Alloy 600, 82/182 Weld Integrity Issue

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MRP Senior Representatives’ Meeting
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Important Locations

Leaks have occurred at underlined locations
Industry Response

• Integrated effort is being coordinated through
  – EPRI Materials Reliability Program (MRP) - Alloy 600 ITG
  – Committees Under Alloy 600 ITG
    • Assessment
    • Inspection
    • Repair/Mitigation
  – NEI
  – Owners Groups

• Work is being performed by
  – Utilities
  – NSSS Vendors
  – Contractors
Industry Response

• Overall Scope of Alloy 82/182 Weld Integrity Activity
  – Safety Assessment and inspection development/support WITH
  – Comprehensive ‘Inspection and Evaluation Guidelines’
    • Similar to BWRVIP approach
    • Identify and rank all susceptible components
      – Provide hardware evaluation (component description and function)
      – Provide safety assessment for each (built from first activity above)
      – Provide ‘conclusions and actions’ recommendations/management approach
    • Integrate with past, existing and future OG activities (no duplication)
MRP Alloy 82/182
Weld Integrity Issue:

Interim Safety Assessment (5/11/01)
- RPV Nozzles
- CRDMS

Safety Assessment & Prioritization (6/30/01)
- All 82/182 locations

Fleet Information
- configurations
- materials
- stress states
- fabrication

Risk

Water Chemistry Guidelines

Crack Growth Rates

On-going Testing
- MRP/EdF
- OGs

Examination of Field Materials
- SG nozzles
- VCS materials
- others(?)

> 3/4t
< 0.1t
uninspectable areas

Susceptibility Screens/Ranking
- Thresholds time temp stress
- Materials
- Manufacturer

I & E Guidelines for Susceptible Components

Inspection Capabilities & Limitations

Mitigation Testing
- MRP/W

Inspection Results

Mitigation Strategies

Data boxes => work needed

Input to Mockups & Inspection Tooling Design

ASME Code Guidance

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PWSCC of Alloy 82/182 Pipe Butt Welds
Interim Safety Assessment for Alloy 82/182 Pipe Butt Welds (MRP 44, Part 1)

- Plants have adequate margin to continue operation
- Cracks expected to be predominantly axial due to stresses
- Axial cracks in butt welds bounded by resistant low alloy steel or stainless steel material
- Critical flaw size for rupture several times width of weld
- V.C. Summer leak discovered long before safety margins were compromised
- Through wall circ cracks will produce detectable leaks before exceeding available structural margins because of high ductility of Alloy 82/182 materials
- Defense in depth
  - These cracks do not significantly increase the core damage frequency
  - Primary pipe break is an analyzed accident per the FSAR
NDE Plan

• All Spring outage plants enhance 88-05 walkdowns considering lessons learned from VC Summer
• For 10 year ISI plants, EPRI mockup used to demonstrate techniques:
  – Changes made to enhance detection
    • Transducer packages/sled design
    • Equipment setup
    • Operator awareness
• Shop welds vs. field welds
  – Shop weld ID contours expected to be smoother
  – All Spring outages with 10 year ISI of vessels were shop welds
    • Some minor liftoff experienced, even on a shop weld
NDE Plan (continued)

- Assess alternative techniques
  - UT still considered the best technique at present

- Appendix VIII qualification, both ID and OD exams, required after November 2002
  - Blocks and test protocols being developed by PDI
CONCLUSION

• Cracking of pipe welds is not a near term safety issue
  – There does not appear to be a widespread generic problem
    • Visual inspections for boric acid are effective in finding leaks
    • Previous ISI would have found major problems with pipe welds
  – Analyses show there is significant margin against failure
  – Pipe weld failures are covered by Defense-in-Depth (FSAR)
• Interim guidance was provided for Spring 2001 outages
  – UT methods have been improved and demonstrated on mockups
  – Awareness of operators and inspectors has been increased
• Significant ongoing actions in assessment, inspection and repair/mitigation to be completed
  – Must address 360° flaw possibility, LBB regulations and SER constraints, crack growth rates, risk assessment
• Long term management plan still needs more detailed development
PWSCC of RV Top Head Penetrations
Schematic View of B&W-Design CRDM Nozzle Area
Recent Experience

• Oconee 1 - a single CRDM and several T/C nozzles found leaking

• Oconee 3 - nine CRDM nozzles leaking, two with circumferential flaws above the weld

• ANO 1 - a single CRDM found leaking

• Oconee 2 - four CRDM nozzles leaking, one with small circumferential flaw above the weld
ONS-1 RV Head Showing Boric Acid At CRDM Nozzle 21
Generic Implications of Head Penetration Cracks

- Axial flaws not safety significant (covered by previous safety assessments), but . .
- Circumferential flaws above the weld, if large enough, could threaten rod ejection accident
- Cracked penetrations leaked VERY little
- Adequacy of visual inspections to detect cracks
  - Masking boron deposits
  - Interference fits on many plants tighter than Oconee/ANO
- Initial volumetric NDE did not call circumferential flaws at ONS 3
Generic Implications of Head Penetration Cracks (continued)

• NDE techniques
  – Only qualified for ID initiated flaws (ET detection/UT sizing)
  – Volumetric of nozzle tubes not yet qualified
  – Volumetric of welds difficult and not yet qualified
  – Other techniques (ET of OD/weld surface) also not yet qualified

• Crack growth rate uncertainties
  – Annulus environment unknown
  – Effect on growth rate not demonstrated

• Visual examinations can be dose intensive (3-5 Rem)
  – Insulation issues MUCH worse at some units

• Manual repairs were extremely costly (Time, $, Dose)
MRP Interim Safety Assessment

- Interim safety assessment submitted May 18, 2001
- Developed a histogram of time for each unit to reach the equivalent time at temperature as ONS 3 (normalized to 600F)
- Recommended plants <10 EFPY from ONS 3 with Fall outages perform visual inspections
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- Had already recommended <10 EFPY plants with Spring outages perform a “best effort” at visual examination
Time-Temperature Histogram

Integrated Histogram
Original Data

No. of Units

EFPY to ONS 3
Visual Inspections Spring 2001

- Several plants performed visual inspections during Spring outages
  - Robinson 2
  - Salem 1
  - Farley 2
  - Prairie Island 1
  - McGuire 1 (partial)
  - SONGS 3 (partial)
  - Others (limited)
- Heads reasonably free of masking boric acid deposits
- No evidence of leakage found
MRP Interim Safety Assessment

• Bases for no significant near-term impact on plant safety:
  – The three Oconee units and ANO-1 are among the lead units in the US based on time at temperature
  – Leaks were found by careful visual inspections
  – Structural integrity evaluations showed the nozzles and welds were well within required margins
  – Leakage should also be detectable in other plants
    • Interference fits at other plants are only slightly larger than Oconee and ANO-1
    • Operating conditions tend to reduce interference fit (open gaps)
  – Several other lead units had already performed inspections from above and below the head without any significant findings
  – A CRDM nozzle ejection is an analyzed event in plant FSARs
  – Existing symptom based EOPs and operator training adequate
• NRC issued NRC Bulletin 2001-01 on 8/3/01, 30 day response

• One time information request:
  – Plant specific data and ranking
  – Volumetric exams by EOY for units with cracking
  – “Plant specific qualified” visual by EOY if <5 EFPY from ONS 3
  – “Qualified VT-2” (effective visual) if <30 EFPY at next refueling outage
    OR
  – demonstration of how regulations are met
Bulletin Response

- MRP preparing generic submittal:
  - Tabulation of data and ranking information
  - Basis for regulatory compliance
  - Inspection capability description

- Templates for utilities to use in preparing plant specific responses
Other Ongoing MRP Activities

- Assessment (focus - safety assessment/response to Bulletin)
  - Risk assessments
  - Probabilistic fracture mechanics
  - Scope expansion criteria
  - Flaw evaluation guidelines
- NDE (focus 2001 and Spring 02 outages)
  - Mockup design and fabrication
  - Technique development and demonstration
  - Information and training package for visual examination
- Repair/Mitigation
  - Review of strategies
  - Development of generic relief requests where needed
Schedule

- Revised Inspection Recommendations - August
- Expert Panel on Crack Growth - First Meeting 8/10/01
- Inspections during Fall 2001 outages
- Final Safety Assessment - Spring 02
- Reassessment of Inspection Recommendations - 2/02