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NRC Assessment of Margin Available at Davis Besse

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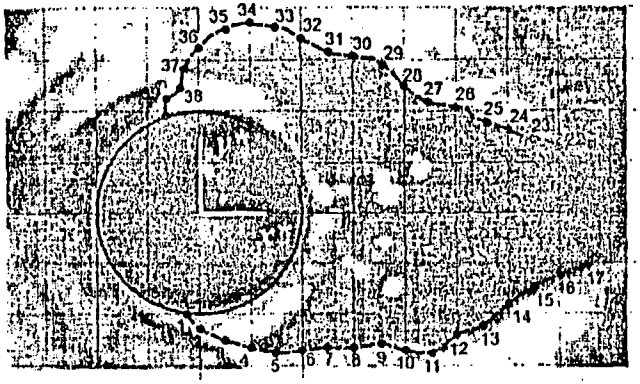
M-2

Overview of Presentation

- **Deterministic assessment of margins**
  - **Scope of investigation**
  - **Analytical tools**
  - **Findings to date**
- **Next steps**
  - **Further deterministic analysis**
  - **Probabilistic analysis**

RES Assessment of Davis-Besse "Margins"



FOOTPRINT OF WASTAGE AREA

- **Margin left in condition that existed at March '02 shutdown**
- **How much**
  - **More pressure, or**
  - **More wastage**

  could have been tolerated without failure?

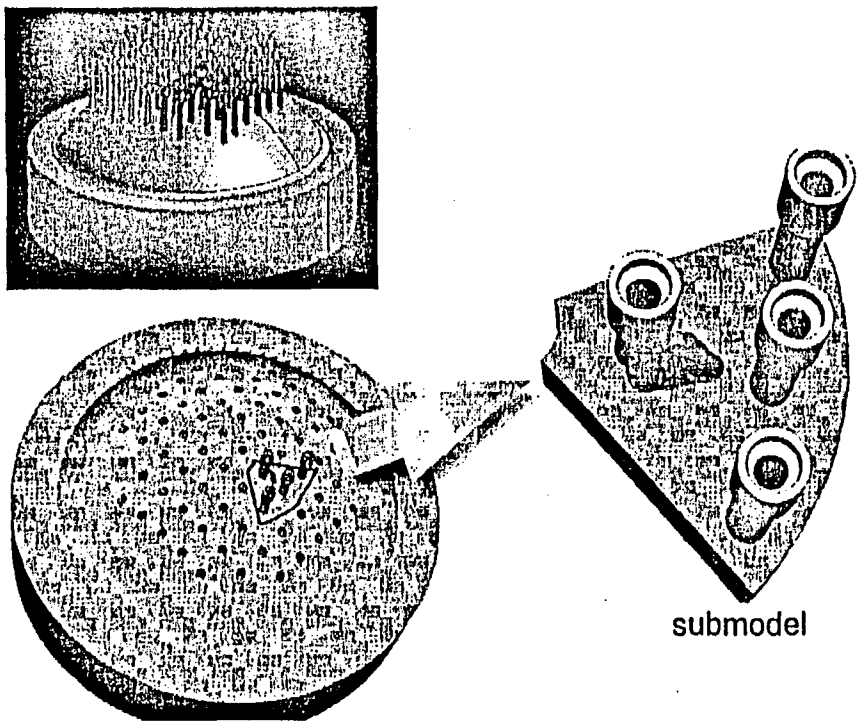
Done

Underway

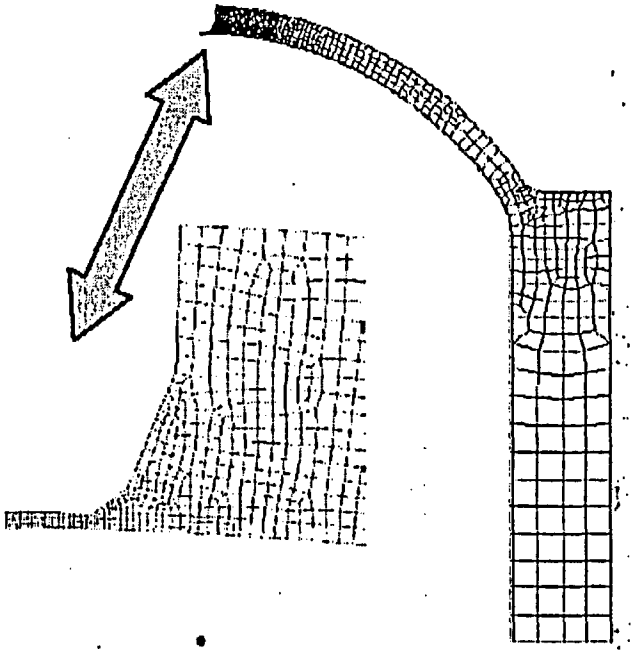
- **Assessment of repair options**

Likely not necessary in view of current licensee plans to procure and modify Midland head

Analytical Tools



- **Most realistic representation of the geometry of both the wastage area and the overall head design**



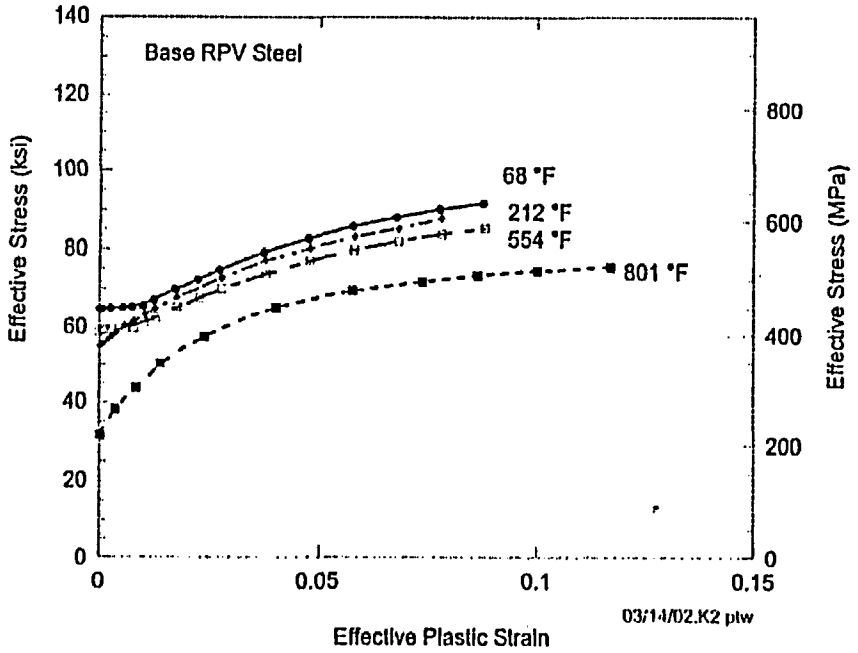
- **Wastage modeled as pit at top of head**
- **More refined cladding model (than possible in 3D)**
- **Allowed easier investigation of additional wastage area needed to produce failure**

Details of Analyses

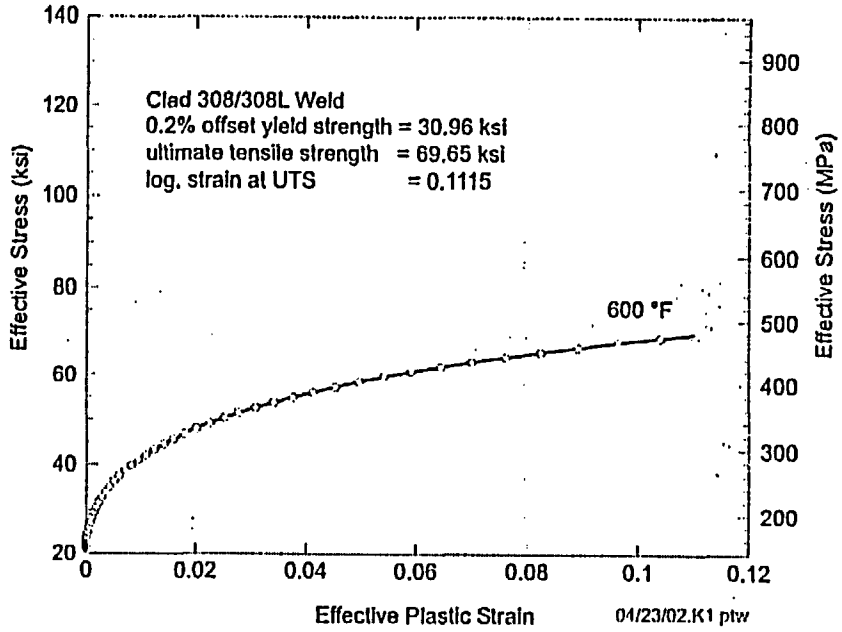
	3D FE Model (*ORNL*)	Axi-Symmetric FE Model (*EMC²*)
Loading	P = Design (2165 psi) or higher T = Operating (600°F), no gradients	
Material Properties	On next page.	
Geometry	■ All penetrations modeled ■ Straight walled 3D cavity ■ Geometry digitized from early photo.	Axial pit at apex of head
Failure Criteria	■ Failure occurs when the average through-thickness equivalent plastic strain in the cladding exceeds 5.5% ■ 5.5% corresponds to the strain at the beginning of plastic instability. Derived from • 11.15% strain in a uni-axial tension test • Assumption that "failure" occurs at same stress level under uni-axial and bi-axial loading.	

Material Stress-Strain Properties

RPV Steel



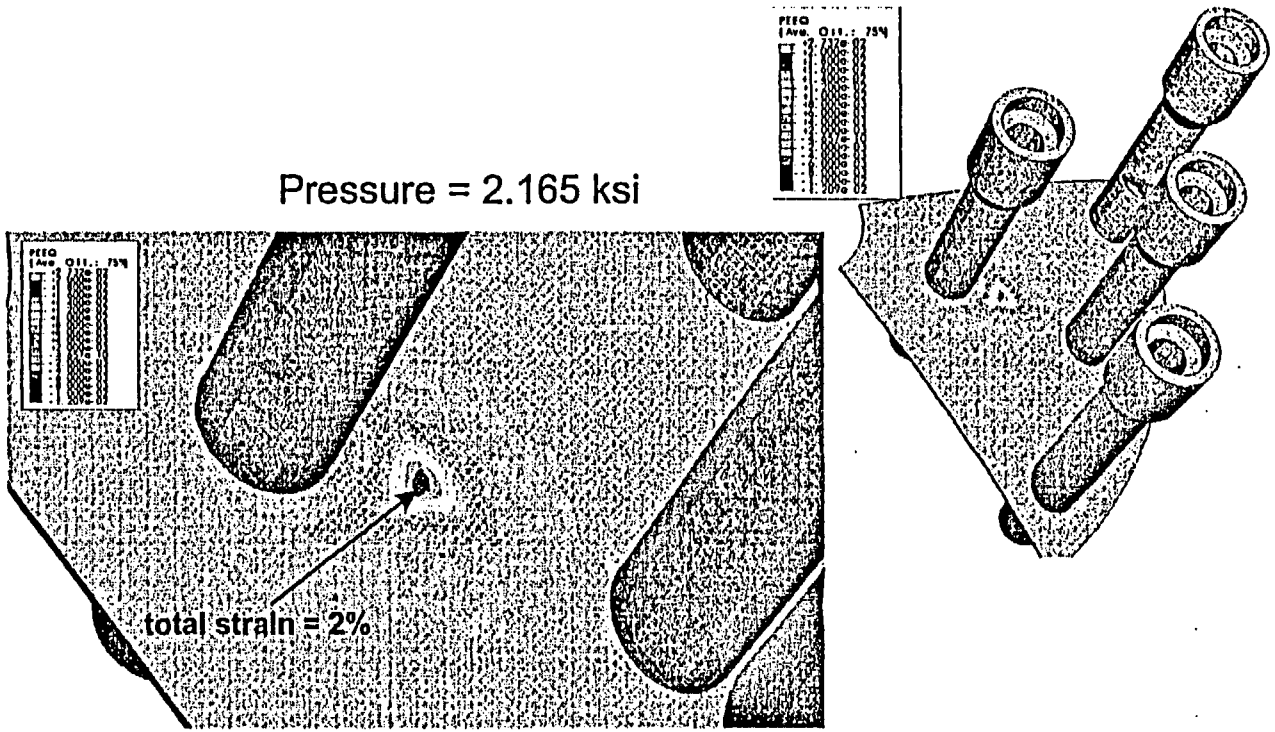
Cladding



Summary of Findings

→ *As-Found Condition* ←

- **At operating pressure (2165 psi) the 3D FE model predicts 2% plastic strain in the cladding**
  - **No failure predicted relative to assumed failure criteria**



Summary of Findings

→ *Margin on Overpressure* ←

- **Depending upon**
  - **The particular failure strain (5.5% *vs.* 11%)**
  - **The strain value (average, minimum, etc.)**
  - **Cladding thickness (design, average measured, minimum measured)**

used in the analysis, different margins on overpressure result:

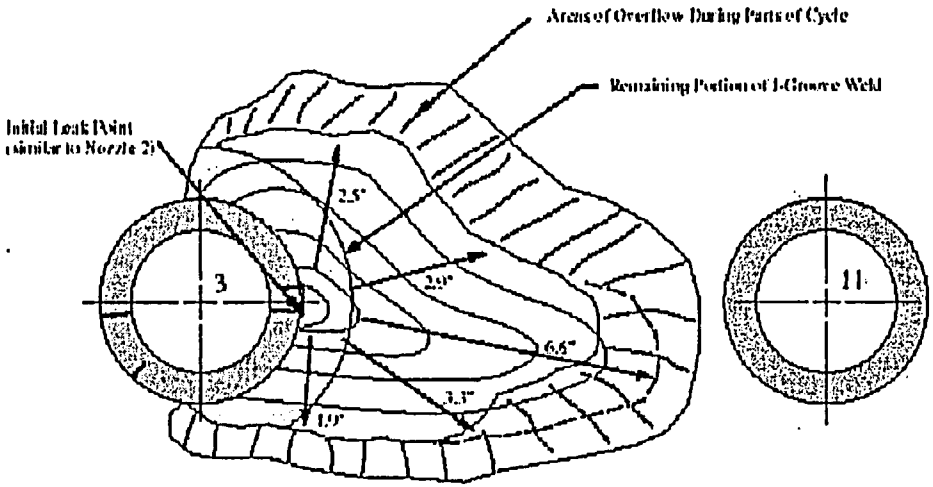
- **SIA (Industry) 3D Analysis: $P_{fail} / P_{oper} = 2.1 - 2.6$**
- **ORNL (NRC) 3D Analysis: $P_{fail} / P_{oper} = 1.4 - 2.0$**
- **EMC^2 (NRC) 2D Analysis: $P_{fail} / P_{oper} = 1.1 - 1.4$**

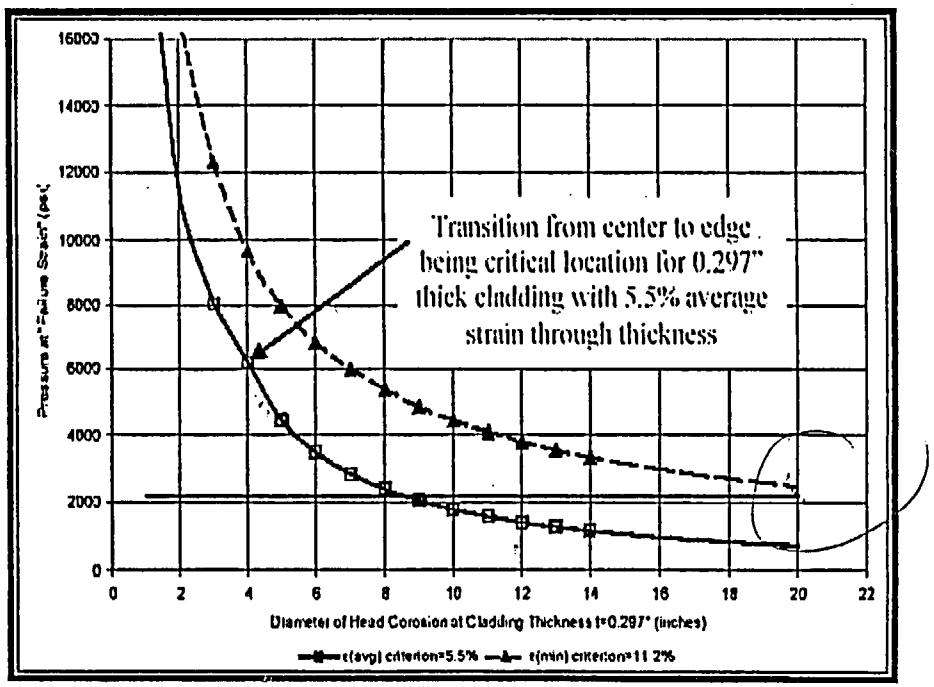
<u>Note</u>: Only the most pessimistic overpressure margins do not exceed the SRV set-point of 110% · P_{oper}

Summary of Findings

→ *Additional Cavity Growth Needed to Fail* ←

- **About 1.9-in. more wastage needed (along maximum growth axis) to cause failure at the operating pressure, assuming**
  - **5.5% failure strain (average through thickness**
  - **Average thickness cladding**
  - **Appropriateness of axi-symmetric model**





Next Steps

- **Better definition of failure criteria**
  - **Calibration relative to appropriate data, if data is available**
  - **Determination of significance of different failure criteria (for probabilistic analysis up to 2500 psi)**
- **Cavity growth rate**
  - **Growth rate data**
  - **Growth models**
- **Probabilistic analysis**

Next Steps (details)

- **Re-analyses using ORNL "best-estimate" 3-D FE model of existing cavity up to 2500 psi to quantify failure probabilities**
- **Further evaluation of clad failure criteria by analyzing measured data obtained from (6-in. dia. x 0.25 in. thick.) SS burst disks**
- **3-D FE analyses of cavity growth scenarios to refine estimates of critical wastage area at P_{oper}**