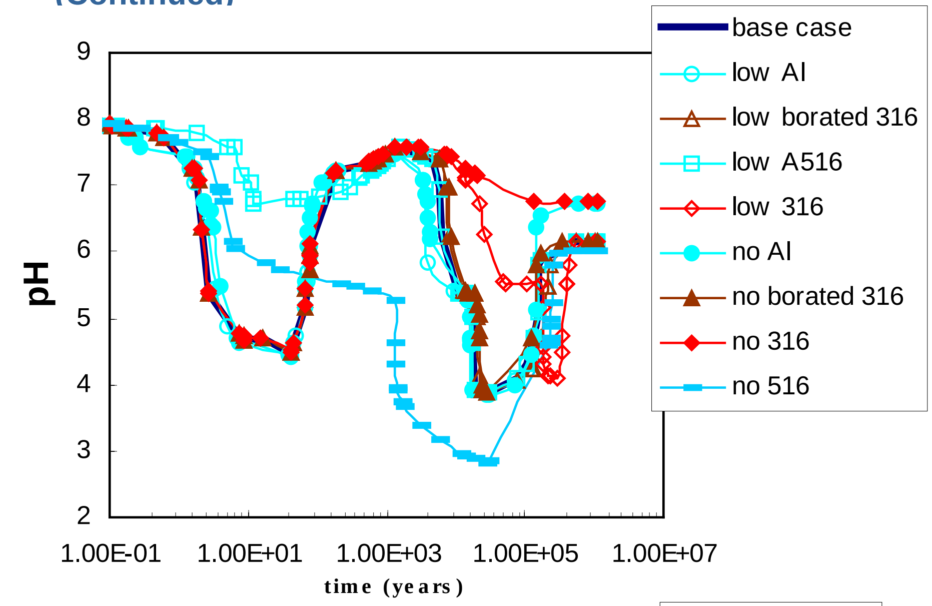
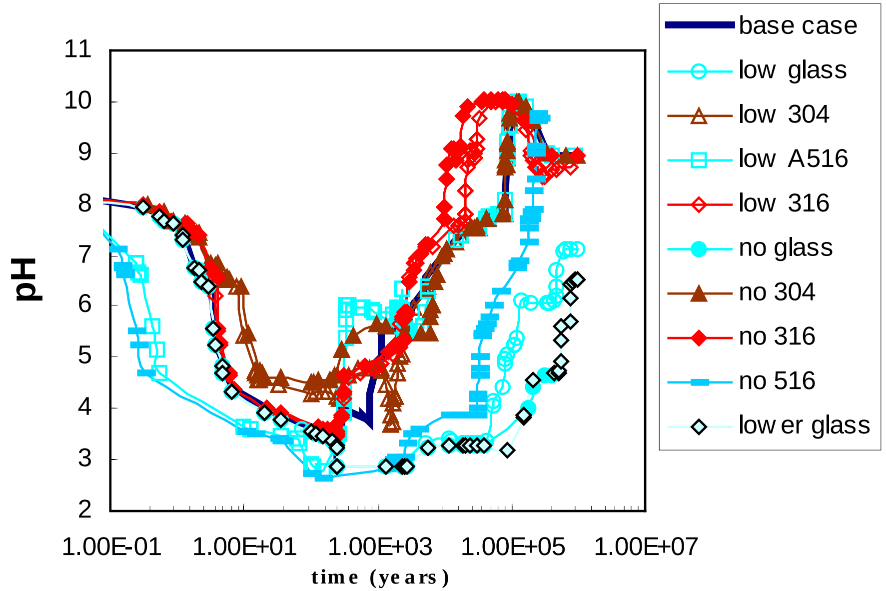


Non J-13 inputs

Steel degradation

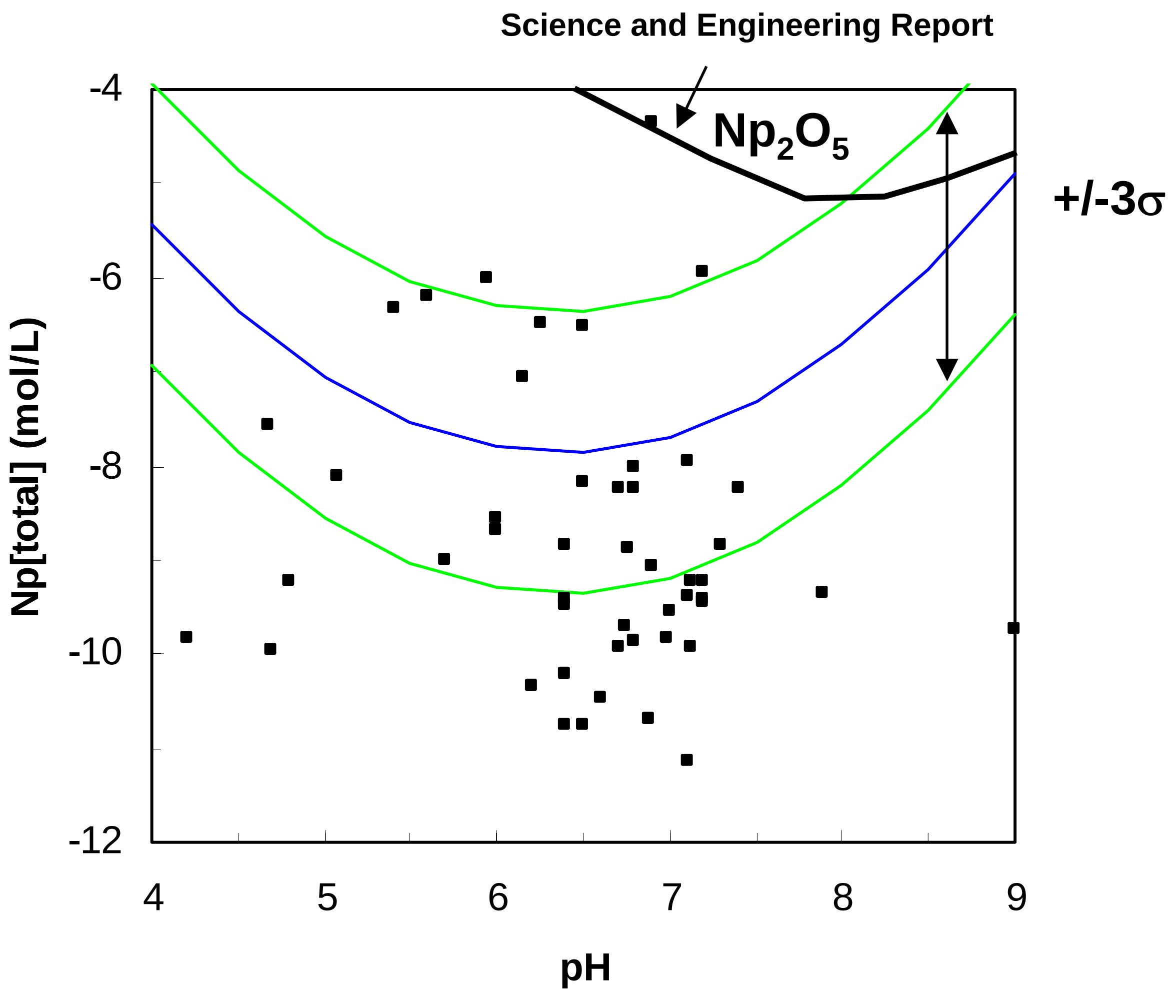
Glass degradation



Conclusion: Glass-free and A516-free cases most significant.

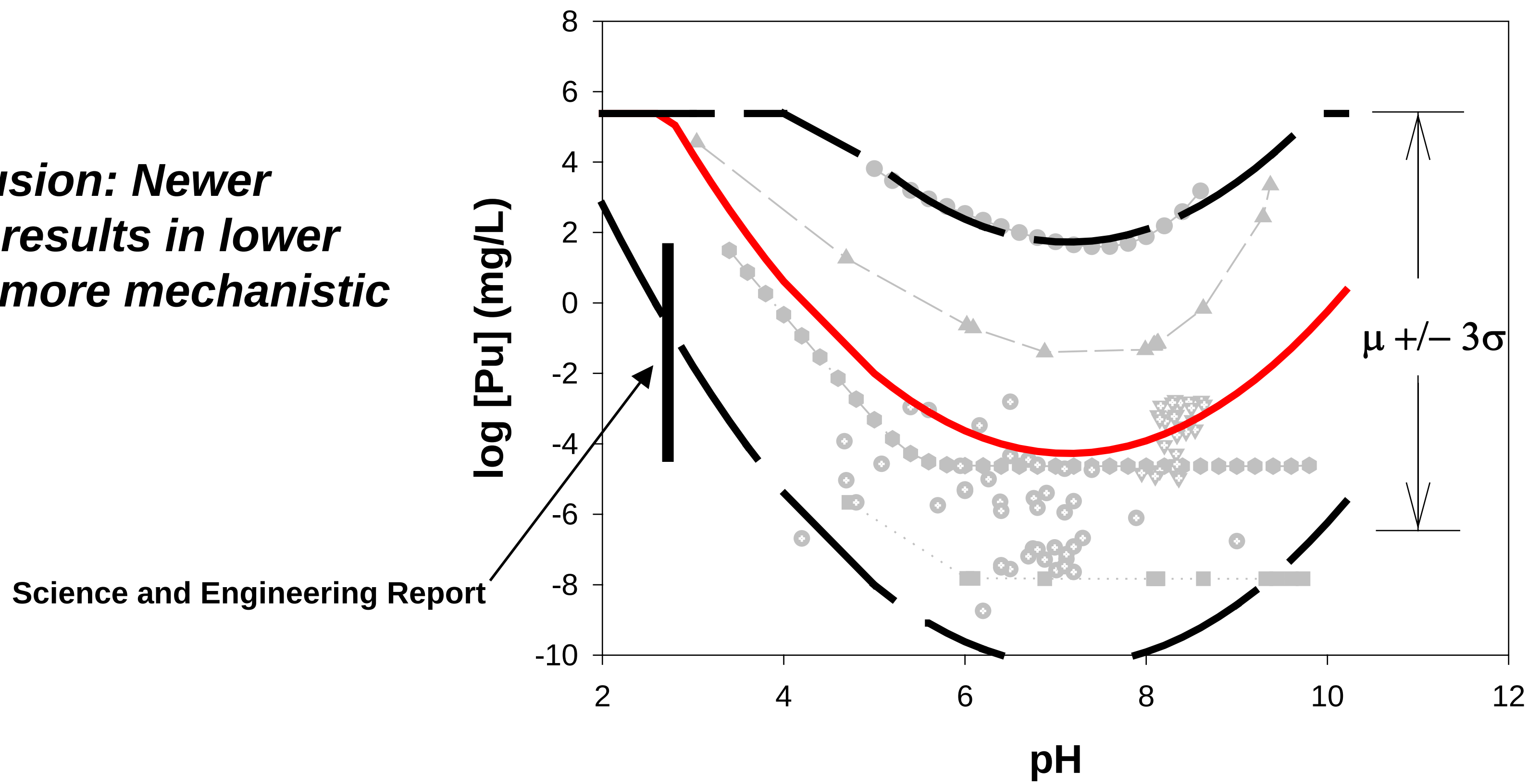
Np Dissolved Concentrations

Conclusion: Secondary phase model results consistent with ANL drip tests, and indicate lower mean, more realistic uncertainty.



Pu Dissolved Concentrations

Conclusion: Newer model results in lower mean, more mechanistic basis.



In-Package Transport

- Estimate amount of H_2O sorbed (Fe_2O_3 and ZrO_2) and water saturation in package
- Estimate diffusion coefficients (Archie's Law) and cross-sectional area of H_2O films
- Calculate diffusion through corrosion products and breaches and along fuel rods

In-Package Transport
(Continued)

In-Package Sorption

- Calculate masses of sorbing phases (iron and copper oxides)
- Establish range of sorption K_d's

Cladding

- Initial cladding perforation
- Creep and stress corrosion cracking perforation (triangular-1.05:2.44:19.4% vs. uniform-0.0:0.5%)
- Local corrosion (F- and Ferric chloride)
- Seismic failure (1.1E-6/yr vs. CCDF-4.9E-6:2.7E-12)
- Rock overburden failure
- Clad unzipping (triangular-1:40:240 vs. CCDF-1:15,000)

Low Temperature Implications

In-package chemistry and Dissolved concentrations

- Retrograde solubilities
- Lower gas solubilities at higher T
- Corrosion rates

In-package diffusion

- Effective diffusion coefficient
- Water adsorption
- Evaporation

In-package sorption

- Increases with temperature

Cladding

- T less important below 350ºC
- Weak WF dissolution rate included in clad unzipping rate

Other Lines of Evidence

In-package chemistry and Dissolved concentrations

- Glass degradation – field studies
- Steel degradation – persistence of reduced iron at YM and elsewhere
- Thermodynamic data – experimental measurements
- Np and Pu concentrations – ANL and PNL drip and batch tests

In-package diffusion

In-package sorption

- Measurements made at hazardous waste sites, sequential extractions of bomb pulse radionuclides

Cladding

- Extensive experimental literature