

5/5/02

NRC Assessment of Margin Available at Davis Besse



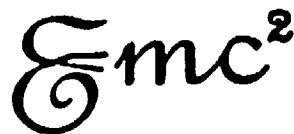
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RES/DET/MEB



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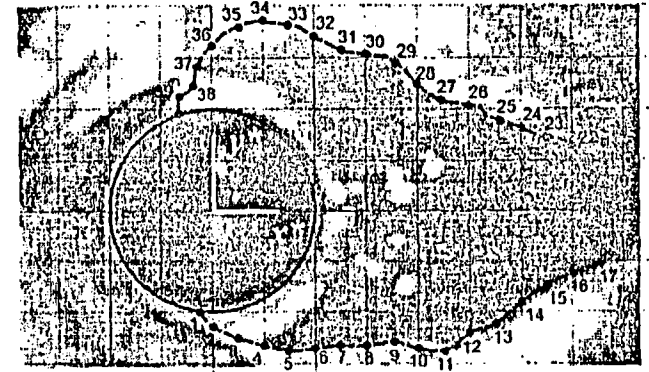
ACRS Briefing: Materials and Metallurgy & Plant Operations Subcommittees
USNRC Headquarters • Rockville, MD • 5th May 2002

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

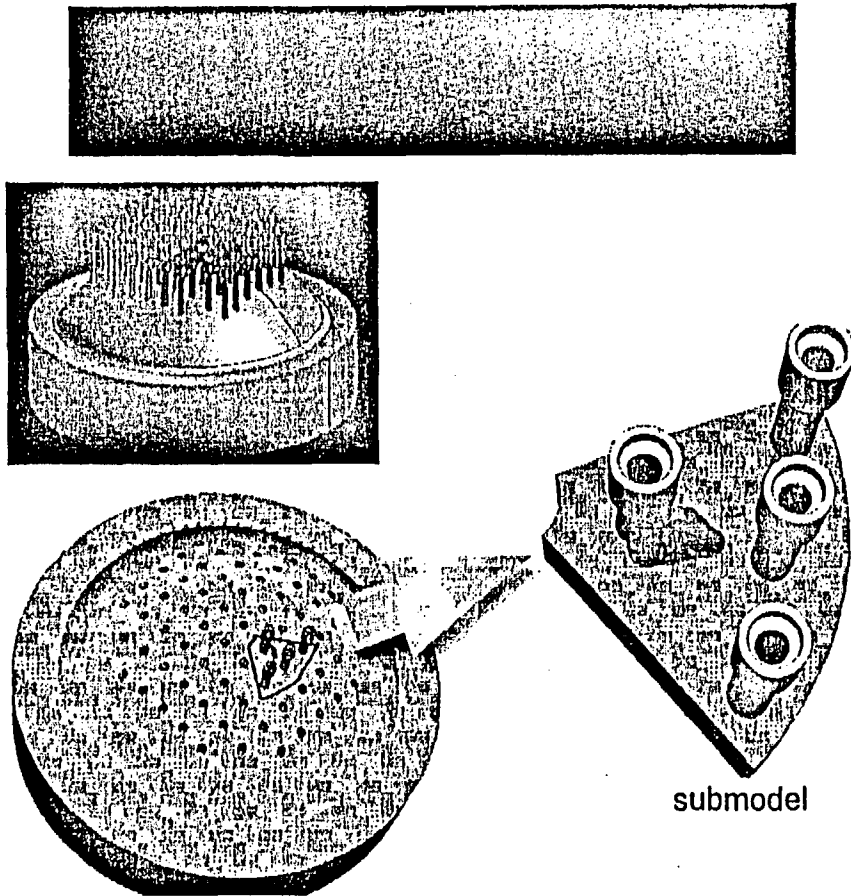


Underway

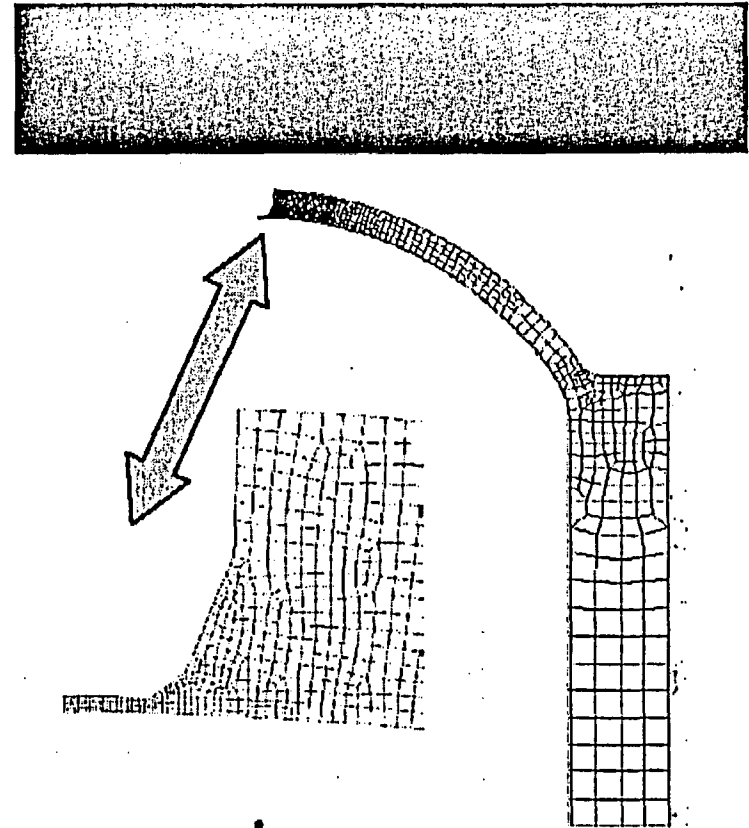
- **Assessment of repair options**

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



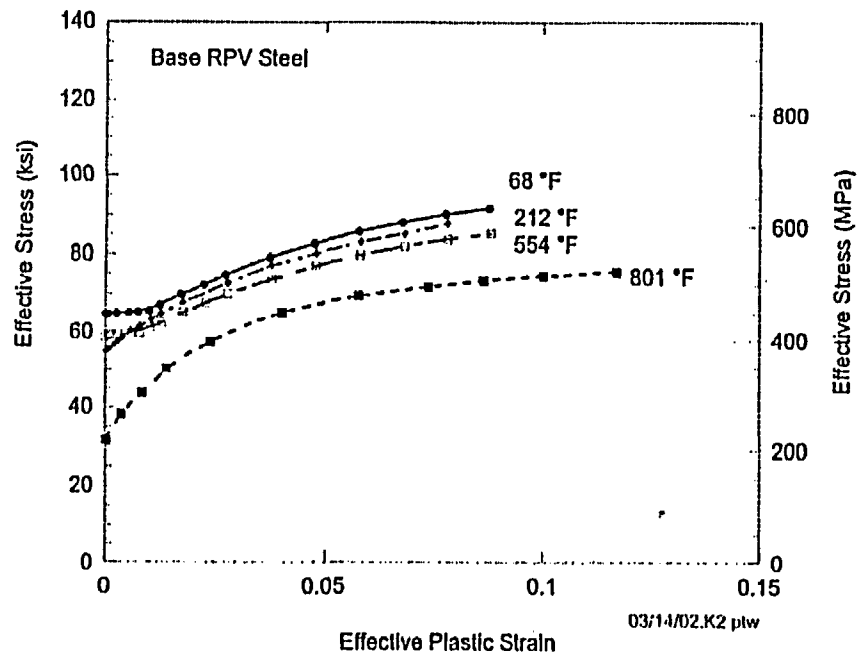
- Wastage modeled as pit at top of head
- More refined cladding model (than possible in 3D)
- Allowed easier investigation of additional wastage area needed to produce failure

Details of Analyses

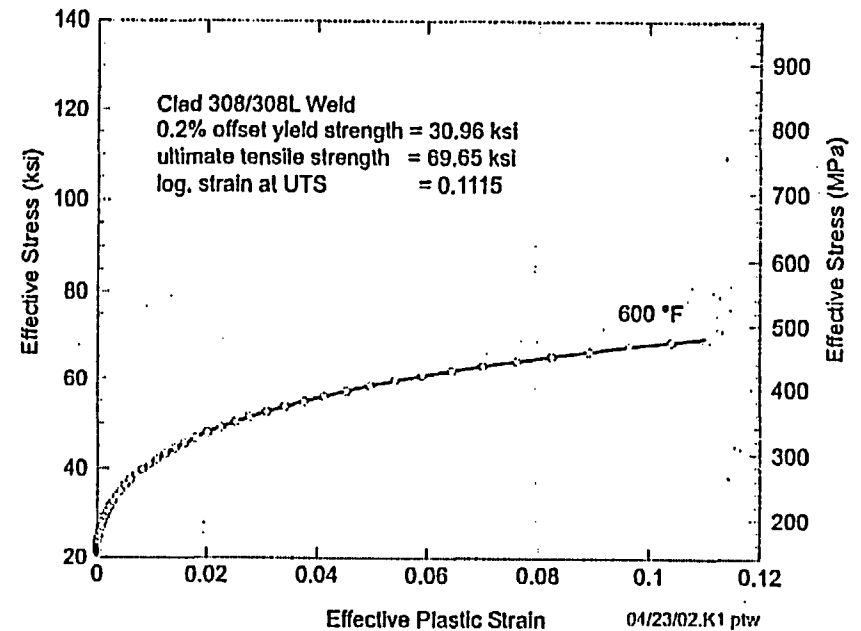
	3D FE Model (<i>ORNL</i>)	Axi-Symmetric FE Model (<i>EMC²</i>)
Loading	P = Design (2165 psi) or higher T = Operating (600°F), no gradients	
Material Properties	On next page.	
Geometry	<ul style="list-style-type: none"> ■ All penetrations modeled ■ Straight walled 3D cavity ■ Geometry digitized from early photo. 	Axial pit at apex of head
Failure Criteria	<ul style="list-style-type: none"> ■ 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 <ul style="list-style-type: none"> • 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



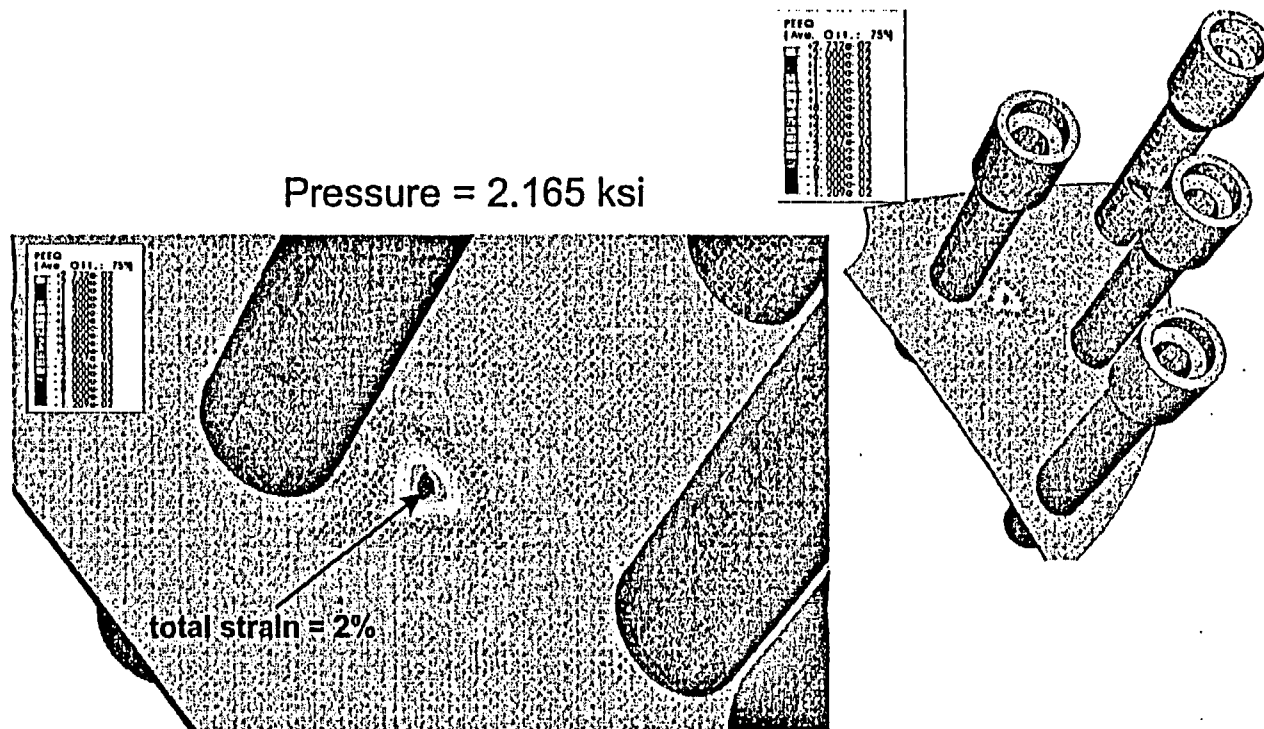
Cladding



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: $P_{fail} / P_{oper} = 1.4 - 2.0$
- EMC² (NRC) 2D Analysis: $P_{fail} / P_{oper} = 1.1 - 1.4$

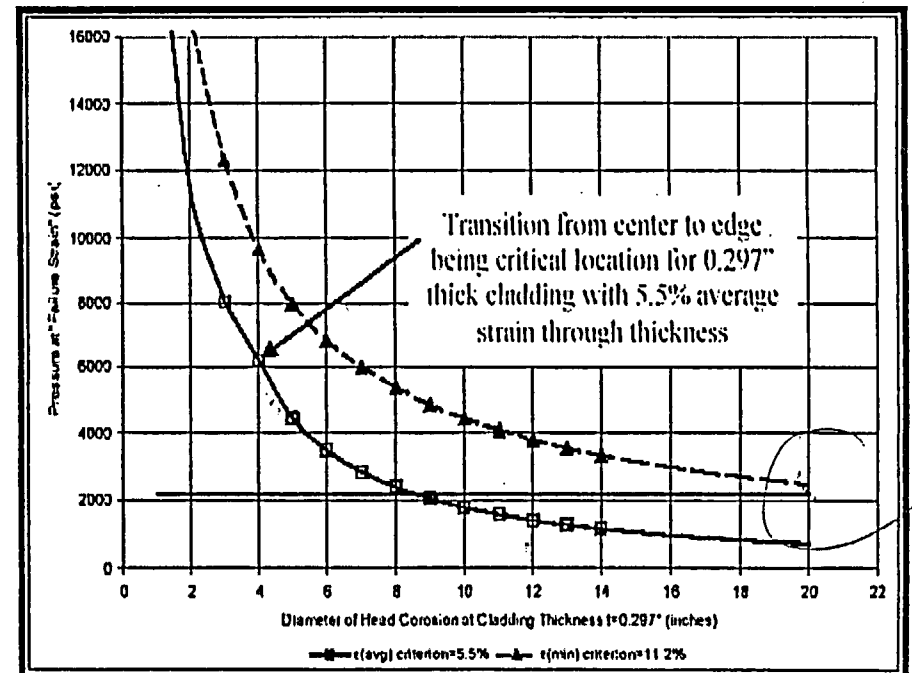
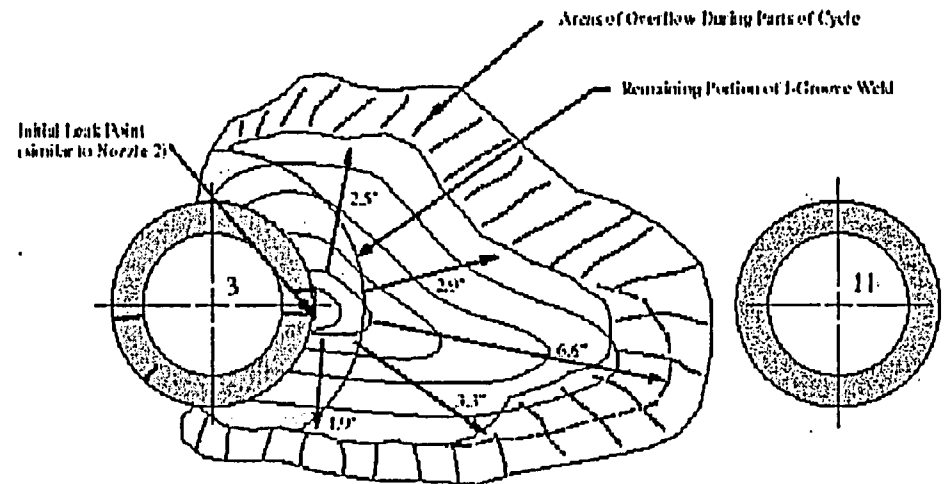
Note: Only the most pessimistic overpressure margins do not exceed the SRV set-point of

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}