U.S. Nuclear Waste Technical Review Board (NWTRB)

EVOLUTION OF ENVIRONMENTS ON WP SURFACES DURING THE THERMAL PULSE

Thure Cerling, Member

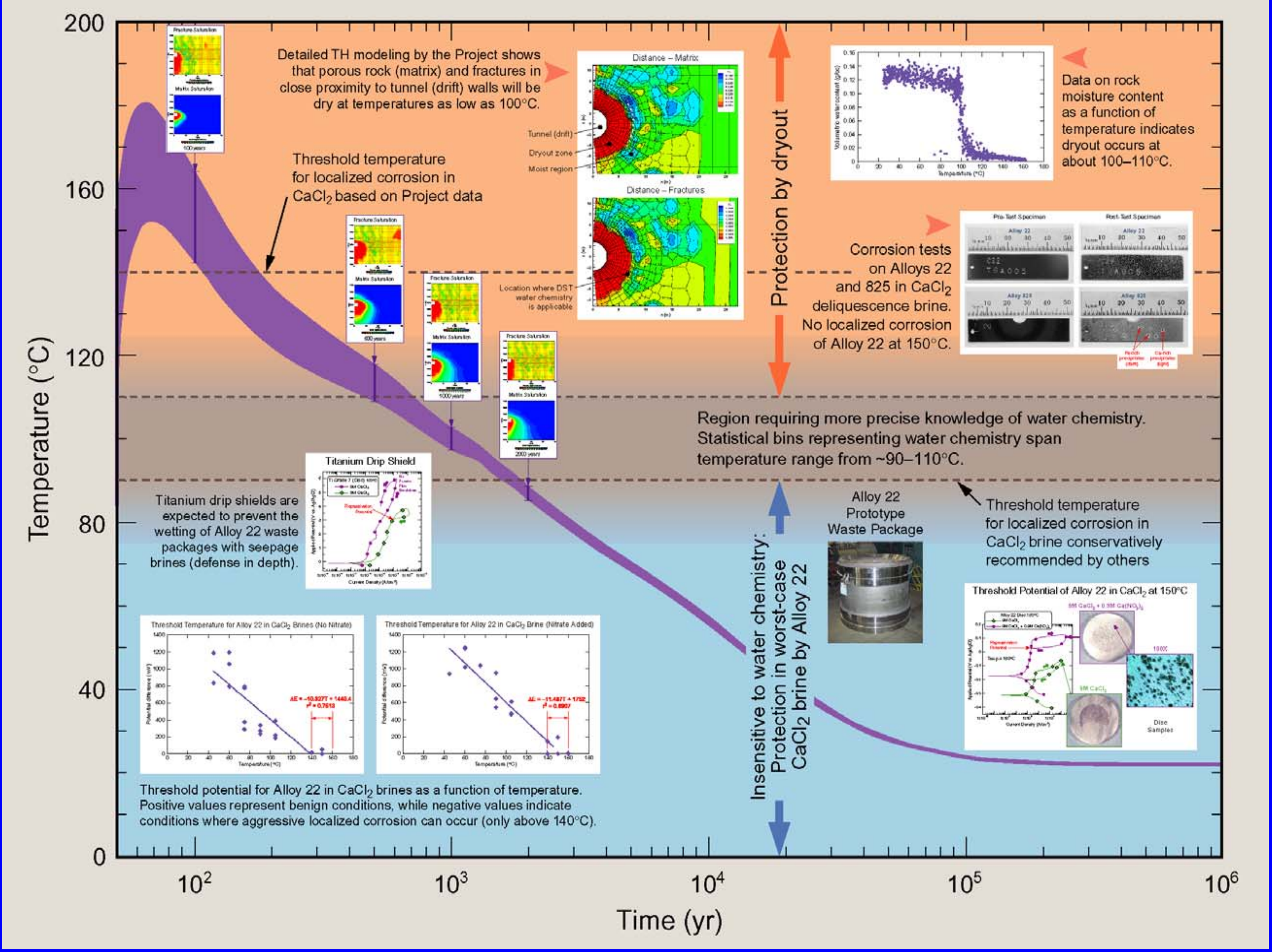
Board Meeting, May 18, 2004

Washington, DC

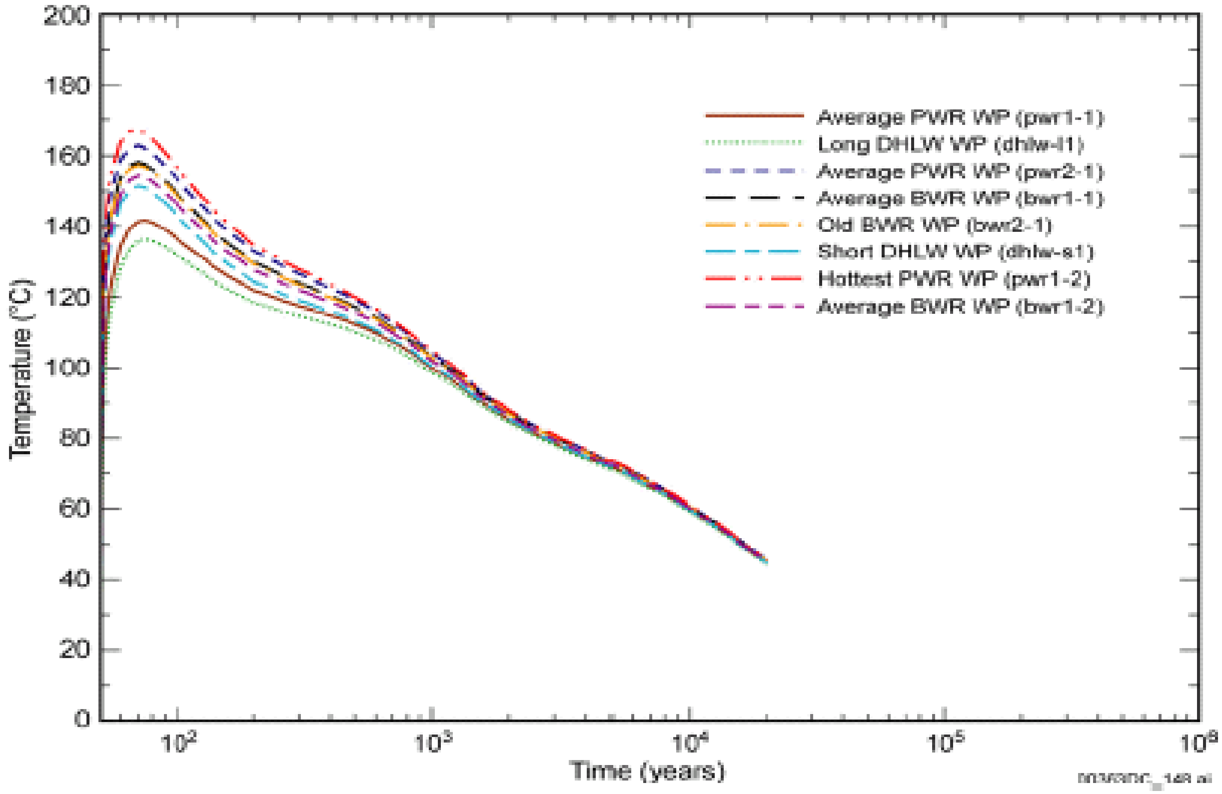
Outline

- Temperature on waste package surface
- Relative humidity on WP surface
- Dust on WP surfaces
- Deliquescence
- Uncertainties in the in-drift environment
- Environmental research recommendation

Thermal Timeline



Temperature (from TBD #6)



Source: BSC 2003e.

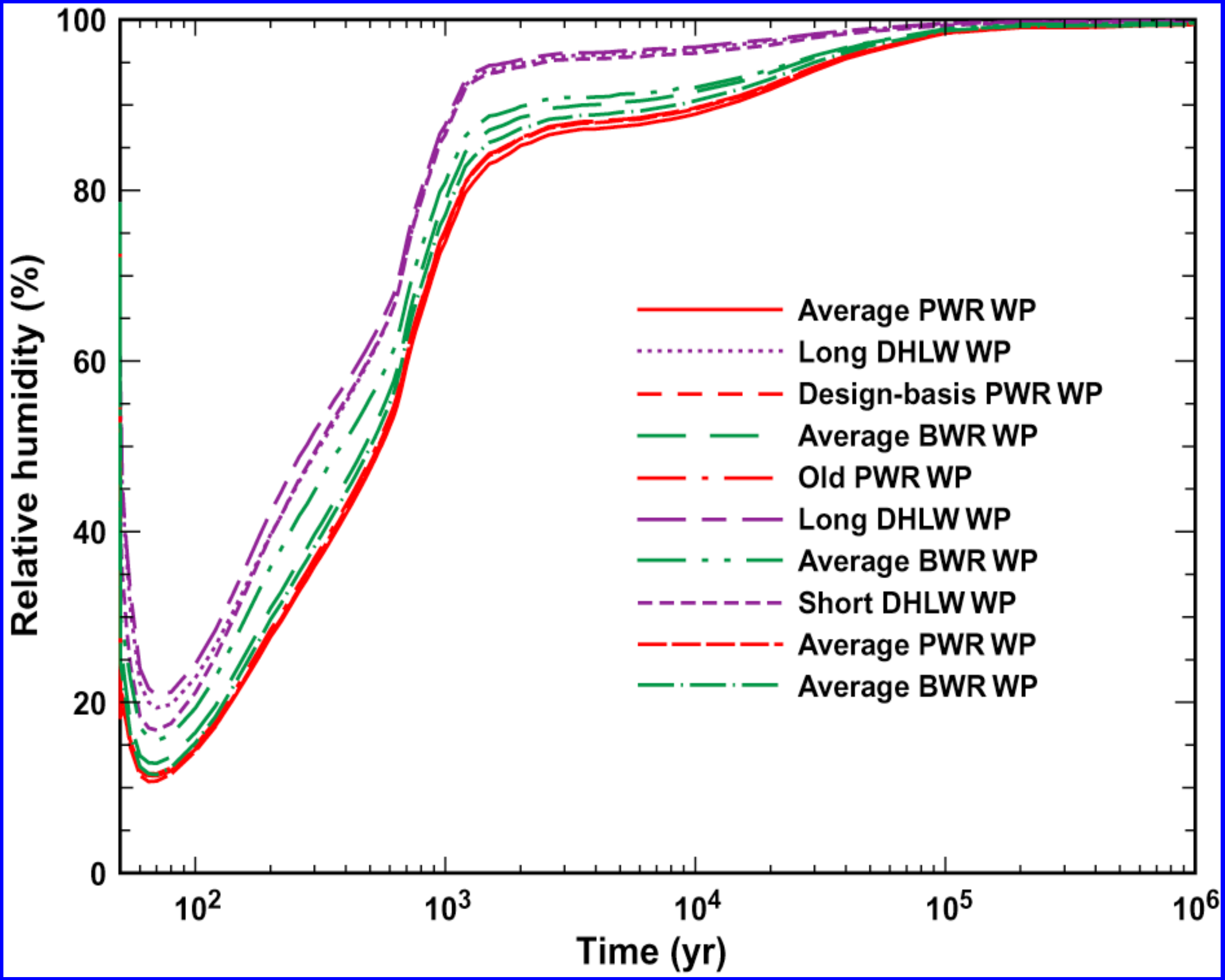
NOTE: These histories are plotted for the P3R7C12 location (in the mountain scale thermal-hydrologic model), which is near the center of the repository in the Tptpll (tsw35) unit. PWR = pressurized water reactor; WP = waste package; DHLW = defense high-level radioactive waste; BWR = boiling water reactor.

Figure 2-1. Typical Waste Package Temperature Histories

Thermal Calculations - Issues

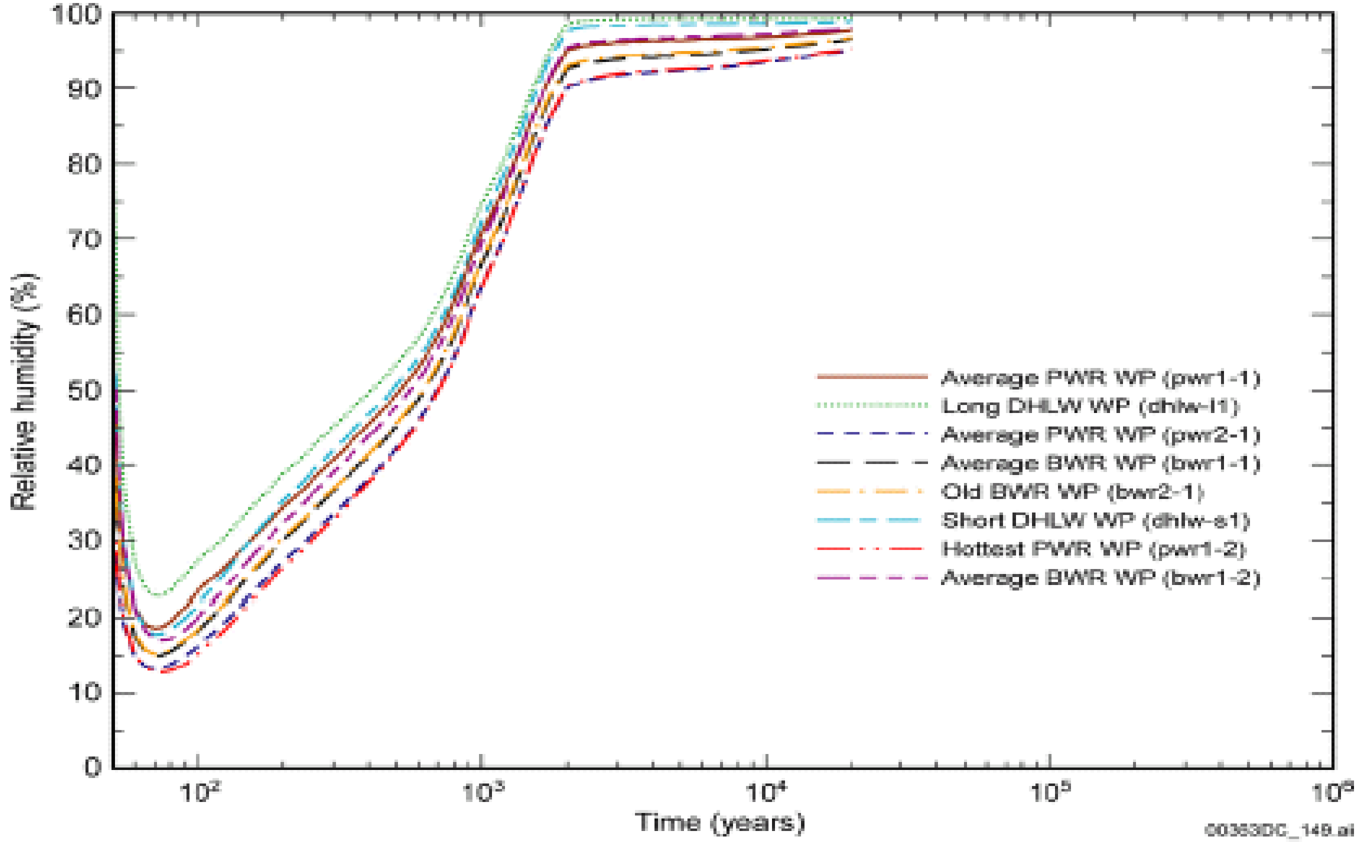
- Thermal conductivity
- Drift degradation
- Natural circulation and ventilation
- Uncertainty in T (and RH) predictions

In-Drift Environment – Relative Humidity



- Analysis from FY01 Supplemental Science and Performance Assessment analysis (SSPA)
- Represents waste-packages at the center of the repository (hottest)
- Waters that are in contact with WPs will be brines because of the low to moderate RHs, other solutions unstable

Relative Humidity (from TBD #6)



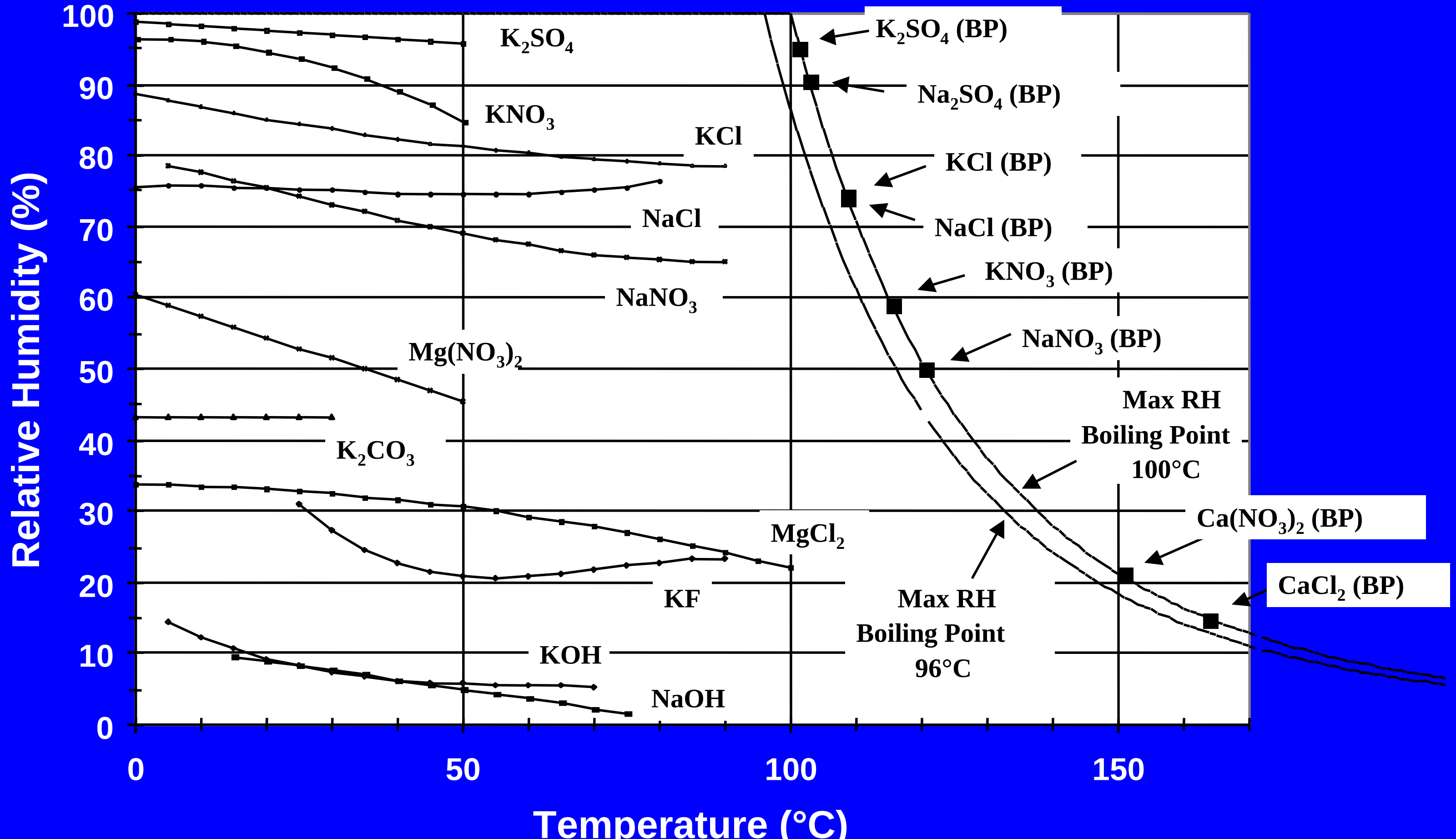
Source: BSC 2003e.

NOTE: These histories are plotted for the P3R7C12 location (in the mountain scale thermal-hydrologic model), which is near the center of the repository in the Tptpll (tsw35) unit). PWR = pressurized water reactor; WP = waste package; DHLW = defense high-level radioactive waste; BWR = boiling water reactor.

Figure 2-2. Typical In-Drift Relative Humidity Histories

Deliquescence Points for Pure Salts

(from Gdowski June 2001)

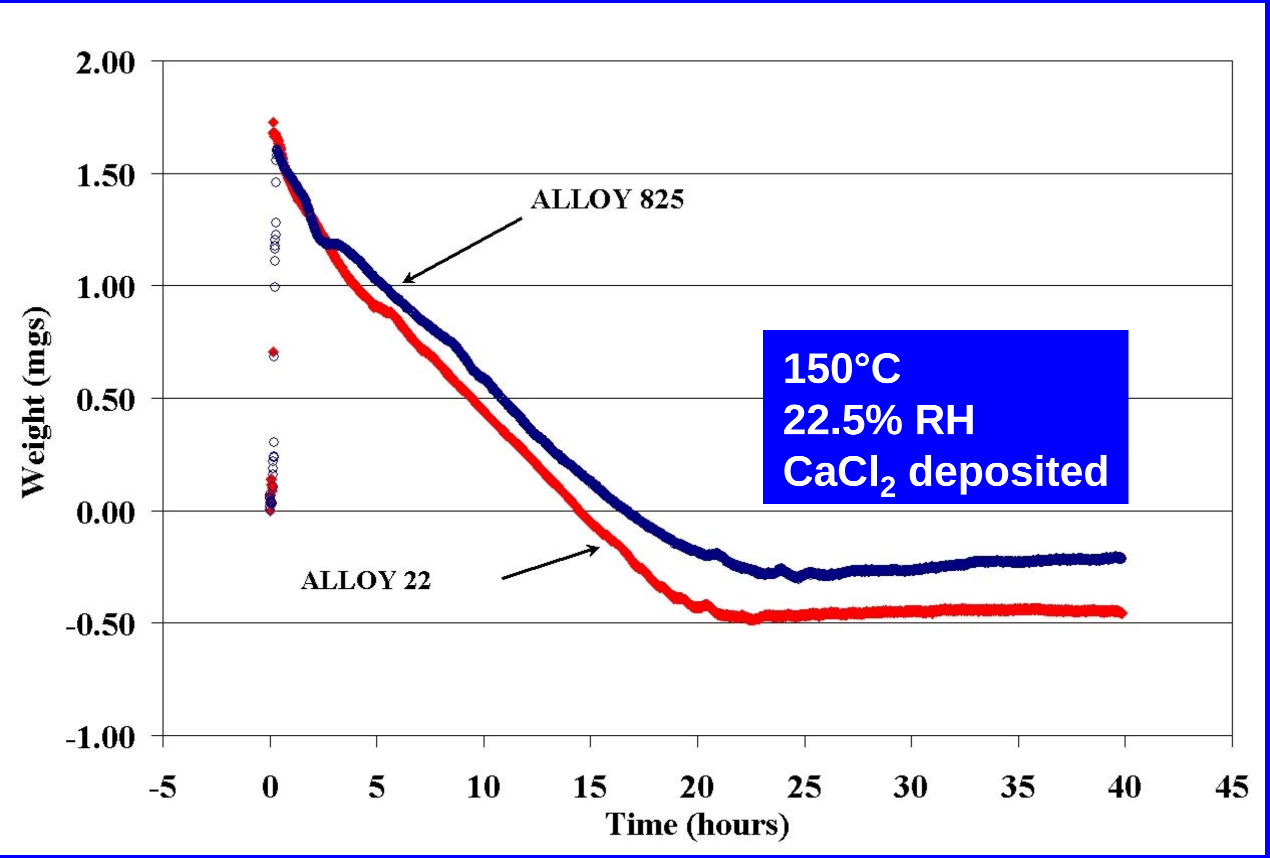


L. Greenspan, *J. of Research of the National Bureau of Standards 81A* (1977) 89-96

F.C. Kracek, *International Critical Tables of Numerical Data, Physics, Chemistry and Technology*, Volume 3, pp. 351-385, 1928.

Dry-out: Temperature ≥ 110°C Deliquescence Brines Studied with Thermogravimetric Analysis

- Initial weight gains are due to the formation of films of deliquescence brine from dust and humidity
- The subsequent weight loss is due to the thermal-driven decomposition of the deliquescence brine, with the volatilization of hydrogen chloride
- No further change in weight after loss of chlorine from surface



- There is no evidence of localized corrosion of Alloy 22 due to deliquescence

However, substantial attack of Alloy 825 (a less corrosion resistant material) is evident

Dust Composition

- Cl^-, NO_3^-, Mg, Ca all present
- Many other elements and compounds present, also
- Much “inerts” and poorly soluble material present

Insufficient Technical Basis

Experimental results to date form an insufficient basis for DOE's conclusion for the following reasons:

1. Brines tested so far may not be representative or bounding of actual brines that would exist in the repository.
2. Experiments to date have been run only over a narrow part of the temperature and relative humidity range over which deliquescence can occur.
3. Experimental apparatus is an "open" system, which may not approximate short-term repository behavior.
4. Samples used in experiments did not have crevices.
5. No explanation has been offered for seemingly contradictory results from other experiments.

Presence of Nitrate

1. DOE has not established that nitrate would inhibit localized corrosion over the entire range of temperatures in which brines could exist, particularly for temperatures higher than about 140°C.
2. Natural processes could separate nitrate and chloride ions.
3. The effect(s) of microbes on nitrates has not been demonstrated.

Environmental Uncertanties

- Capillary barrier
- Refluxing
- Drift collapse
- Vaporization barrier

Additional Technical Comments

- Relative humidity and vapor mass transport
- Deliquescence
- Diffusion transport

Research

- Temperature estimates
- Dust composition
- Deliquescence