

3rd NRC – AERB Nuclear Safety Projects Meeting
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Materials Degradation Management Regulatory Strategies



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OUTLINE

- Regulatory Framework
- Vessel Upper Head Generic Letter and Bulletins
- Order EA-03-009 (issued February 11, 2003)
 - ? Inspection requirements
 - ? Relaxation requests
- Bulletin 2003-02
- Pressurizer Heater Sleeves
- Regulatory Options
- Outlook for Additional Regulatory Actions for Inspecting / Managing Degradation

Component/ Regulatory Hierarchy	Vessel Welds	Vessel Upper Head Penetrations	Vessel Lower Head Penetrations	Pressurizer Heater Sleeve Penetrations	Other RCS Penetrations	Dissimilar Metal Welds	Similar Metal Welds
GDCs, Part 50 App B	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TS Oper. Leakage	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Performance Regulations For Example: 10 CFR 50.55a Appendix G Appendix H 10 CFR 50.61	Yes Yes Yes Yes	ASME B-P VT-2 Exams w/ insulation No Volumetric or Surface	ASME B-P VT- 2 Exams w/ insulation No Volumetric or Surface	ASME B-P VT-2 Exams w/ insulation No Volumetric or Surface	ASME B-P VT- 2 Exams w/ insulation No Volumetric or Surface	ASME B-P VT-2 Exams Volumetric or Volumetric and Surface or RI-ISI	ASME B-P VT-2 Exams Volumetric or Volumetric and Surface or RI-ISI
New Inspection Rule	Considering	Considering	Considering	Considering	Considering	Considering	Considering
Orders	No	Yes	No	No	No	No	No
Regulatory Guides	Yes	No	No	No	No	No	No
Bulletins	No	Yes	Yes	No	No	No	No
Generic Letters For Example: GL 88-05 GL 97-01	Yes No	Yes Yes	Yes No	Yes No	Yes No	Yes No	Yes No
Commitments	Yes - FSAR	Yes - Thru Bulletins; Orders supersede	Yes - One Time thru Bulletin	No	No	Yes - FSAR	Yes - FSAR
NRC Inspections- Reactor Oversight Process	Yes	Yes	Yes	Yes	Yes	Yes	Yes



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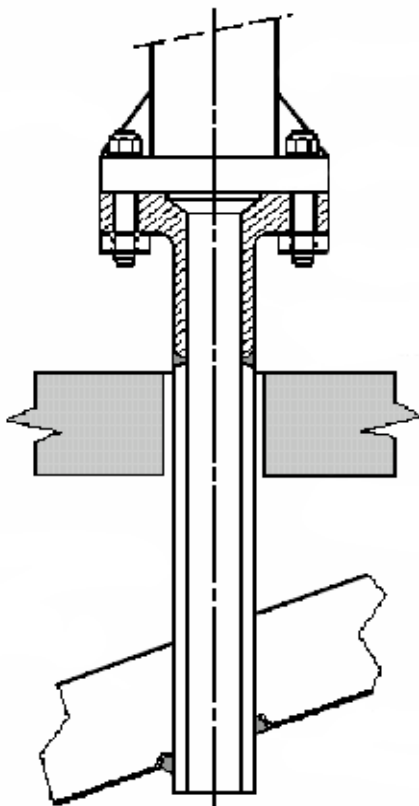
BACKGROUND

- Control rod drives above reactor vessel in pressurized water reactors
- Control rod drive penetrations in the vessel upper head also called vessel head penetrations (VHP)
- Generic Letter 97-01 issued to motivate inspections of VHPs



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Typical CRD Housing



Cross-section showing the important components of a control rod drive housing and a section of the reactor head.

Depending on the location of the penetration, the J-groove weld will be nearly symmetric (at or near the top of the head), or significantly asymmetric (at a downhill location). The two extremes are reflected in substantially different distributions of the residual stress.

To the residual stress, the hoop stress (due to pressure), and any stresses from the interference fit must be added.



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BACKGROUND

- Industry proposed inspections at limited number of high susceptibility plants based on time at temperature model (GL 97-01)
- Eddy current inspections conducted prior to November 2000 identified no weld cracks, limited axial penetration cracking, and circumferential cracking outside the pressure boundary
- Cracking attributed to primary water stress corrosion cracking (PWSCC)



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BACKGROUND

- Fall 2000
 - ? Oconee Unit 1 identifies deposits - axial crack (UT)
- Spring 2001
 - ? Oconee Unit 2 and 3 identify axial cracks (UT) and circ cracks (dye-penetrant)
 - ? ANO Unit 1 identifies a leaking nozzle – axial crack (UT)



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CRDM Leakage Noted at Oconee-1





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Bulletin 2001-01

- **NRC issues Bulletin 2001-01 - August 2001**
 - ? Focus is safety issue (circ cracks) for high susceptibility plants
 - ? Reference for susceptibility model in bulletin (high, moderate, low)
 - ? Visual examinations considered acceptable



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BL 2001-01 Timeframe

- Fall 2001
 - ? Circ cracks identified - Crystal River 3, Oconee 3
 - ? Leaks and repairs at Surry 1, North Anna 2, TMI
- Spring 2002
 - ? Davis-Besse identifies RPV head wastage & circ cracking



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Bulletin 2002-01

- **NRC issues Bulletin 2002-01 - March 2002**
 - ? Focus - safety issue of vessel and balance of reactor coolant pressure boundary due to wastage from boric acid corrosion
 - ? Boric acid in reactor coolant for reactivity control
- Spring 2002
 - ? Millstone identifies part through-wall cracks in VHPs (moderate susceptibility plant)



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Bulletin 2002-02

- **NRC issues Bulletin 2002-02 - August 2002**

- ? Focus is adequacy of inspection programs
 - methods (non-visual NDE for high susceptibility) and frequency

- ? Licensee responses generally vague on future program, many cite MRP-75 program



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Bulletin 2002-02

- Fall 2002
 - ? North Anna 2 identifies
 - Prevalent weld cracking & leak from a repaired nozzle
 - Circ cracking at weld root without boron deposits
 - ? ANO Unit 1 identifies leak from a repaired nozzle
 - ? Oconee Unit 2 identifies possible through-wall cracking without boron deposits on RPV head
 - ? Head corrosion at Sequoyah Unit 2 - above head boron source



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NRC Order EA-03-009

- **NRC issues Order EA-03-009 - Feb 2003**
 - ? Mandates inspections for all PWRs
- Regulatory Basis for orders: Adequate Protection
 - ? ASME Code inspections are inadequate
 - ? Code revisions to inspection requirements are not imminent
 - ? RPV head degradation and nozzle cracking pose safety risks if not promptly identified, corrected
 - ? Provides a clear regulatory framework



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Order Requirements

- Evaluate susceptibility - effective degradation years (EDY), based on operating temperature and time
- High plants - bare metal visual AND non-visual NDE at EVERY RFO
- Moderate plants - BMV and non-visual NDE at alternating RFOs
- Low plants - BMV by next 2 RFOs (repeat every 3rd RFO or 5 years), non-visual by 2008 (repeat every 4th RFO or 7 years)



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Order Requirements

- Non-visual NDE is either:
 - ? Ultrasonic with evaluation of interference fit leakage, or
 - ? Wetted-surface examination
- Each RFO must perform visual inspections to identify boric acid leaks from components above the RPV head



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Order Requirements

- Flaw evaluation per NRC guidance
- Orders also apply to new RPV heads, either Alloy 600 (Davis-Besse) or Alloy 690 (North Anna 2 and many others)
- Post-outage report 60 days after restart



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Licensee Options under Order

- Requests for relaxation for specific VHP nozzles will be evaluated based on:
 - ? the proposed alternative will provide an acceptable level of quality and safety
 - ? compliance would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety



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Need for Order

- Licensees were placing heavy reliance on BMV
- Bulletins a one time inspection commitment
- Rulemaking would have taken at least 2 years
- Orders can be revised or rescinded as necessary
- Concerns that above RPV head leakage could result in undetected RPV head degradation



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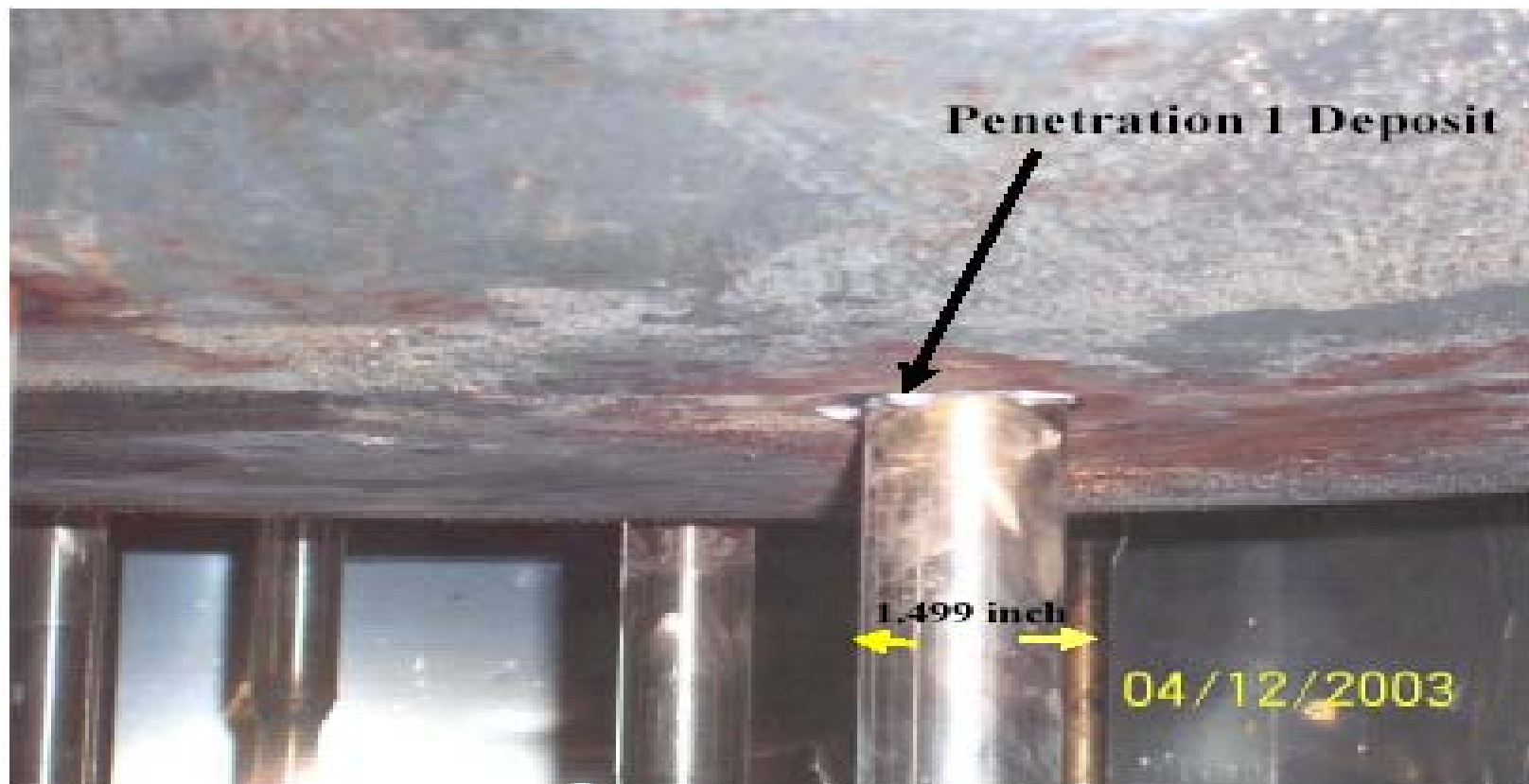
Vessel Lower Head Inspections

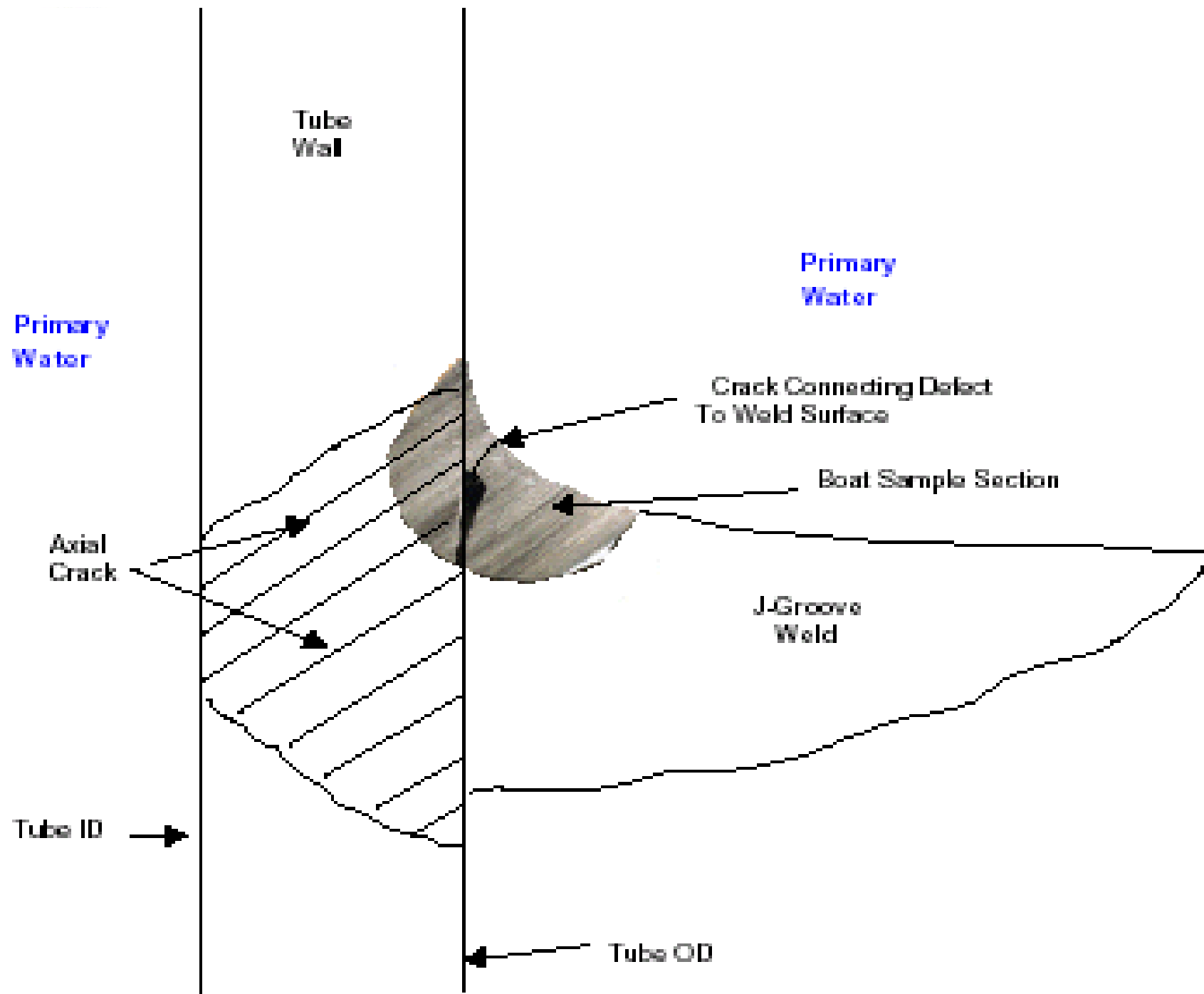
- South Texas Unit 1 - boron deposits on two lower head penetrations in Apr 2003 outage
- Boron deposits observed during bare metal visual exams performed by licensee
- Visual exams were beyond Code requirement
- Cracking attributed to PWSCC
 - ? initiation site believed to have been associated with fabrication



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Vessel Lower Head Inspections







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Bulletin 2003-02

- **NRC issues Bulletin 2003-02 - August 2003**
 - ? Focus is inspections of bottom head Alloy 600 nozzles of PWRs
- Inspections at 23/69 plants to date have not identified further leaking penetrations



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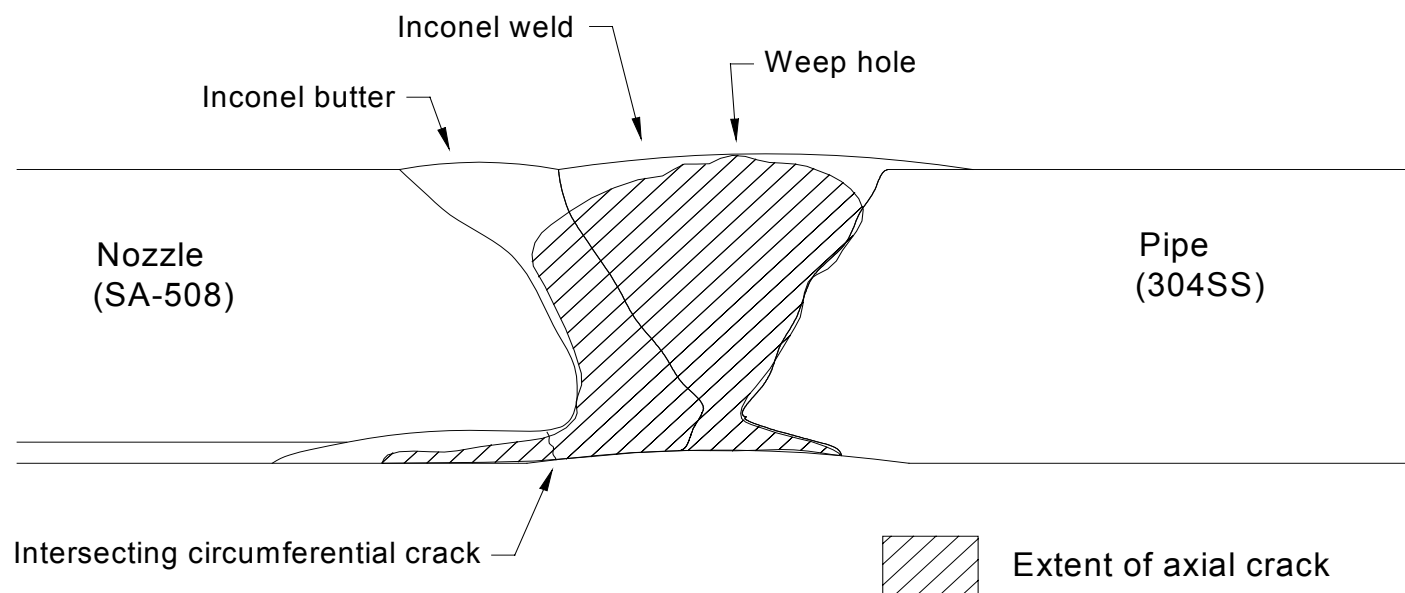
Pipe Crack at V.C. Summer

- PWR Westinghouse 3 loop
- Commercial operation Jan. 1984
- October 2000 boric acid deposits identified during refueling outage
- Confirmed an axial crack in the A hot leg in 182/82 weld metal to but not through base metal in a repaired area



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V.C. Summer A Hot Leg Weld





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Dissimilar Metal Pipe Welds

In addition to through-wall flaws in DM pipe welds at V.C. Summer

- Part-through axial flaws found at TMI-1
- 10" nozzle-to-safe end surge line hot leg weld
- 0.48" in depth from ID surface, believe wholly contained within the Inconel butter & weld
- No length-sizing was performed
- Weld overlay repair



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Dissimilar Metal Pipe Welds





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Dissimilar Metal Pipe Welds

- TMI-1 surge line flaw concluded to be PWSCC
- PWSCC becoming increasingly common in Alloy 600/82/182 materials
- ASME Code inspection requirements for dissimilar metal welds generally insufficient
- NRC staff considering another bulletin



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Pressurizer Heater Sleeve Cracking

- Heater sleeve cracking has been observed in CE units since the late 1980s
- Industry relying on visual examinations to identify degradation prior to gross rupture
- NDE at Palo Verde 2 in Fall 2003 showed thru-wall circ indications in non-pressure boundary portion of 5 sleeves
- NRC staff considering another bulletin



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Outlook/Regulatory Options

- Goal - “permanent” requirements for inspections to ensure integrity of reactor coolant pressure boundary
- Options include
 - ? Additional regulatory actions – GLs, BLs, orders
 - ? ASME Code revisions
 - ? New NRC rulemaking
- In interim, NRC likely to continue to issue bulletins and orders