

STATUS OF NRC OFFICE OF RESEARCH INITIATIVES ON REACTOR VESSEL HEAD PENETRATION CRACKING

Workshop on Alloy 600 Cracking Issues
SMiRT 16 Meeting
Washington DC

Ed Hackett
Assistant Chief, Materials Engineering Branch
Office of Nuclear Regulatory Research

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NRC Office of Research Initiatives on
Reactor Vessel Head Penetrations (VHPs)

- At the request of NRR (June, 2001), the NRC Office of Research (RES) formed an independent group of experts to review technical aspects of the recent VHP cracking occurrences at Oconee and ANO. The expert group has completed their initial assessment as of June 29, 2001. Preliminary conclusions and recommendations will be summarized.
- RES staff and contractors have continued to provide technical support to NRR through on-going programs:
 - Environmentally Assisted Cracking
 - Non-destructive Evaluation
 - Structural Integrity/Fracture Mechanics
 - Probabilistic Risk Assessment
- RES is planning on support of NRR for any VHP inspection oversight activities for Fall 2001 outages

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Reactor Vessel Head Penetrations
Independent Group of Experts

- Dr. William Shack (Argonne National Laboratory) - Environmentally Assisted Cracking
- Dr. Steven Doctor (Pacific Northwest National laboratory) - Non-destructive Evaluation
- Dr. Gery Wilkowski (Engineering Mechanics Corporation) - Leakage Integrity
- Dr. Richard Bass (Oak Ridge National Laboratory) - Structural Integrity
- Mr. Mark Cunningham (Office of Nuclear Regulatory Research, Probabilistic Risk Assessment Branch) - Risk Assessment

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Charter for Independent Group of Experts

- Evaluate technical/safety bases for continued operation
- Evaluate technical issues and provide conclusions/recommendations relevant to:
 - Contents of Bulletin 2001-01
 - Guidance for inspection activities for Fall 2001 outages

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Preliminary Conclusions/Recommendations

- Susceptibility Evaluation
 - Significant uncertainty
 - Industry model - time and temperature
 - Other factors (yield strength, fabrication, etc.) can significantly influence susceptibility
 - Best available information for now

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Preliminary Conclusions/Recommendations (cont.)

- Environmentally Assisted Cracking
 - Annulus region between the head and VHP will likely be a site for concentration of aggressive chemical species
 - Initiation frequency and crack growth rates for this situation are not known, but would likely be more rapid than those observed for PWSCC
 - Initiation at multiple sites around the circumference is likely
 - Crack growth rates in excess of 1 inch/year are possible

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Preliminary Conclusions/Recommendations (cont.)

- Detection and Characterization of Boric Acid Deposits from Annulus Leakage is Subject to Significant Uncertainties:
 - Interference fits
 - Occlusion of annulus by deposits
 - Quantity and differentiation of deposits
 - Configuration of head insulation
 - Need for plant-specific qualification

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Preliminary Conclusions/Recommendations (cont.)

- Need for and Reliability and Effectiveness of Volumetric Examinations:
 - Volumetric examinations are indicated for plants with known cracking and would be the preferred inspection method for high susceptibility plants
 - Vendors have current equipment capabilities but not qualified inspection methods
 - Inspections can be effective if adequate pre-qualifications can be performed
 - There will be limitations on the number of qualified industry methods and teams that could be fielded by Fall 2001 outages

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Preliminary Conclusions/Recommendations (cont.)

- Potential for On-line Monitoring for Leakage or Cracking:
 - On-line monitoring for leakage or cracking is technically feasible
 - On-line leakage monitoring for certain French plants is accomplished through N-13 monitoring
 - Acoustic emission monitoring has demonstrated potential for identifying cracking in nuclear plant applications
 - Application of either on-line leakage or crack monitoring for VHPs in U.S. PWRs will require development efforts that would be longer-term (beyond Fall 2001 outages)

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Preliminary Conclusions/Recommendations (cont.)

- Structural Margin:
 - Expert group has verified structural margin calculations by the industry
 - Alloy 600 is capable of tolerating very large through-wall circumferential cracks while still maintaining adequate structural integrity
 - Margin calculations do not consider crack growth

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- RES and NRR are developing an integrated technical perspective on the issue through consideration of the expert group reports, industry and staff analyses, and other applicable analyses and data
- The integrated perspective is being documented in a memorandum - expected completion - August, 2001
- The memorandum will be made available to the public upon completion
- Perspectives and recommendations from the expert group have been factored into development of NRC Bulletin 2001-1
- Continuing technical evaluation will focus on the framework and appropriate inputs for a probabilistic fracture mechanics (PFM) assessment of the issue
- With regard to the PFM assessment, it is important to focus on validation of, and reduction of uncertainties in the input variables