NRC Assessment of Davis Besse Head Degradation

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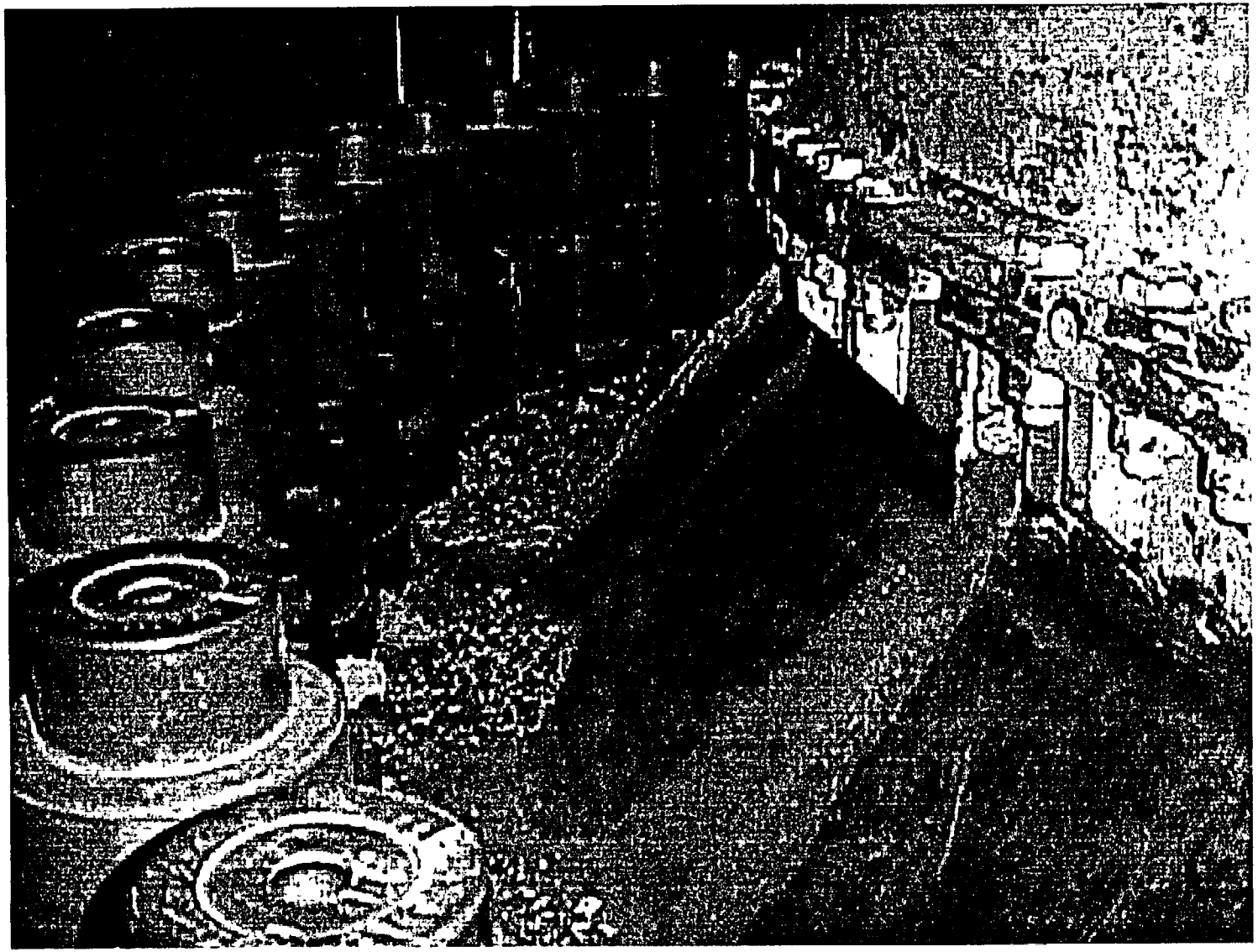
Overview of Presentation

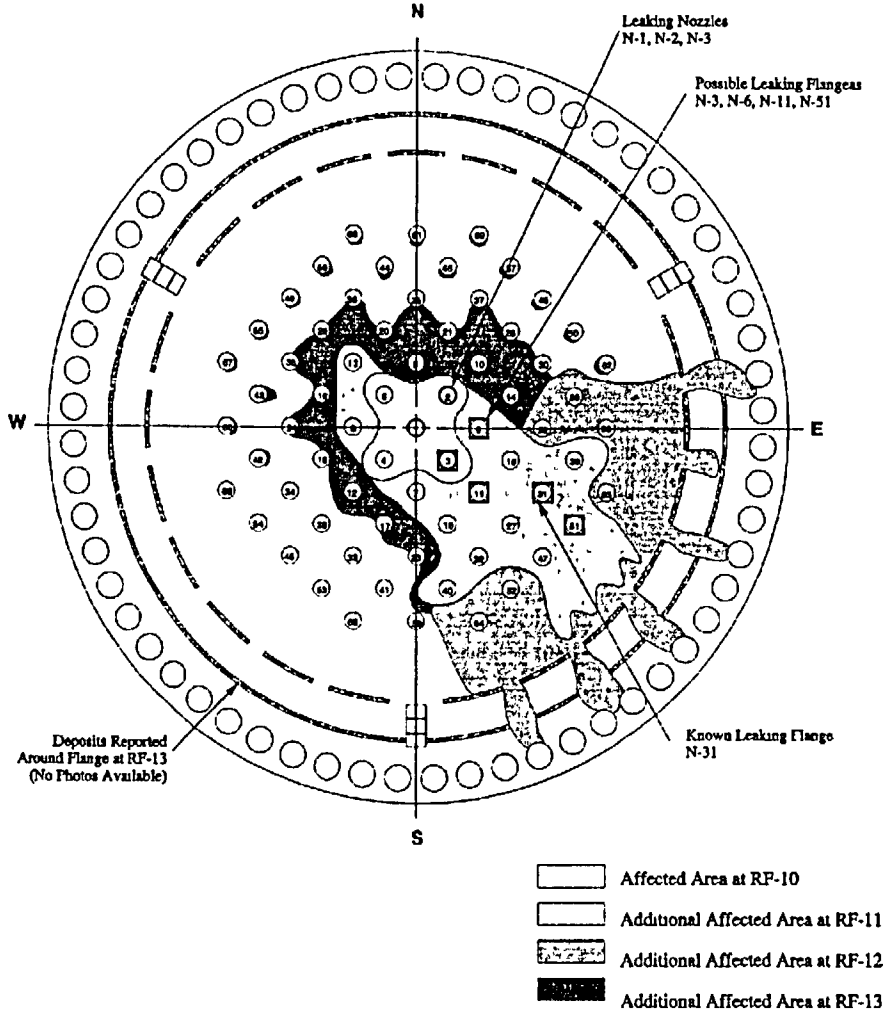
- **Wastage found in the vessel head**
- **Scope of analysis performed by RES**
- **Finite element model (and basis of model)**
- **Failure criteria**
- **Next Steps**
- **Lessons Learned**

Reactor Vessel Head

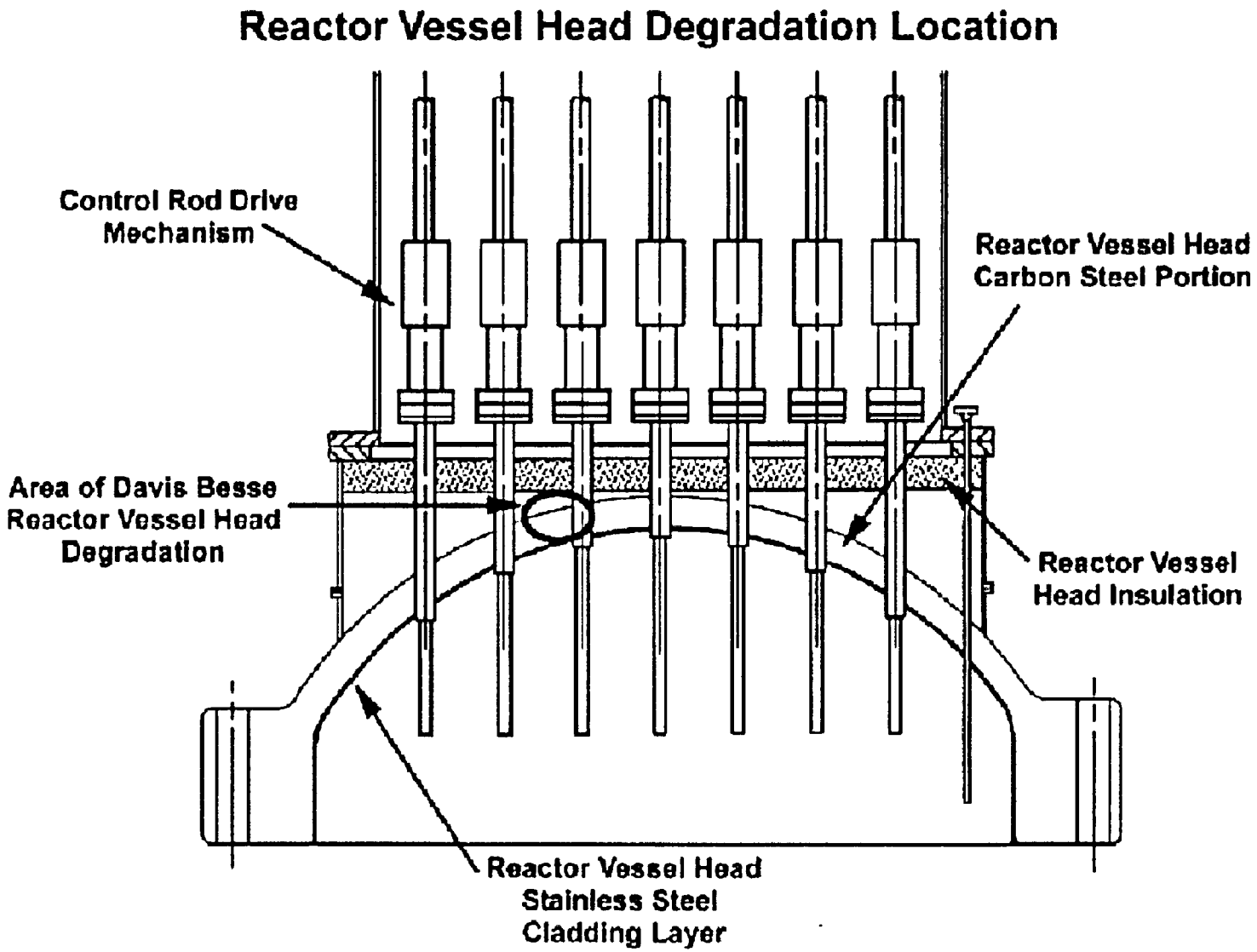


Boric Acid Deposits on Head

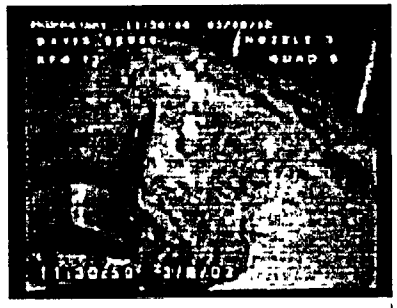
Source: EPRI/DEI

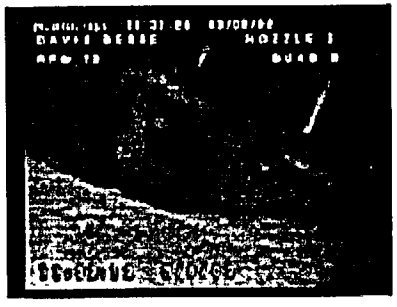


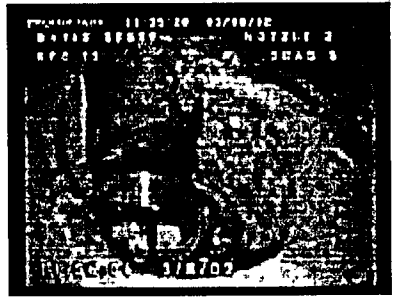
Location of Head Corrosion



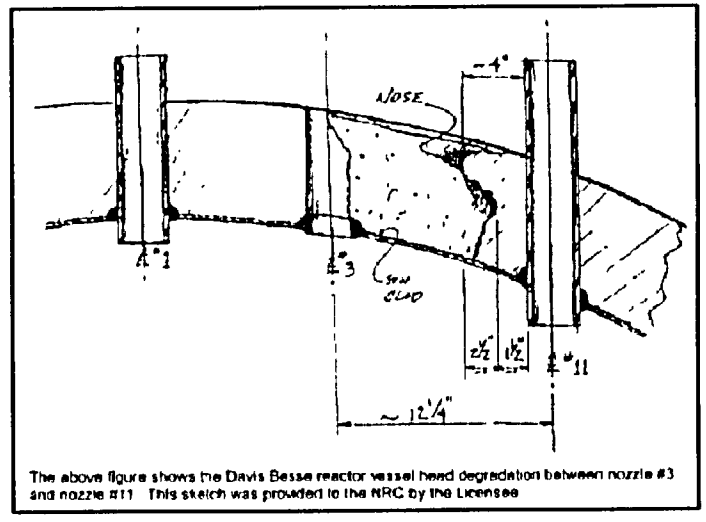
Wastage found in the Vessel Head



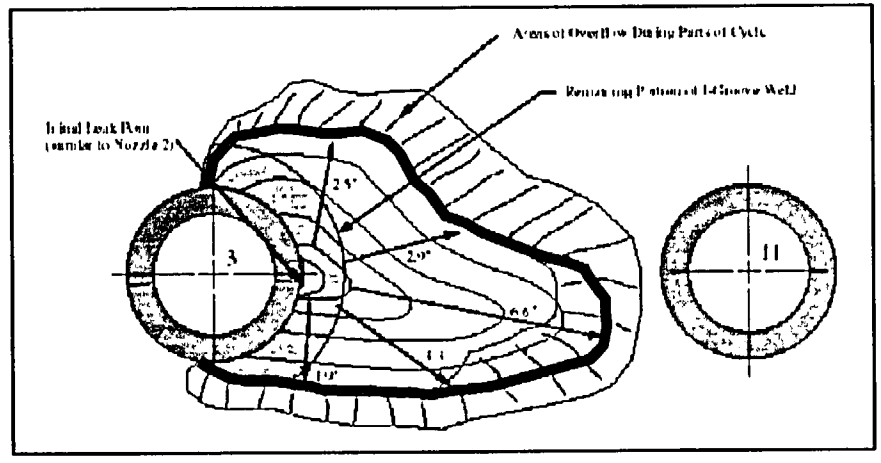




Measurements Reported 15th April 2002 by Davis Besse Power Station

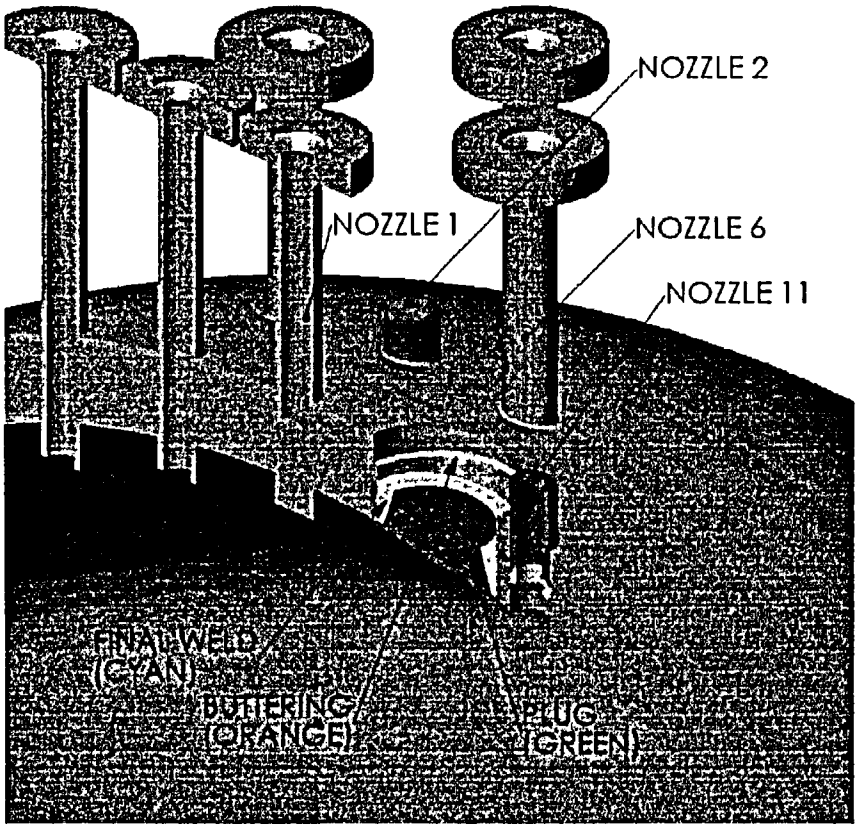


The above figure shows the Davis Besse reactor vessel head degradation between nozzle #3 and nozzle #11. This sketch was provided to the NRC by the Licensee

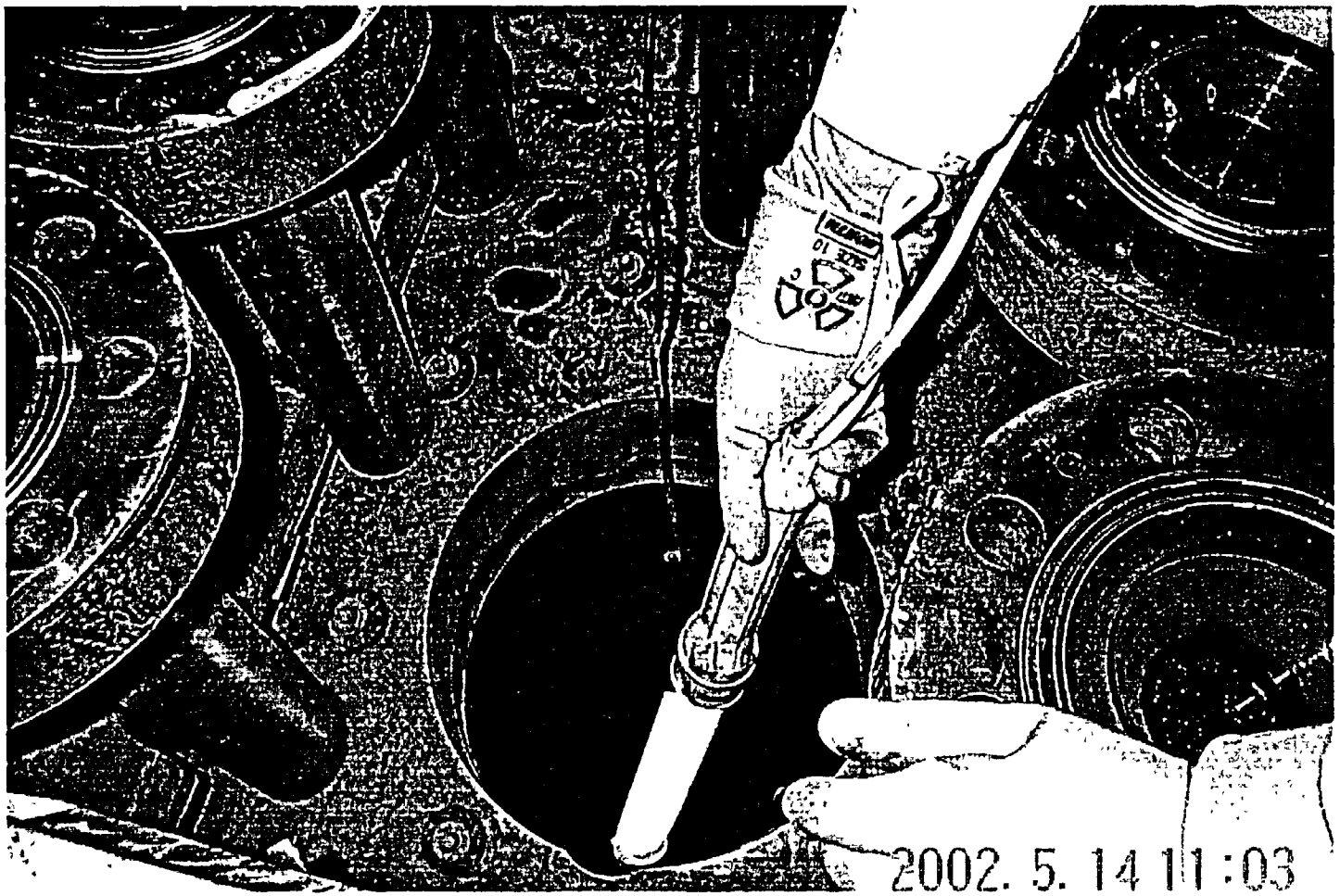


Nozzle #3 Corrosion Cavity

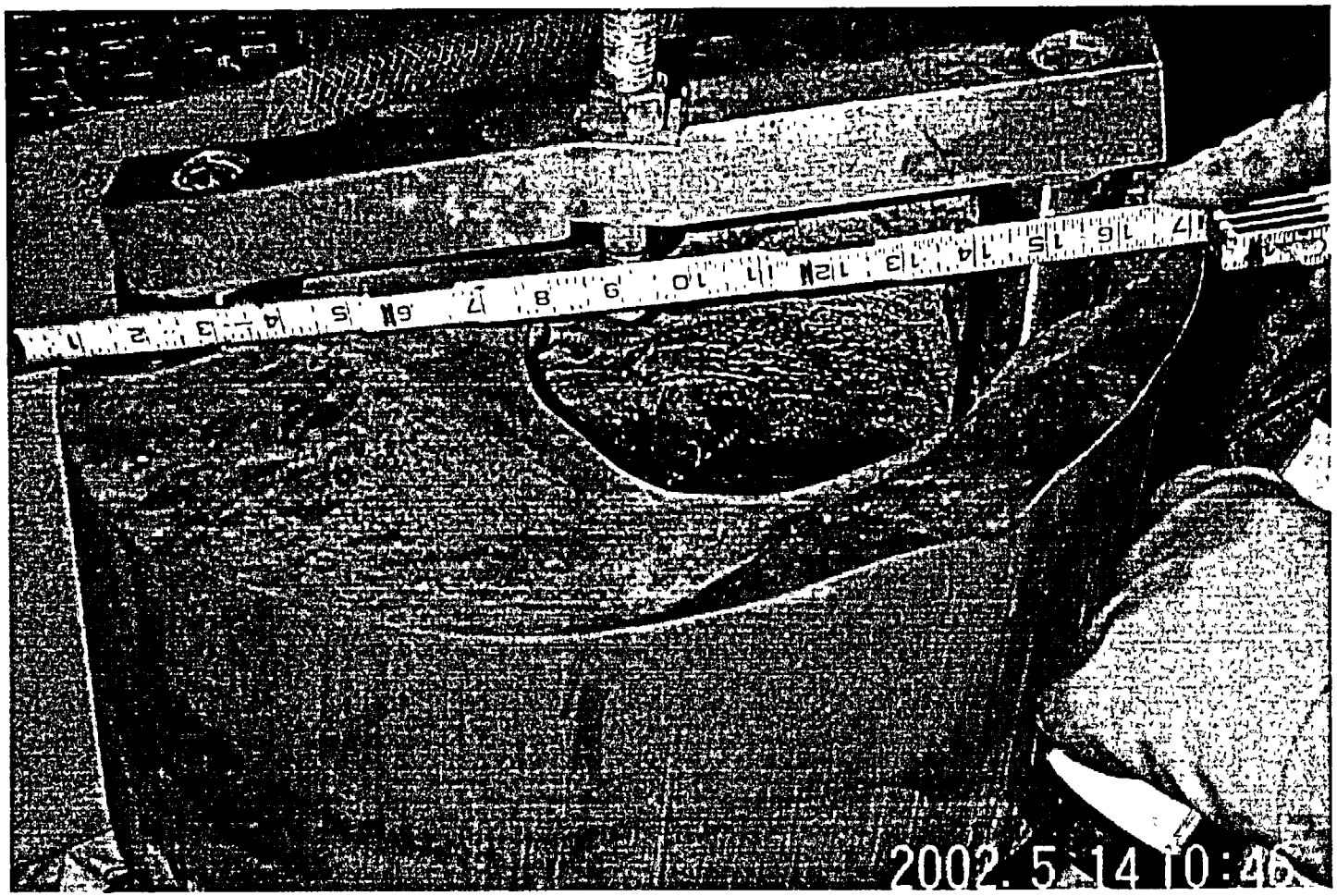
Initial Repair Proposed



Head Cavity Removal



Removed Head Cavity



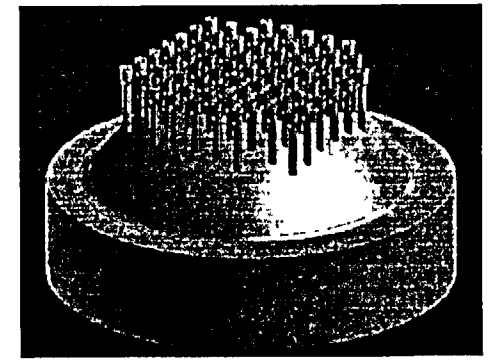
Scope of Analysis Performed by RES

- **Analysis of vessel in as-found condition**
  - **Initial deterministic analysis**
  - **Probabilistic analysis**

- **Analysis of potential future states**
  - **Cavity growth leading to cladding failure at pressures in the range of the operating pressure (2165 psi)**
  - **Estimates of the additional operation time needed to achieve failure at pressures in the range of the operating pressure (2165 psi)**

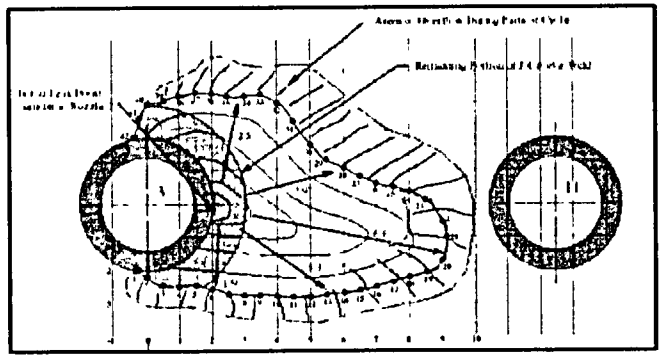
Basis of Finite Element Model

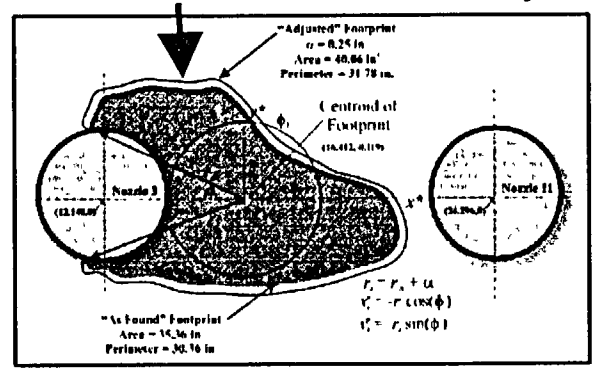
Design of the Head



Wastage Geometry

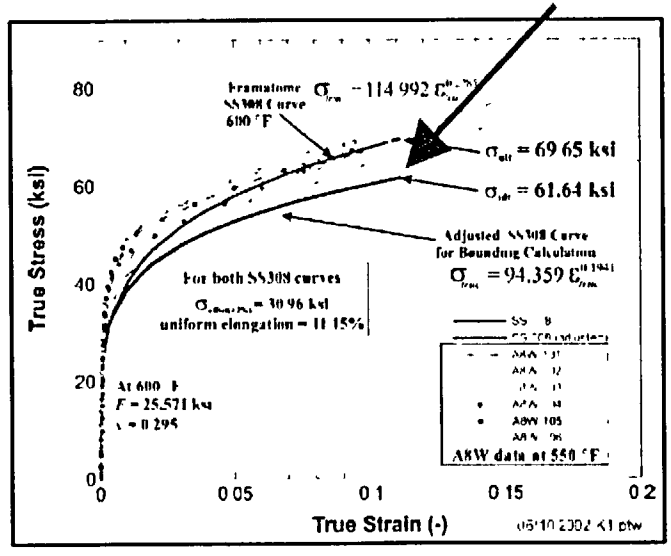
(upper-bounded from April '02 licensee measurements)





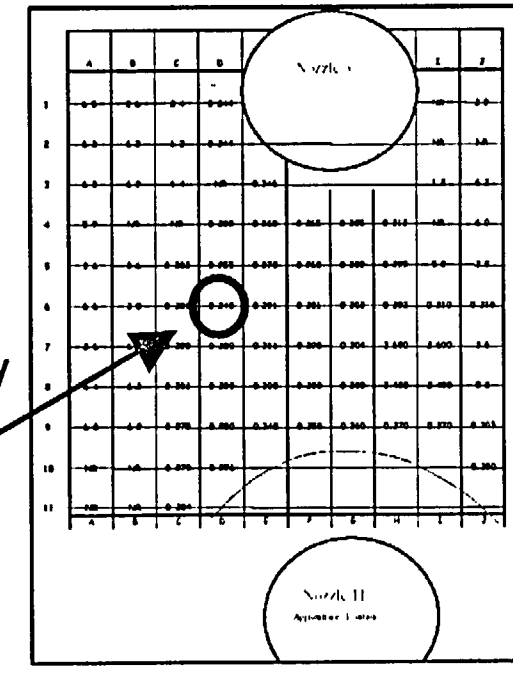
Cladding Tensile Properties

(lower-bounded from available data)

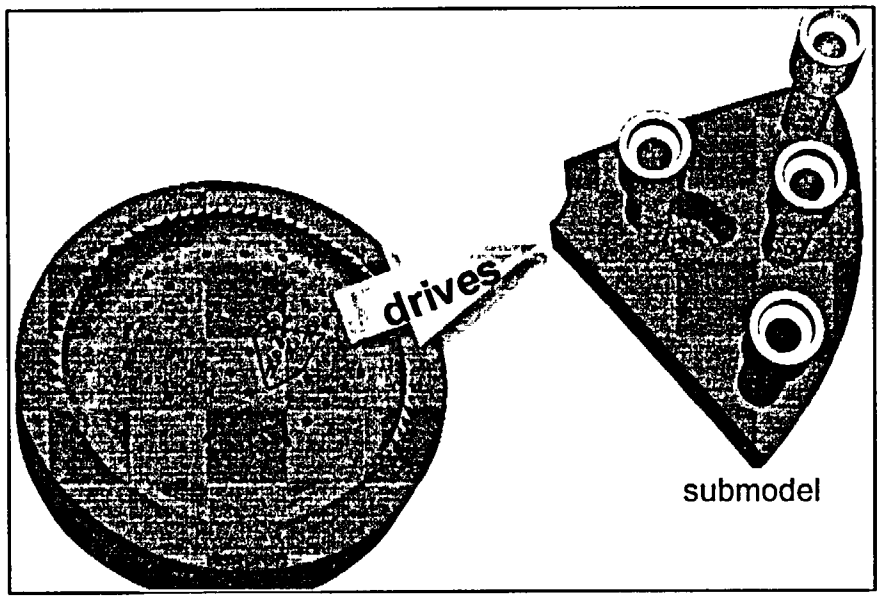


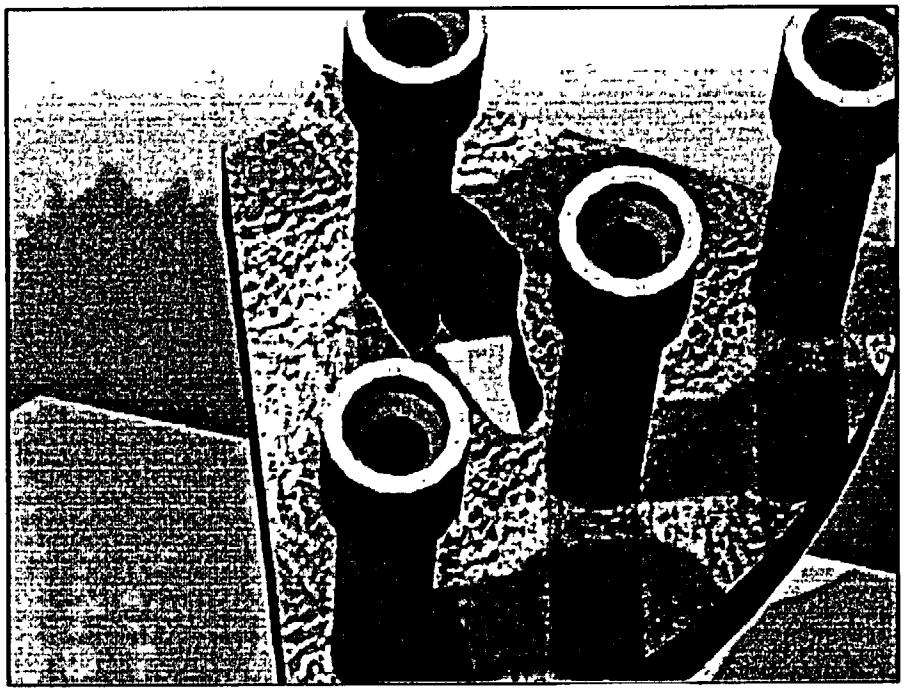
Cladding Thickness

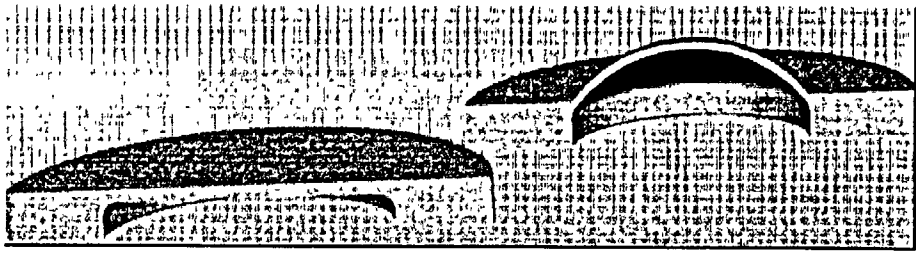
(minimum reported by licensee 0.24-in.)



Finite Element Model

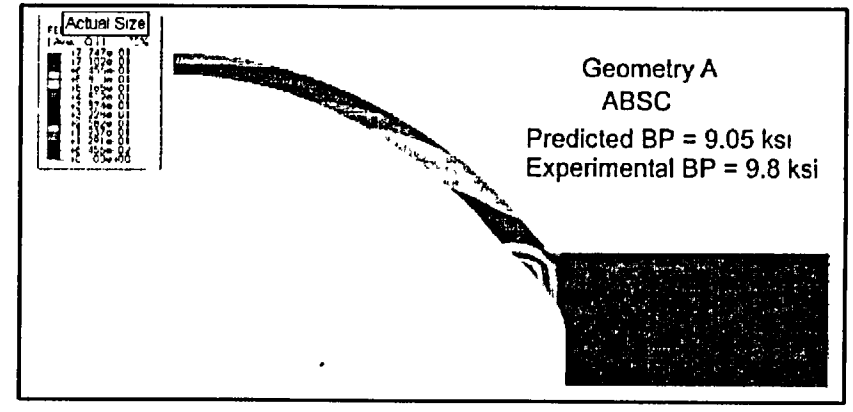


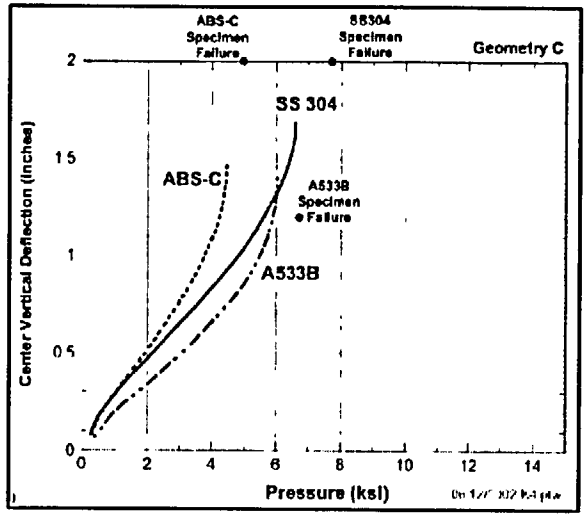


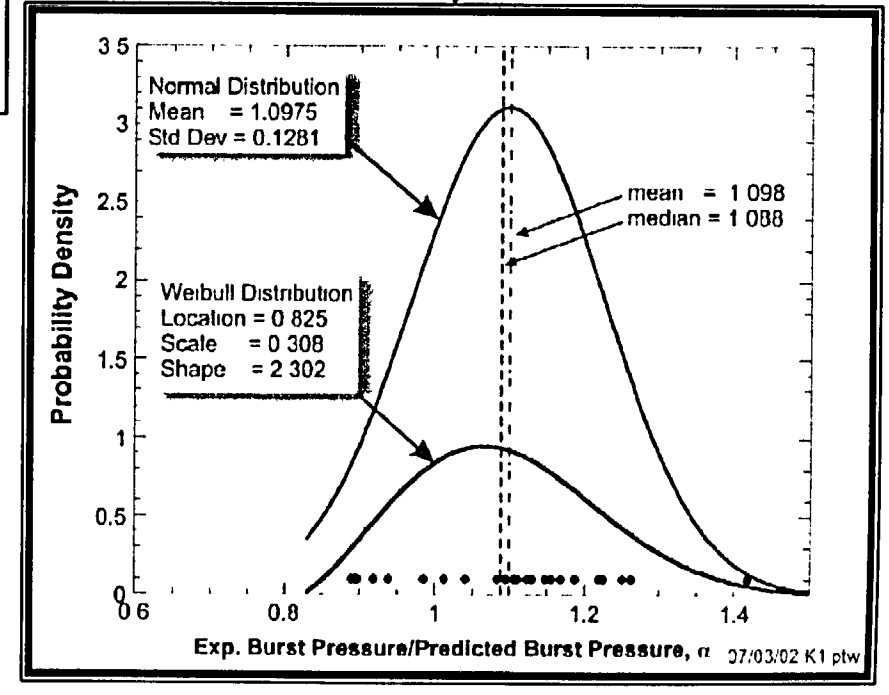


Failure Criteria

- → **Calibrated to disc burst tests reported by P. Riccardella [ASME '72 PVP]**
  - → **6-in. diameter**
  - → **1/8 and ¼-in. thick**
- → **Experiments used to quantify uncertainty and bias in using FE analyses to predict rupture of an unsupported membrane subjected to pressure loading**
- → **This statistical distribution is then used along with 3D FE model of Davis Besse cavity to assess probability of cladding rupture in the "as found" condition**







Findings & Next Steps

- **Complete preliminary analysis to determine probability of failure for the "as found" vessel head condition utilizing simplified configuration**
- **Further analysis could be performed including definitive measurements of**
  - **Cavity geometry**
  - **Cladding thickness & thickness variation**
  - **Cladding tensile properties**

  made directly on the Davis Besse head
- **Calculation of cladding rupture probabilities associated with larger wastage areas**
- **Estimation of the time needed for the boric acid corrosion to progress from the as-found condition to the size of these larger wastage areas**

Lessons Learned

- **Significance analysis may need to consider other factors**
- **Precursors were apparent to plant engineers**
  - **Increased accumulation of boric acid deposits on head and color changes in these deposits**
  - **Boric acid deposits in Containment Air Coolers necessitated frequent cleaning**
  - **Corrosion deposits on Radiation Element Filters caused frequent clogging**
- **Effective engineering organizations understand the limits of their knowledge and analysis**