YUCCA
MOUNTAIN
PROJECT

Studies

Approach to Waste Package Degradation Modeling and Abstraction for TSPA-VA

Presented to:
DOE/NRC Technical Exchange on
Total System Performance Assessment
Las Vegas, NV

Presented by:
Joon H. Lee
Senior Performance Assessment Analyst
CRWMS M&O/Duke Engineering & Services

November 6, 1997

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

L/m. 20

Outline of Presentation

- Introduction
- Conceptual model for waste package degradation Modeling for TSPA-VA
- Base case waste package degradation model for TSPA-VA
- Key parameters for waste package degradation model derived from Waste Package Degradation Expert Elicitation (WPDEE)
- Representation of variability and uncertainty in waste package degradation
- Concluding remarks

Aspects of Waste Package Performance That Impact Total System Performance

- Waste containment - time of waste package failure
  - waste package failure defined as the first perforation (pit penetration or crack propagation) through the container wall
  - corresponds to the initiation of waste form degradation inside the failed waste package

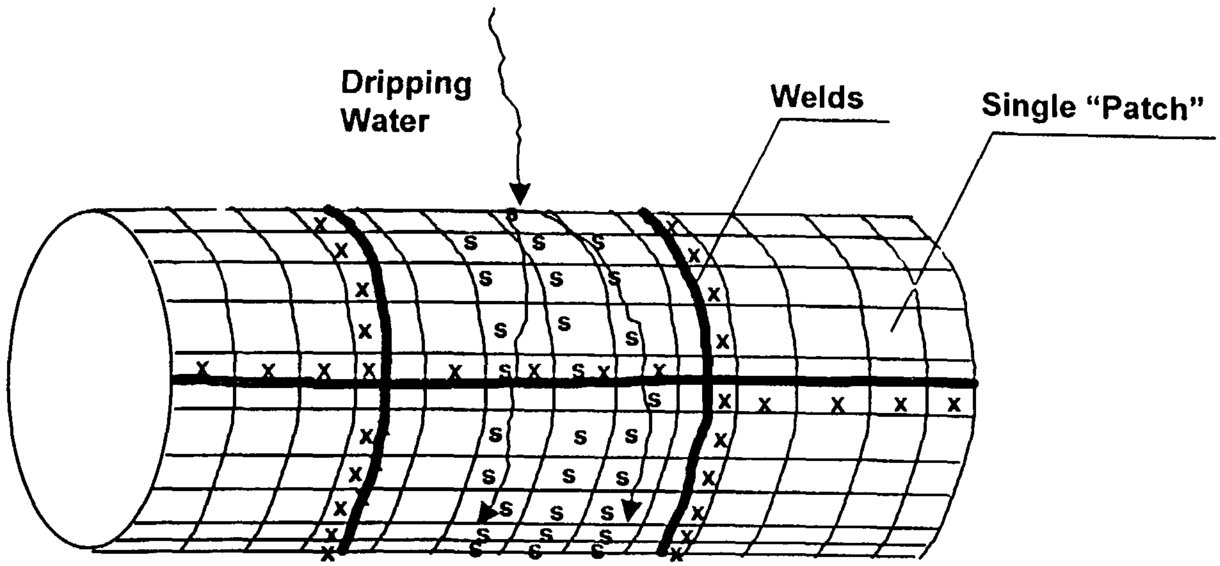
Aspects of Waste Package Performance That Impact Total System Performance
(Continued)

- Controlled/gradual release of radionuclides - waste package failure rate, and subsequent perforation rate of failed waste container
  - waste package failure rate provides the rate of waste inventories that become available for release
  - subsequent perforation rate of failed waste container provides the area in the waste container available for radionuclide transport by diffusion and/or advection

Schematic of the Conceptual Model for WP Degradation Modeling and Abstraction for TSPA-VA

* T, RH, in-drift water dripping across repository from drift-scale T-H model

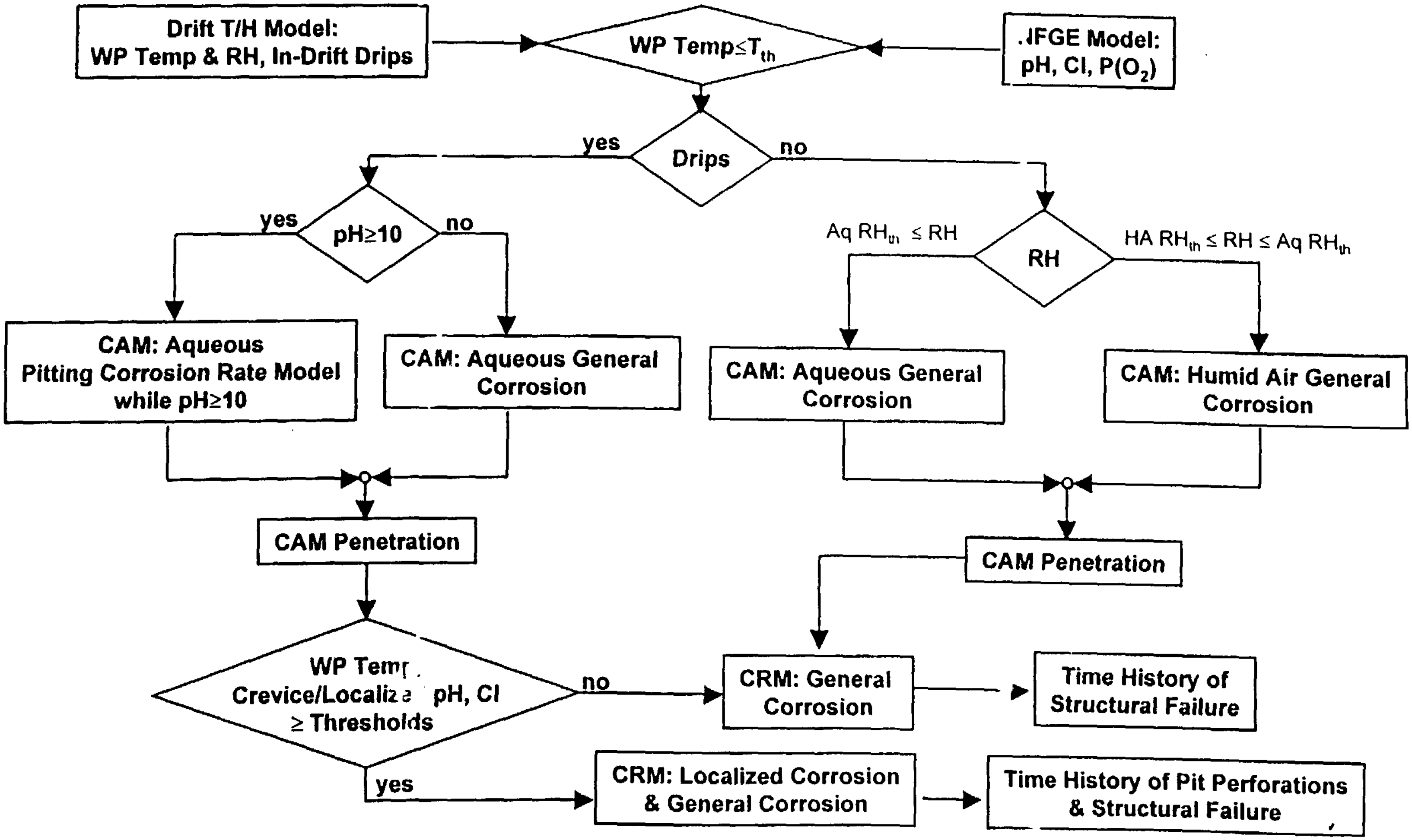
* pH, [Cl⁻] of dripping water, $P(O_2)$, across repository from NFE model



s - Patches with drips; Potential salt deposits; CRM localized corrosion

x - Patches with welds

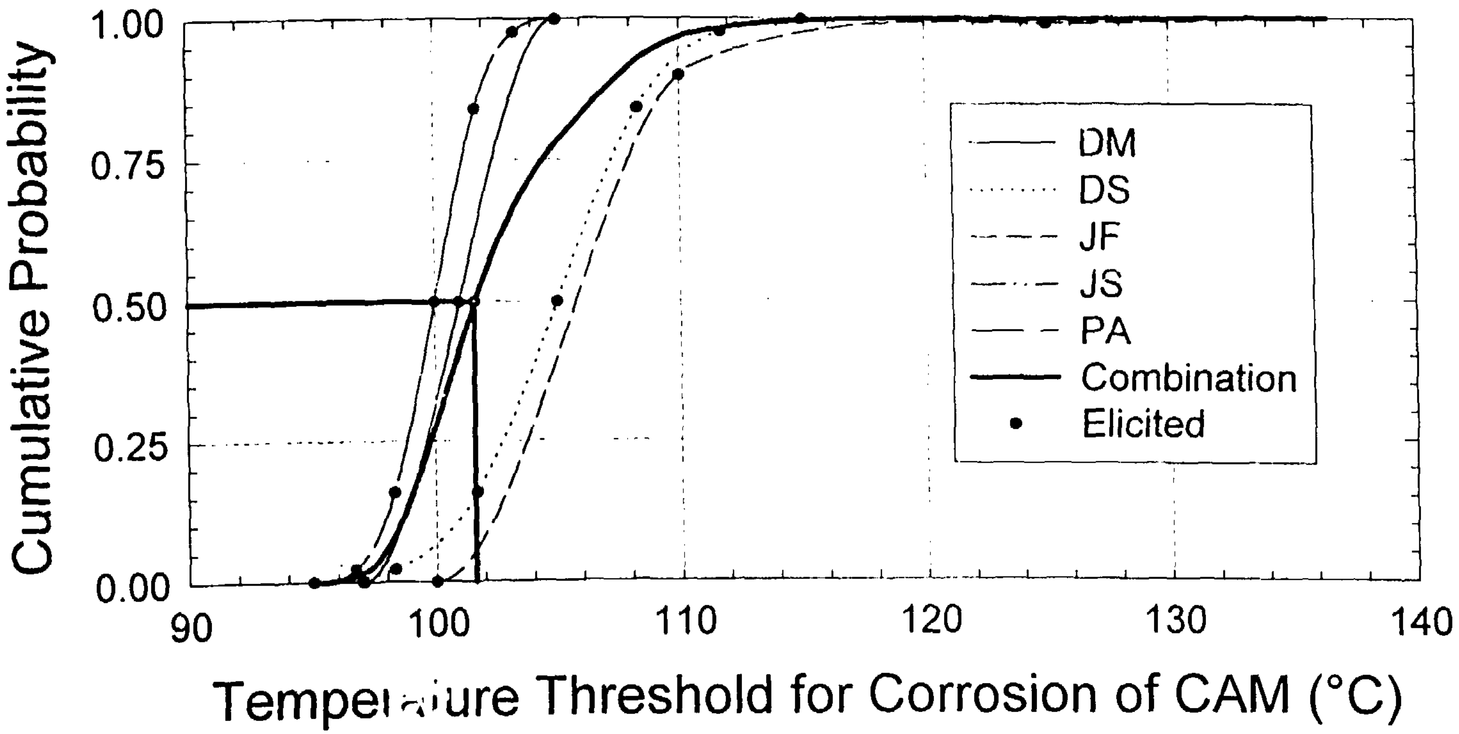
Logic Diagram for the Base Case TSPA-VA WP Degradation Model



Key Parameters for the TSPA-VA Base Case Waste Package Degradation Model

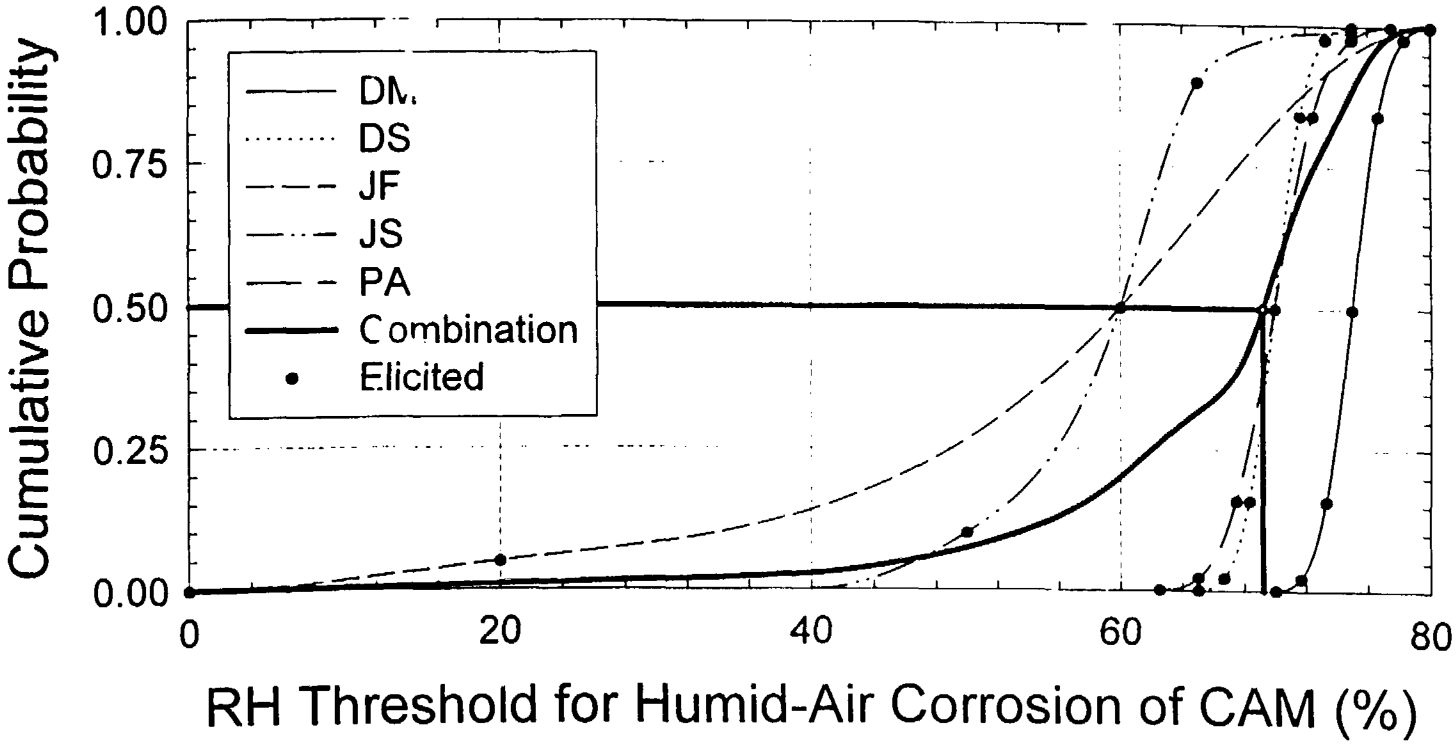
- Thresholds for CAM corrosion initiation
  - thresholds dependent on the surface condition (dust, oxides, salts), dripping, location on a WP (top, sides, bottom)
  - temperature threshold
  - RH threshold for humid-air corrosion
  - RH threshold for aqueous corrosion

Distribution for Temperature Threshold for CAM Aqueous or Humid Air Corrosion Initiation



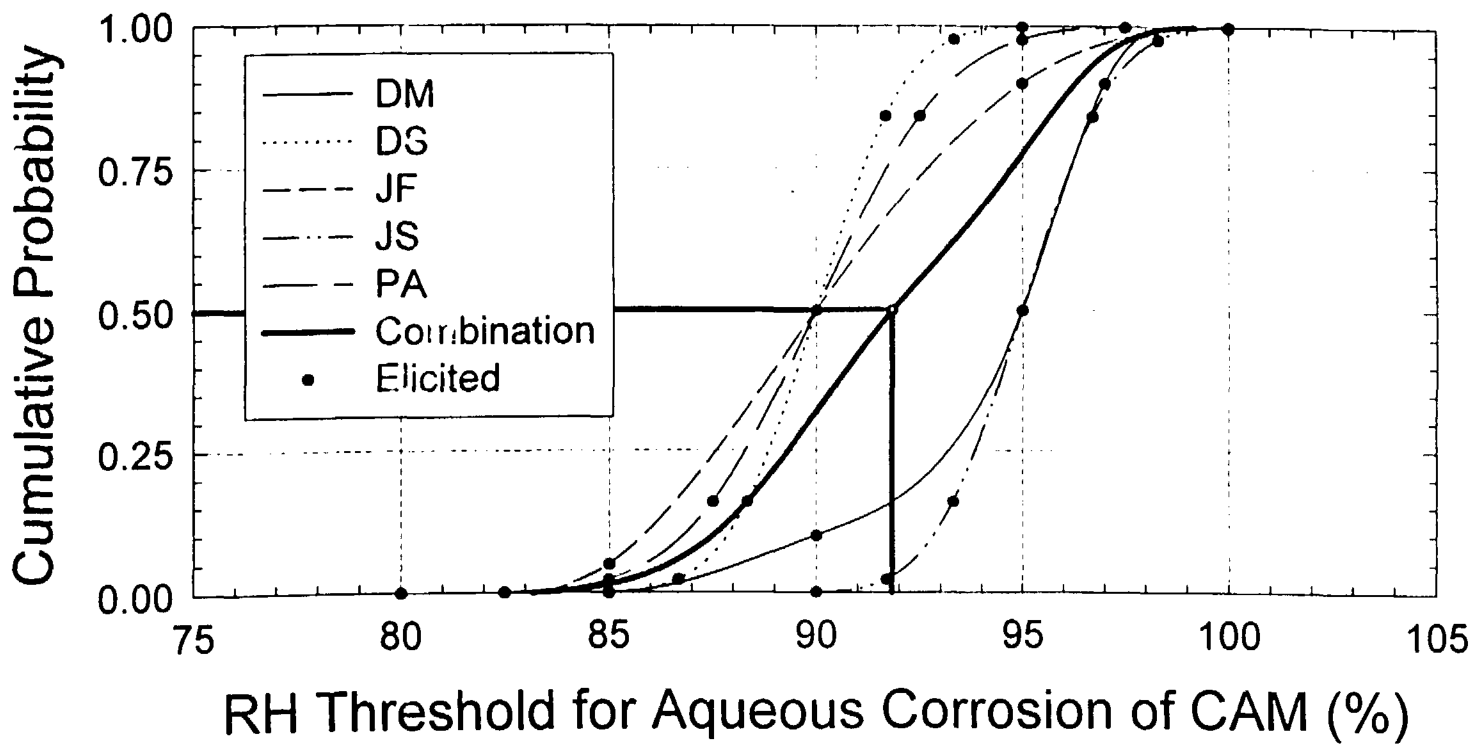
"Preliminary Draft"

Distribution for RH Threshold for CAM Humid-Air Corrosion Initiation



"Preliminary Draft"

Distribution for RH Threshold for CAM Aqueous Corrosion Initiation



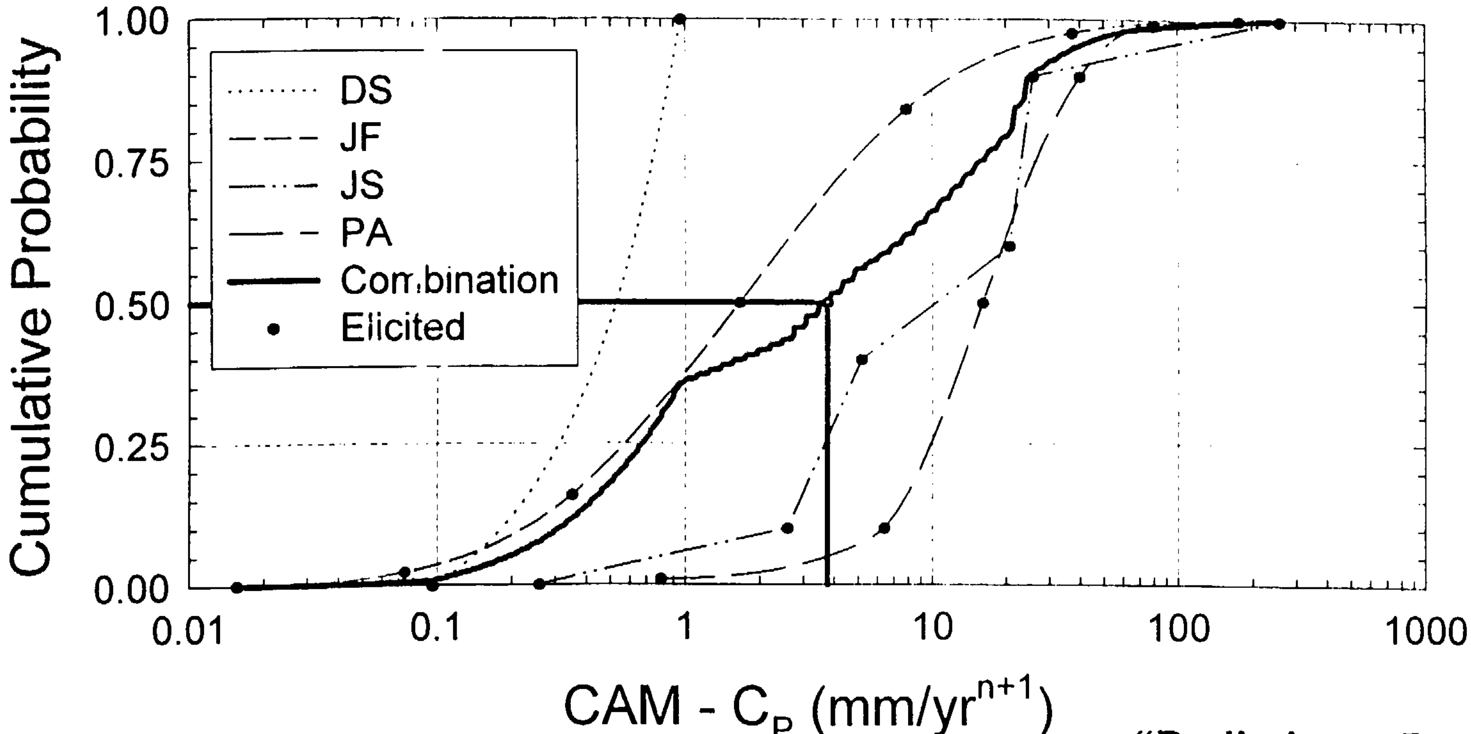
"Preliminary Draft"

Key Parameters for the TSPA-VA Base Case Waste Package Degradation Model

(continued)

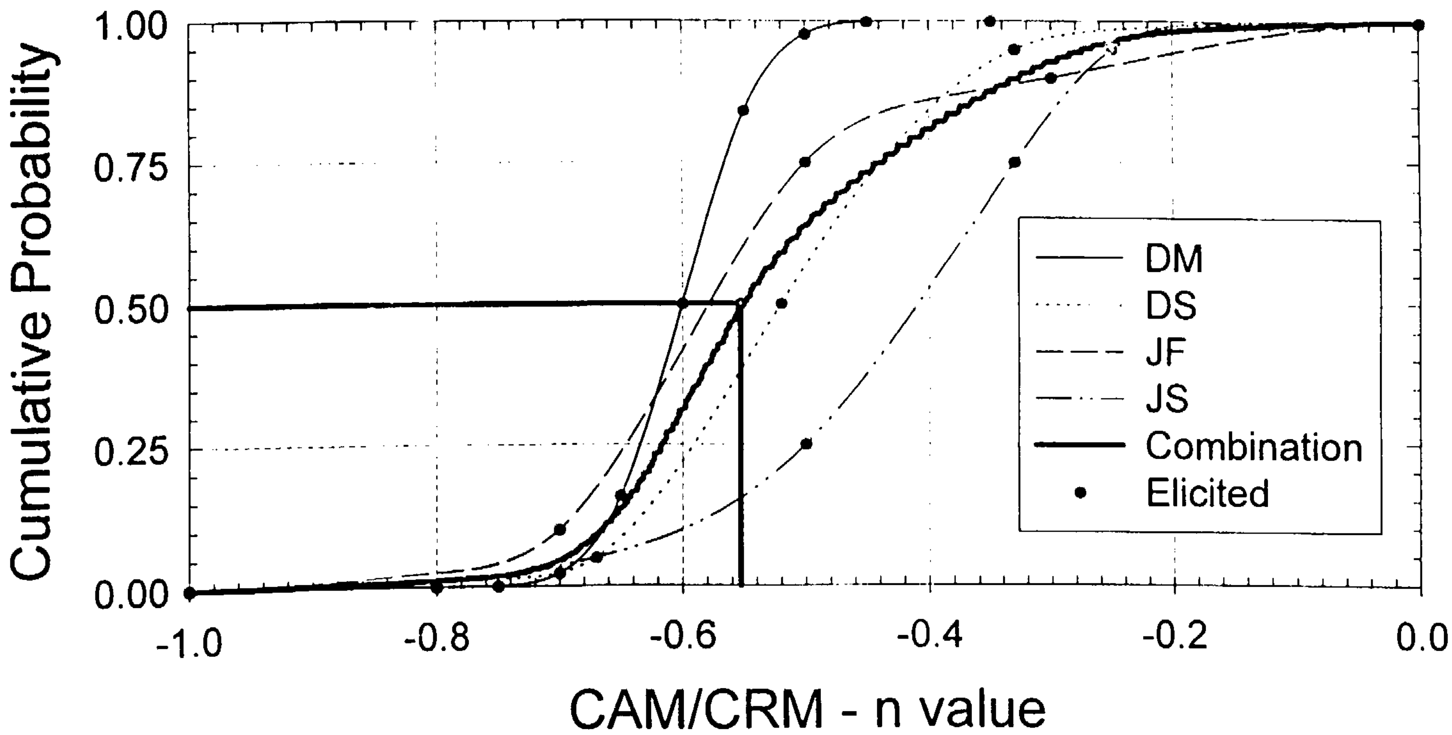
- CAM corrosion modes
  - humid-air or neutral pH (4 to 10) aqueous condition
    - » use TSPA-95 model for neutral pH aqueous general corrosion
    - » use TSPA-95 model for humid-air general corrosion
    - » general (uniform) corrosion with low localized variations
  - alkaline (pH≥10) aqueous condition
    - » high aspect ratio pitting model
    - » use pit growth law, rate = $R_G + C_P t^n$
      - R_G = general corrosion rate
      - C_P = constant for pit growth rate
    - » use "modified" TSPA-95 model for $R_G = f(t,T,pH)$
    - » pit density

Distribution for Constant 'C_P' of Pit Growth Rate (= $R_G + C_P t^n$) for CAM Pitting Corrosion in Alkaline Conditions (pH≥10)



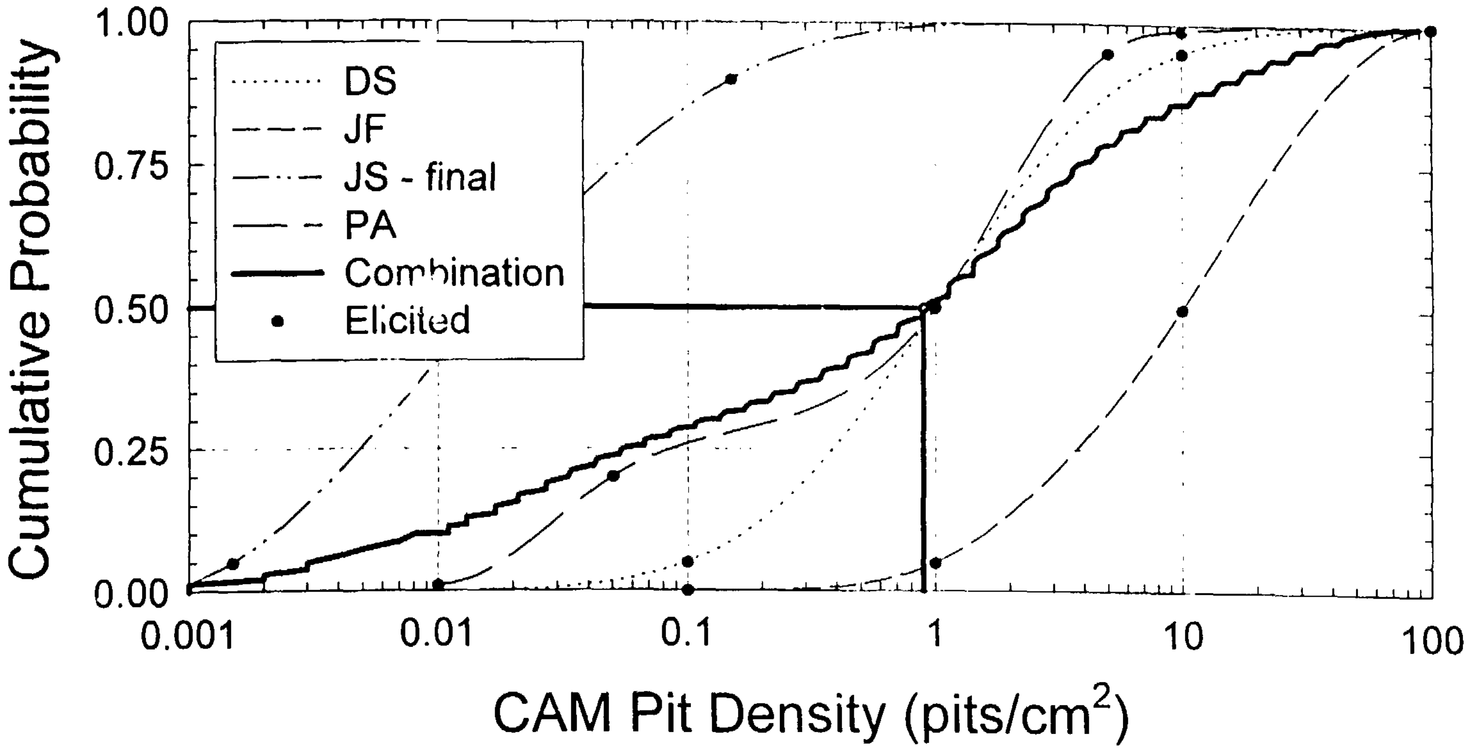
"Preliminary Draft"

Distribution for Constant 'n' of Pit Growth Rate (= $R_G + C_P t^n$) for CAM Pitting Corrosion in Alkaline Conditions (pH≥10)



"Preliminary Draft"

Distribution for Pit Density of CAM in Alkaline Conditions (pH≥10)



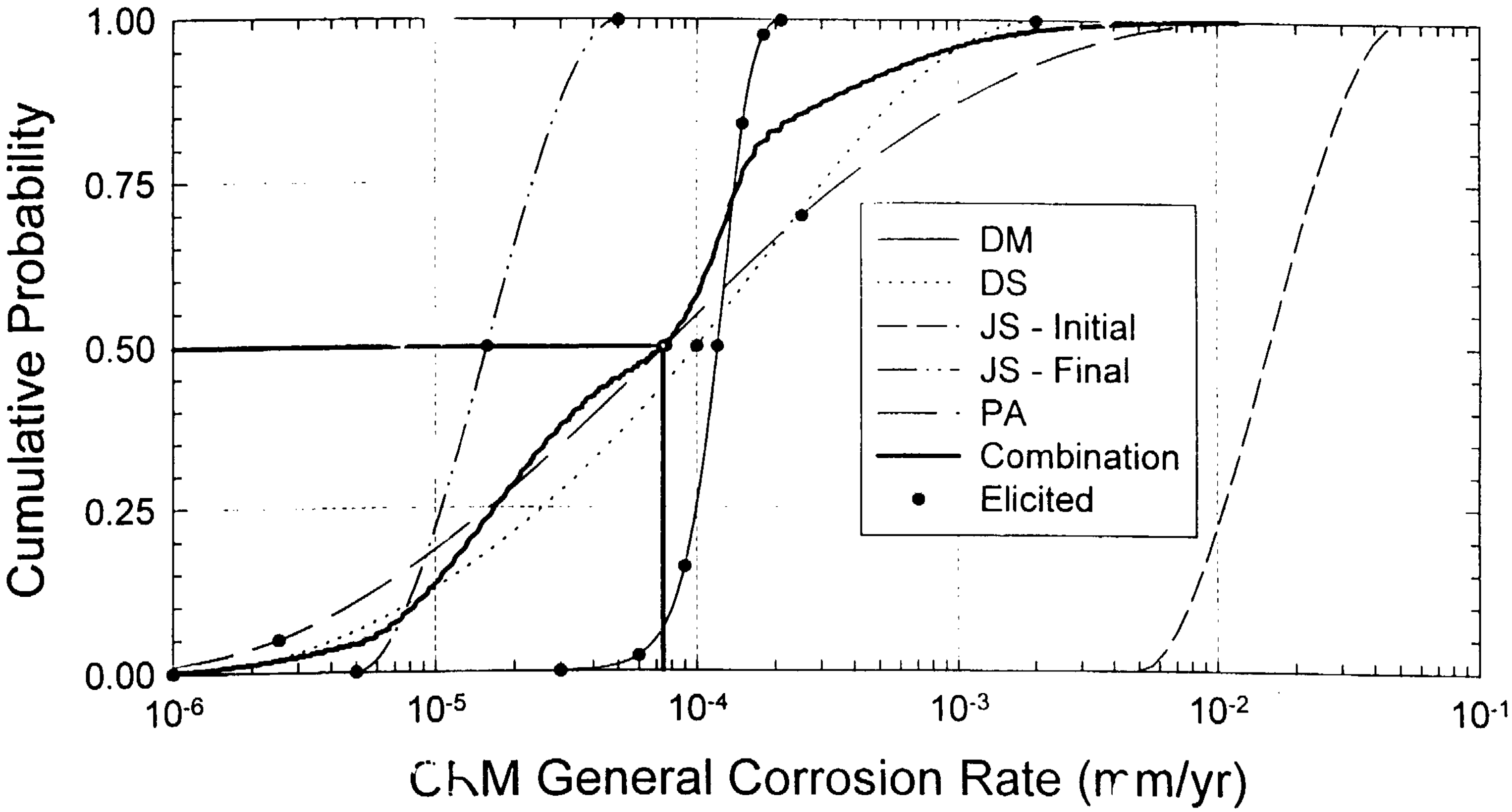
"Preliminary Draft"

Key Parameters for the TSPA-VA Base Case Waste Package Degradation Model

(continued)

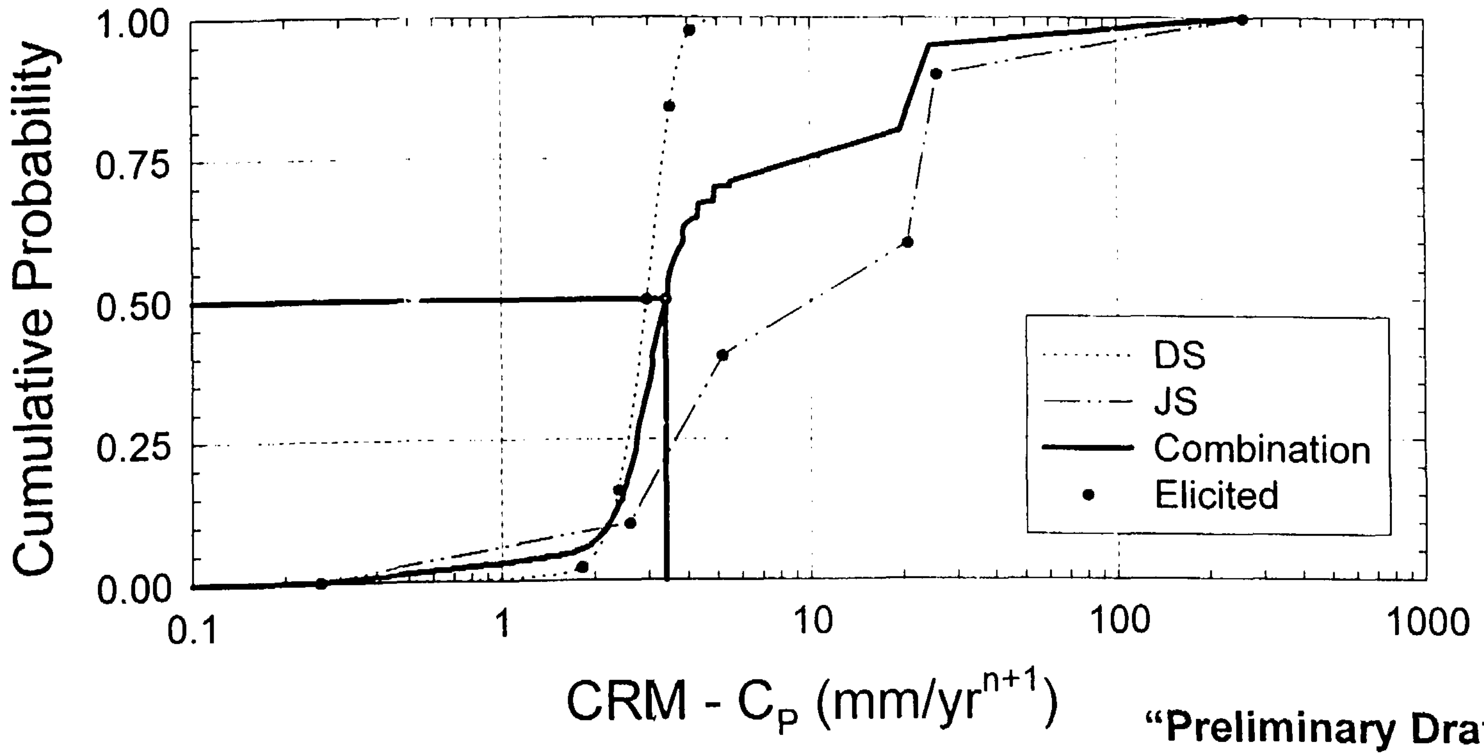
- CRM corrosion mode
  - general corrosion of CRM under humid-air or "non-dripping" aqueous condition
  - marginal galvanic protection of CRM (a few 100 years at most)
  - localized (pitting/crevice) corrosion requires drips with elevated Cl^- and low pH within a crevice and pit
  - use pit growth law for pitting and crevice corrosion
    - » pit growth rate = $R_G + C_P t^n$
      - R_G = general corrosion rate
      - C_P = constant for pit growth rate
    - » pit density and pit diameter

Distribution for Constant 'R_G' of Pit Growth Rate (= $R_G + C_P t^n$) for CRM Pitting/Crevice Corrosion



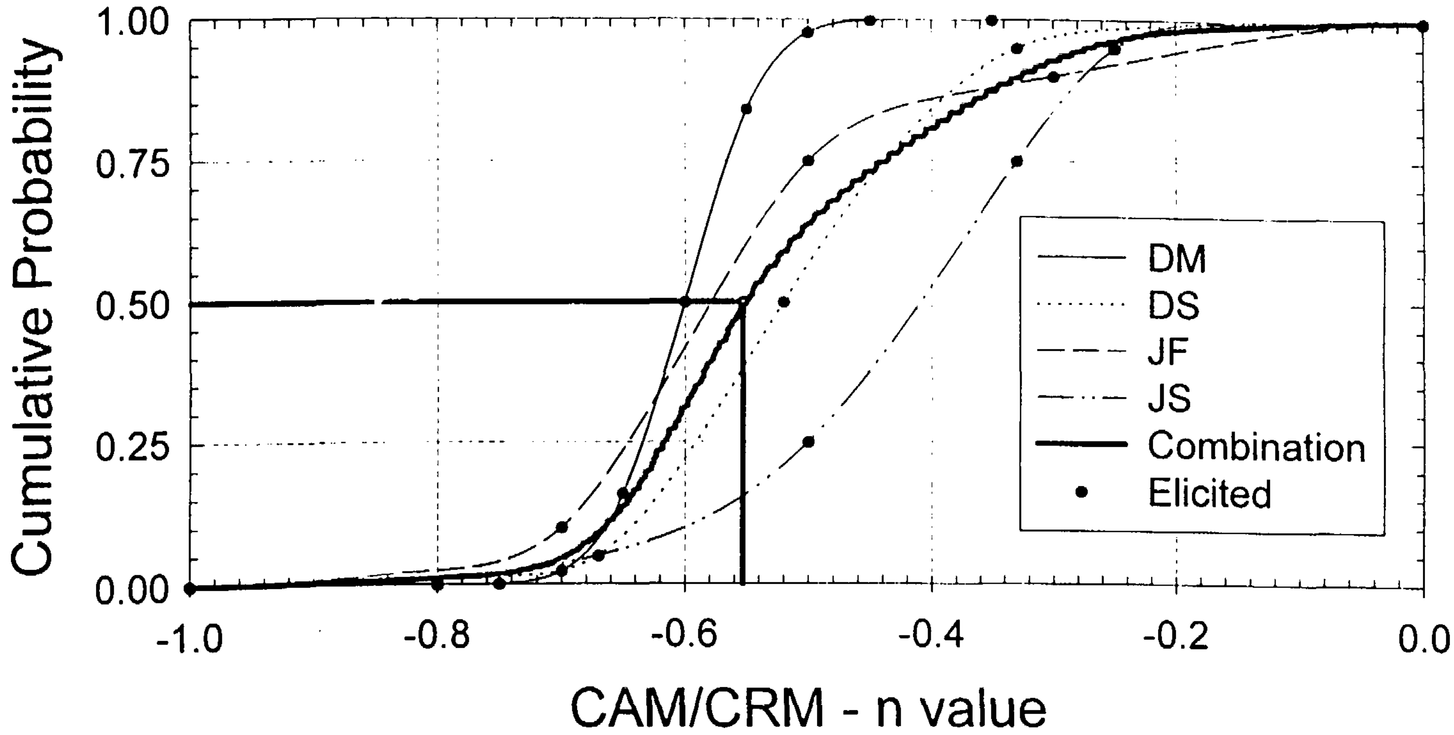
"Preliminary Draft"

Distribution for Constant 'C_P' of Pit Growth Rate (= $R_G + C_P t^n$) for CRM Pitting/Crevice Corrosion



"Preliminary Draft"

Distribution for Time Constant 'n' of Pit Growth Rate (= $R_G + C_P t^n$) for CRM Pitting/Crevice Corrosion



"Preliminary Draft"

Representation of Variability and Uncertainty in Waste Package Degradation

- Potential sources of variability in waste package degradation
  - WP materials. WP fabrication including welds
  - temporally and spatially varying (bulk) exposure conditions
    - » WP surface temperature, RH
    - » drip location, drip rate and frequency, drip water chemistry (particularly pH and Cl-)
    - » gas phase composition (particularly O_2 partial pressure)
  - variable local environments
    - » crevice formation between the barriers, under corrosion products and/or mineral deposits
    - » water chemistry within crevice and pit
    - » rockfalls

Representation of Variability and Uncertainty in Waste Package Degradation
(continued)

- Potential sources of uncertainty in waste package degradation
  - uncertainties in corrosion conceptual models and process models
  - uncertain exposure conditions
    - » drip location, drip rate and frequency, drip water chemistry (particularly pH and Cl-)
  - uncertain local environments
    - » crevice formation between the barriers, under corrosion products, and mineral deposits
    - » water chemistry within crevice and pit
    - » rockfalls

Representation of Variability and Uncertainty in Waste Package Degradation
(continued)

- Incorporate explicitly the effects of temporally and spatially varying exposure conditions
  - Temperature, relative humidity, in-drift water dripping
  - chemistry of dripping water (pH, Cl), oxygen partial pressure
- Development underway to represent the effects from other sources not explicitly accountable