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DOE AND NRC APPROACHES TO MODEL THE EFFECTS OF INITIAL FAILURES OF CONTAINERS

Presented by

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TOPICS FOR DISCUSSION

- Definition of initial failure
- Approach used in TSPA-VA
- NRC/CNWRA approach in TPA 3.2
- Alternative considerations of initial failure

DEFINITION OF INITIAL FAILURES

- Implied in TSPA-VA and TPA 3.2
  - Failures that occur essentially instantaneously (compared to the expected period of performance) due to one or more large initial defects
  - These defects and failures are undetected during fabrication, emplacement, and performance confirmation periods
  - Account for fabrication defects and other unknown failure modes
- General definition
  - Failures that occur at times less than expected for the nominal system resulting in a decreasing hazard function with time

INITIAL FAILURES IN TSPA-VA

- Subsumes a variety of processes and model uncertainties
  - fabrication defects
  - faulty emplacement
  - faulting and seismic effects
- Assumed 1 in 10,500 waste packages (range of 1 to 10) with through-wall defect
- Assumed failure time to be 1000 years

DOE ANALYSIS OF INITIAL FAILURES

- Analysis of pressure vessels
  - 2.3×10^{-4} to 8.5×10^{-4} per vessel
- Assuming independent failure modes of dual overpack system
  - 5.8×10^{-6} per WP
- Preferred method (Massari, 4/1999)
  - Determine probability of various WP defect generation mechanisms
  - Adjust corrosion models accordingly

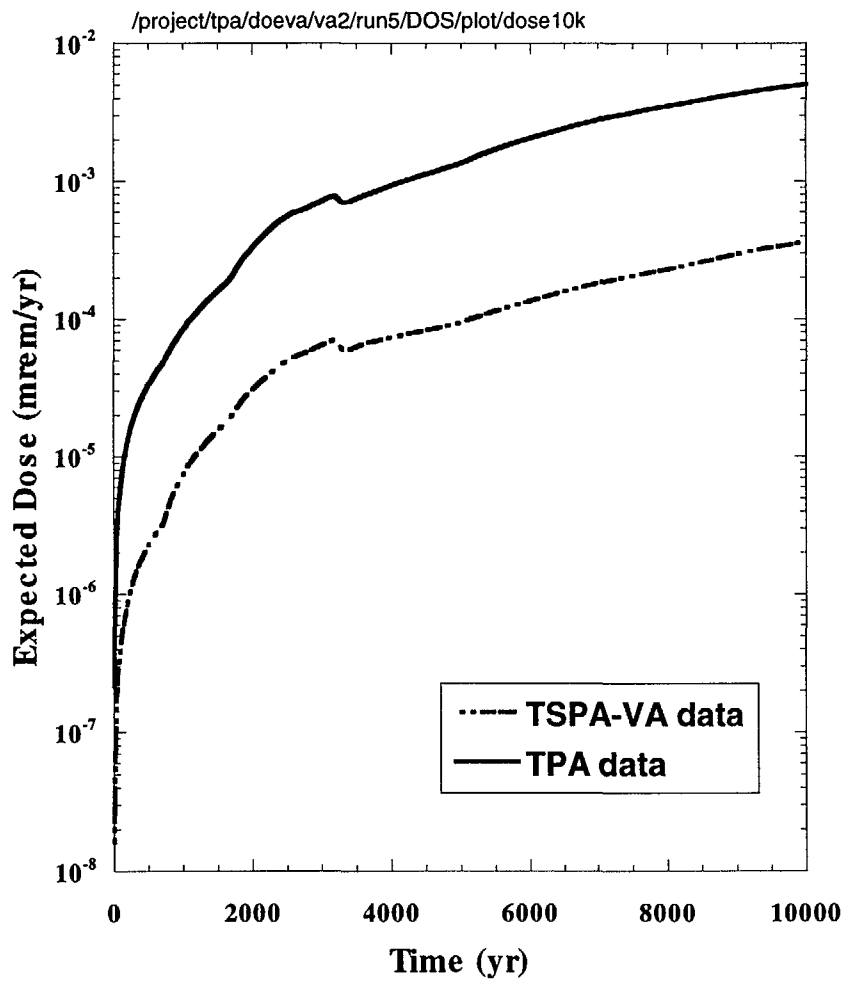
INITIAL FAILURES IN TPA 3.2

- Assumes that initial failure occurs due to
  - Fabrication defects
  - Unknown failure mechanisms
- Assumed failure probability of 10^{-2} to 10^{-4} per subarea (Average of 35 out of 7000 containers)
- Assumed failure time at t=0

NRC/CNWRA ANALYSIS OF INITIAL FAILURES

- Fuel rod failures
  - Initial defects estimated to be less than 8.2×10^{-6} to 2×10^{-6}
  - Low probability because of simple design and large experience base
- Aircraft component failures (Timmins, 1999)
  - 17 percent of failures - fabrication defects
  - 16 percent - design errors
  - 7 percent - defective material
  - Total percentage loss of aircraft: 0.4 percent in 1985
- Chemical and Offshore applications (Timmins, 1999)
  - 4 - 16 percent of failures due to poor fabrication

COMPARISON OF PERFORMANCE CALCULATIONS



- TPA 3.2 calculation using DOE and NRC initial failure rates
- Time to initial failure was at 0 years for both TSPA-VA and TPA data

ISSUES IN DETERMINING INITIAL FAILURES

- Initial failures based on experience in unrelated systems and applications
- Difficulty in separating mechanisms of initial failures
- Relationship to detectability of defects unclear
- The effect of experience on initial failure rate not considered

FACTORS AFFECTING INITIAL FAILURES

- Fabrication defects
  - Lack of fusion, penetration
  - Surface contamination (e.g., poor degreasing)
  - Laps, iron contamination
  - Improper filler metal
  - Iron dilution (bimetallic welds)
  - Inclusions/primary carbides
- Heat treatment
  - Improper temperature/time
- Material mix-up
- Material handling (dents, scrapes)
- Resolution of non-destructive examination methods

DETECTION OF DEFECTS

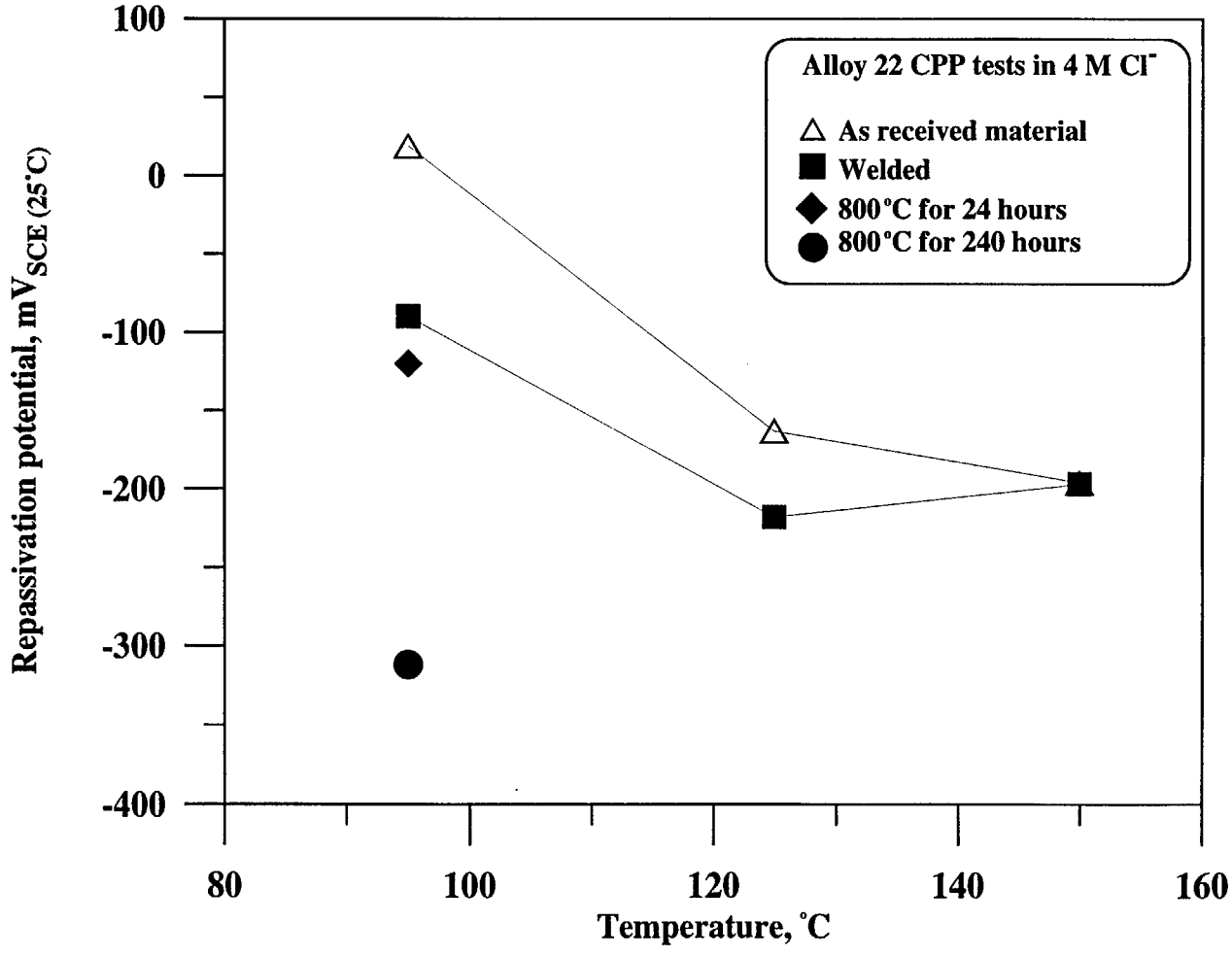
- Dye penetrant inspection (Timmins, 1999)
  - 90/95 percent of defects: 6 mm long
  - Longest crack missed: 3.98 mm
  - Smallest crack detected: 0.5 mm
- Ultrasonic inspection of copper canisters (Bowyer, SKI Report 97-19, 1997)
  - Smaller defects can be detected
  - Less penetration in large grained areas (welds)
- Resolution of defects in C-22 welds not known at present

EFFECT OF HEAT TREATMENT ON CORROSION RATE OF ALLOY C-22

4M chloride solution at 95°C

Condition	Anodic Current Density, (A/cm^2)	Corrosion Rate (mm/y)	Life Time of 20 mm Overpack (years)
Annealed	$4x10^{-8}$	$4x10^{-4}$	50,372
Heat Treated 800 C/24 hours	$2x10^{-2}$	198	0.1

MODELING THE EFFECT OF HEAT TREATMENT IN TPA



SUMMARY

- The initial failure rates assumed in TSPA-VA are lower than that assumed in TPA 3.2
  - DOE considered failure probabilities of dual overpacks
- Higher initial failures resulted in higher dose
- Better technical basis needed for both NRC and DOE approaches
- Need to provide a better link between initial defects and failure rates
  - Consideration of detectability
  - Explicit consideration of performance of defective containers