ENCLOSURE 2.B

Leak Path Assessment NRR Update,
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Leak Path Assessment NRR Update

11/24/2008

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Presentation Layout

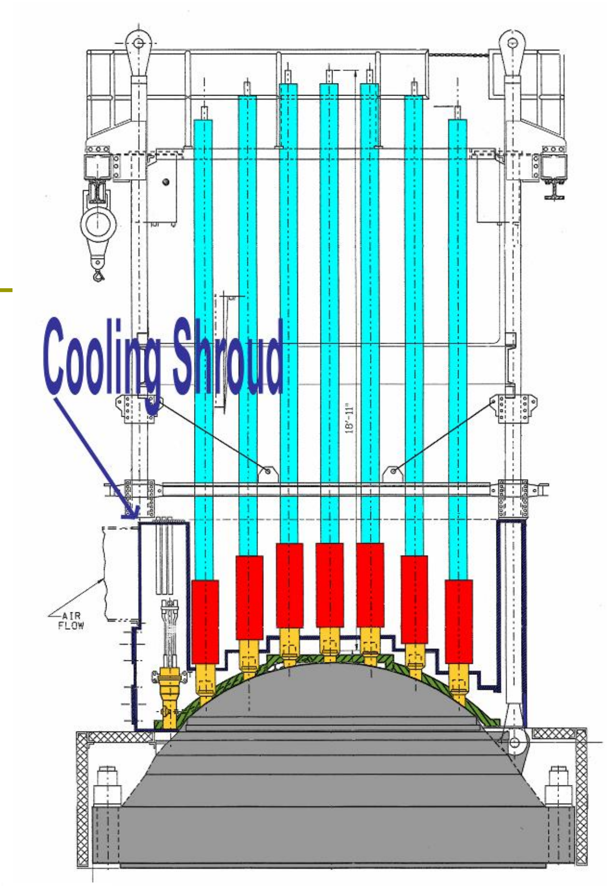
- Purpose of Meeting
- Intro & Inspection Requirement
- Leak Path Demonstration
- Conclusion

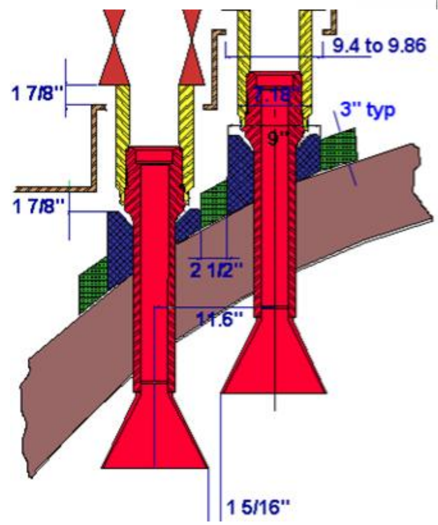
Meeting Purpose

- 10-30-2008 Entergy/NRR conference call
  - NRR response regarding leak path assessment
    - "... because the term "demonstrated" is not specifically defined or described, that it is the responsibility of the licensee to manage this process under the provisions of their 10CFR50, Appendix B Quality Assurance Program and be able to show the adequacy of what has been performed"
    - "... if additional information is available that adds rigor to prove the effectiveness of current techniques, that this may be adequate to meet the term demonstrated"
- Update NRC staff on current body of information supporting continued use of UT Leak Path (UTLP) assessment as defense in depth exam

Why Leak Path?

- Bulletin BL-2001-01 required bare metal visual examinations
- BMV was not possible for some plants
  - Due to close fitting insulation and shroud
  - All plants insulation now modified
- UTLP inspection performed in lieu of BMV
- Some penetrations masked with boron
  - Baseline exams have been performed and heads cleaned as needed to satisfy the Order
- Both vendors internally demonstrated UTLP





Current Examination Requirement

- 10CFR50.55a RPV CRDM Nozzle
  - Volumetric exam per ASME CC N-729-1 as modified by the rule
  - Demonstrated volumetric or surface leak path assessment through all J-groove welds
  - Per 10CFR 50.55a - Leak path assessment adds defense in-depth

Leak Path Technical Basis

- Original deployment
  - Vendor internal development and demonstration programs
- Current application
  - Original vendor demonstrations
  - Significant field inspection experience
  - Lab & field DE results
  - Ø Solid basis to evaluate UTLP effectiveness over time

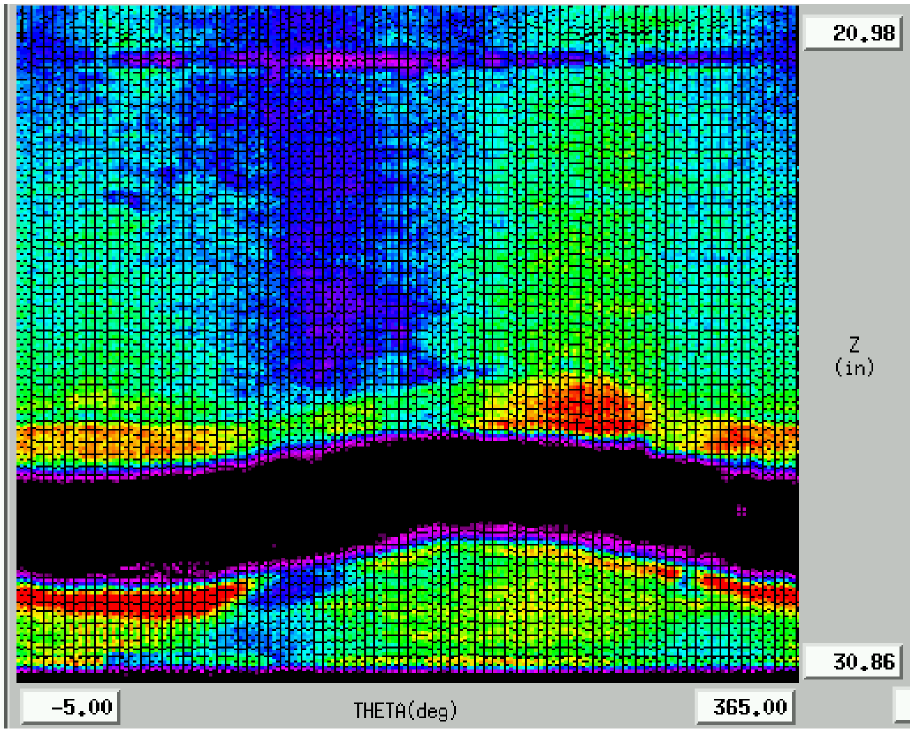
- UTLP - proven effective in field examinations

Leak Path Demonstration

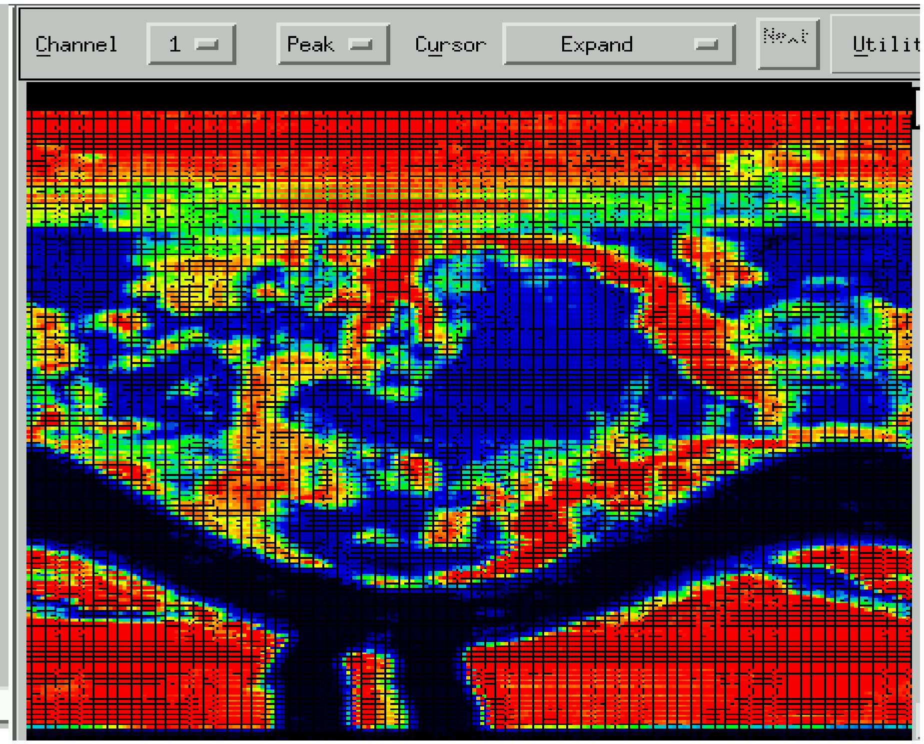
CRDM Leak Path Basis

- UT theory for leak path assessment
  - Changes in acoustic impedance at the nozzle backwall can be detected with UT processes
  - Boron deposits and erosion/corrosion of RV head at the interference fit causes acoustic impedance changes
  - By measuring these changes it can be determined if the nozzle is leaking regardless of crack location
  - C-scan plots of the nozzle backwall are used to map the leak path

Leak Path Detection: Typical Response for Normal Interference Fit vs Leak Path



Typical response for a non-leaking nozzle



Crack at the low hillside with leak path

CRDM Leak Path Basis

Theory is demonstrated with actual field data

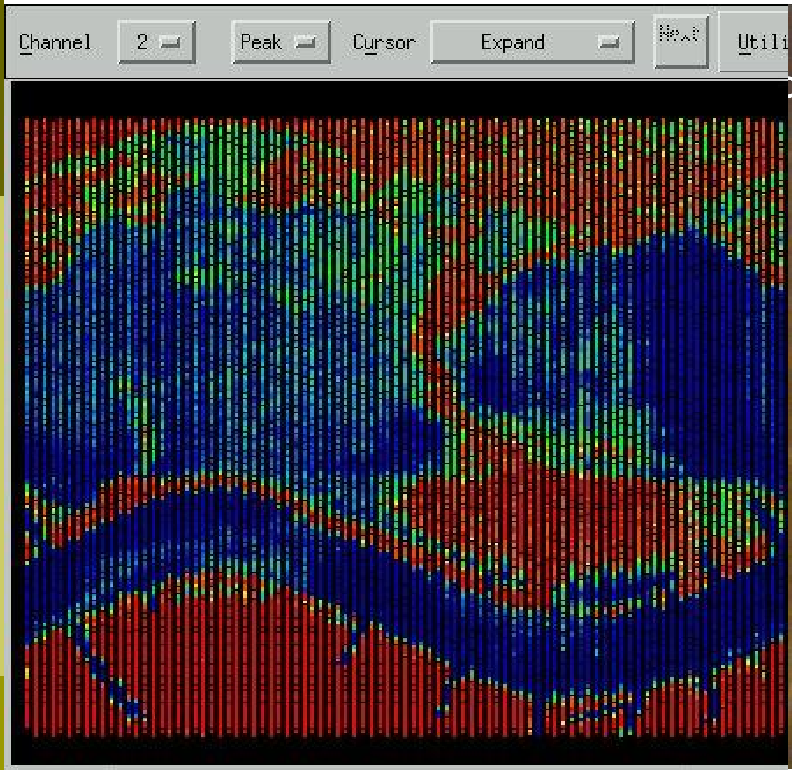
- Data obtained during development of UTLP *
  - 8 operating plants (targeted inspections)
  - 163 nozzles examined with volumetric UT
  - 185 flaws detected and characterized with UT
  - Examinations included UT, ET, PT, BMV
  - Destructive evaluation/correlation provided during repair operations (and later DT results from PNNL)
  - Detailed docketed reports by both vendors demonstrating leak path
  - Relevant parameters were extracted from data and included in UT procedure for leak path assessment

* Numbers are subject to verification

Original NDE Experience that Developed & Demonstrated the Leak Path Assessment Effectively Detects Leakage

Plant	Outage	# Nozzles With Visual Leakage	Flaw Location	# Nozzles with UT Leak Path Detected
A	2001	9	Nozzle	9
B	2001	4	Nozzle	4
C	2001	1	Nozzle	1
D	2001	2	Weld	2
E	2001	2	Weld	3
F	2001	5	Nozzle	5
G	2002	6	Weld	5
H	2004	1	Weld	1

Leak Path Between the Vessel Head and CRDM Nozzle



UTLP signature

Visual confirmation during repair

CRDM Leak Path Basis

- Has been incorporated into examination procedures and has been used since 2002
- Process is supported by ET, PT and VT examination results and by both DE results from North Anna 2 removed nozzles and observations made during field repair process using Inside Diameter Temper Bead (IDTB) repair.

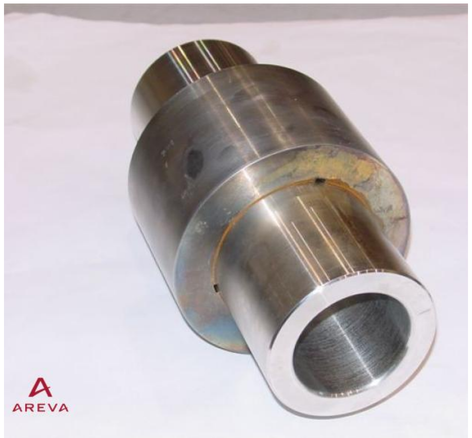
AREVA and Westinghouse Field Data

- 3 missed by UTLP but found with BMV
  - AREVA - 2 nozzles
    - UT clean, no leak path signature – nozzle repaired
    - No wastage observed during repair
  - Westinghouse
    - UTLP data saturated (procedure was later modified based on OE to resolve this potential challenge)
- 3 with UTLP signature were not evident by BMV
  - AREVA - 2 with no UT indications in nozzle, but leak path signature and PT indications reported in the weld
  - AREVA - 1 with masked leakage from above, no UT indications in nozzle, but leak path signature and confirmed PT linear

  (Westinghouse had a similar experience with an incipient leak displaying a “reverse river bed”)

UTLP Mockups

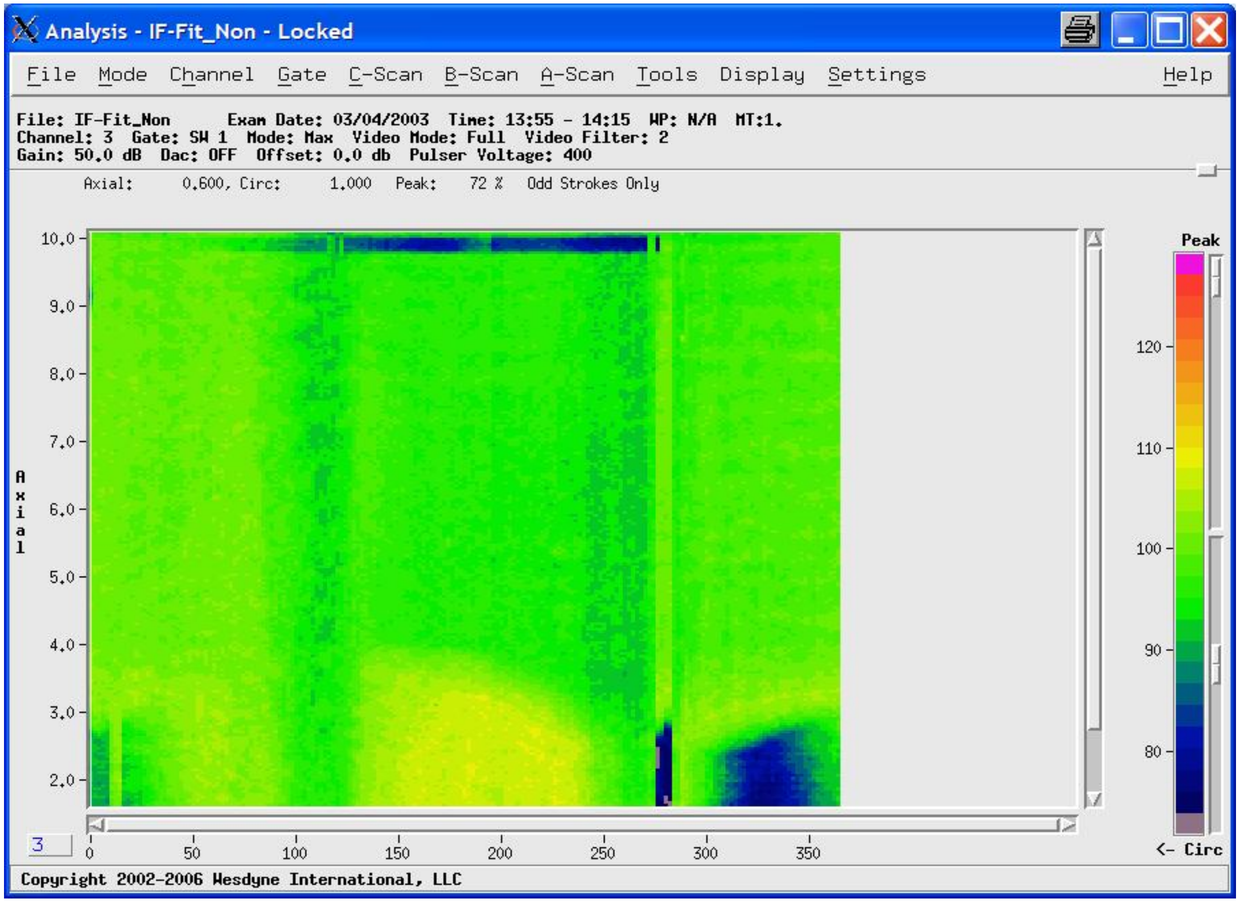
- 3 mockups built
  - One with slip fit (0-0.5 mil interference)
    - 1/8” and 1/16” wide channels made (dremel tool)
    - Coarse machining done for “worst case”
  - One with 2 mil shrink fit
    - 1/8” and 1/16” wide channels made (dremel tool)
    - Coarse machining done for “worst case”
  - One with 5 mil shrink fit
    - 3 grooved EDM
    - 0.25” width X 3.75”



UTLP Mockup Test Results

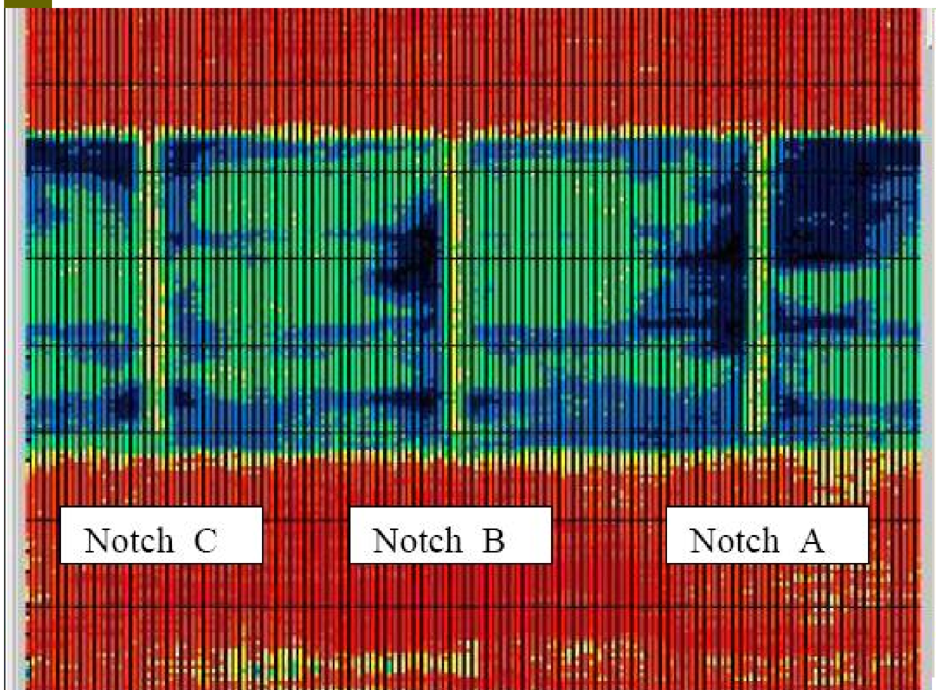
- Slip Fit (0-0.5 mil interference)
  - As expected for the slip fit mockup, no UTLP signature was detected
- Shrink Fit
  - Shrink fit mockups: UT detected >1/8” wide
  - Shrink fit mockups: Approximately 50% of 1/16” channel detected

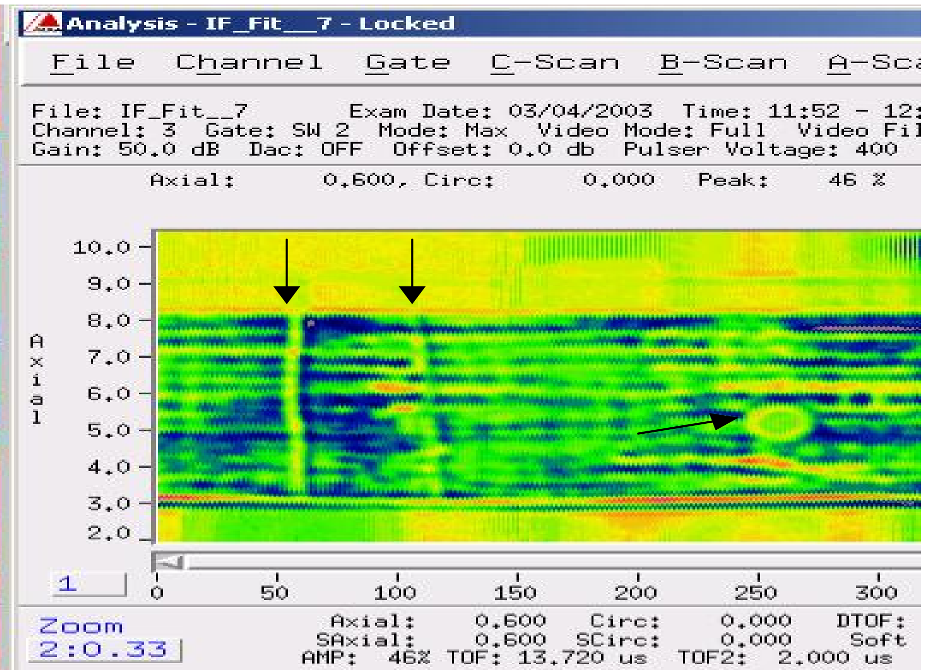
C Scan Slip Fit (0-0.5 mil interference)



1/8” and 1/16” grooves were not detected

C-Scan 5 and 2 mil Interference Fit





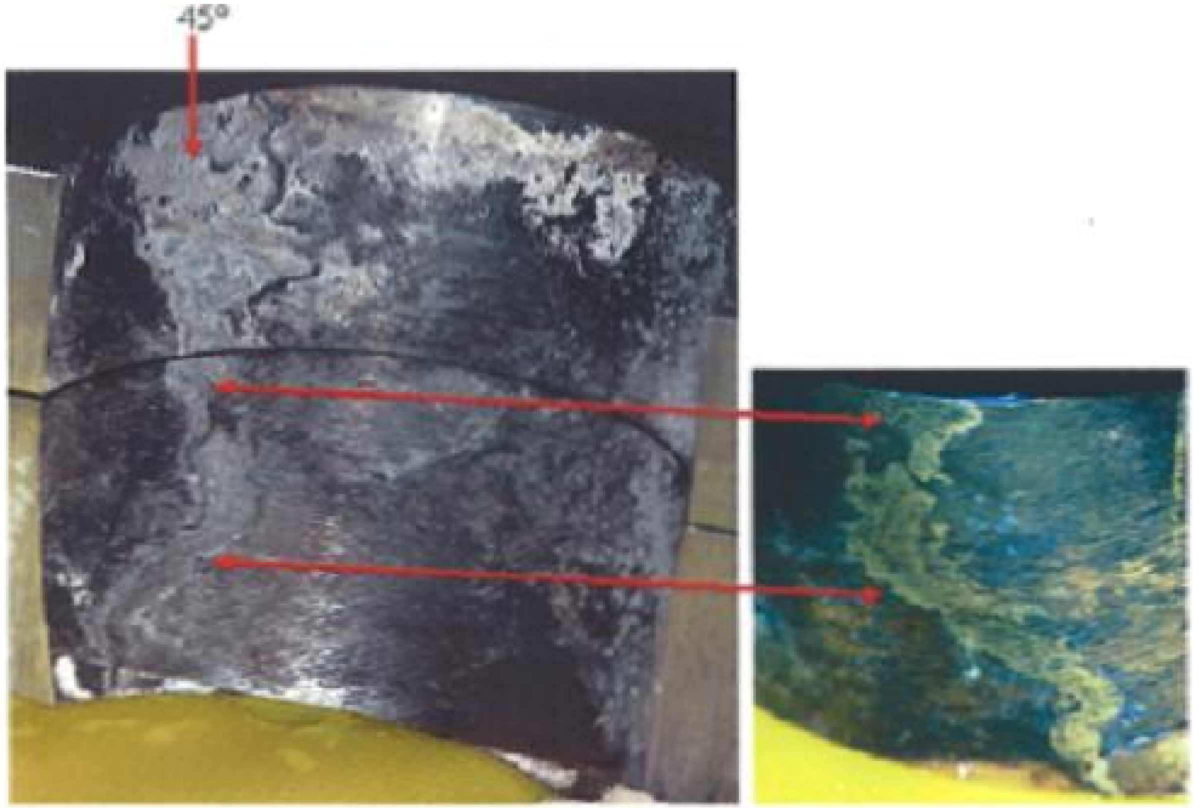
5 mil shrink fit
3 grooved EDM
0.25” width X 3.75”

2 mil shrink fit
1/8” and 1/16” grooves
coarse machining done
for “worst case”

Three Additional Scenarios

- “Open” annulus (during operation)
  - Creates a steam cut path
  - No UTLP detection, BMV detection
- “Tight” annulus (early stage of leakage)
  - UTLP detectable, potentially no BMV detection
- “Tight” annulus (later stage of leakage)
  - Compacts boron
  - Washes away a riverbed path
  - UTLP and BMV detectable

Open Annulus (from PNNL results)



Carbon Steel Annulus ID   Penetration Tube OD

Figure 2: Mirror-image damage to the carbon steel annulus and a section of the Alloy 600 penetration tube. The wetted surface is towards the top of the samples.

- Did not detect with UTLP but was detected with BMV

Open Annulus (from PNNL results)

- Minor steam cutting observed
  - Less than depth of bore machining marks imprinted onto the A600 nozzle
  - Same metal loss on both the carbon steel surface and the A600 nozzle surface
    - Therefore, leak path was not boric acid wastage
  - No UTLP detection
  - “Popcorn” observed on the head

Open Annulus (from PNNL results)

- Field and lab UT data
- No UT leak path observed in this region

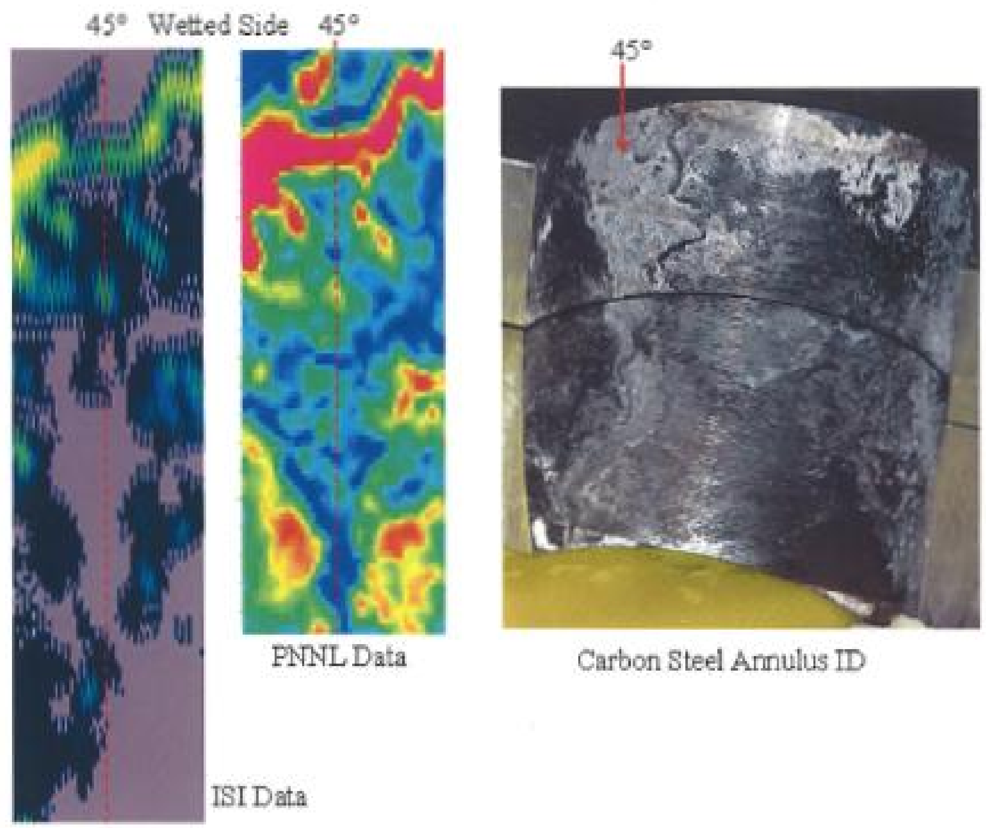


Figure 10: A comparison of the UT data and the apparent wastage of the carbon steel near 45 degrees.

Tight Annulus with “riverbed” (from PNNL results)

- Field data shows clear riverbed effect
- Initiation point aligns at the triple point with the throughwall crack in weld
- Boron acts as UT couplant reducing backwall response
- Both Westinghouse and AREVA scans match

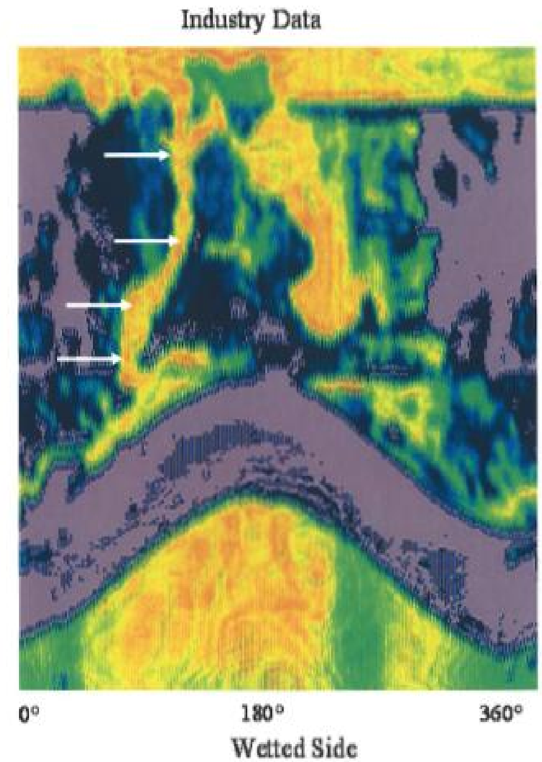
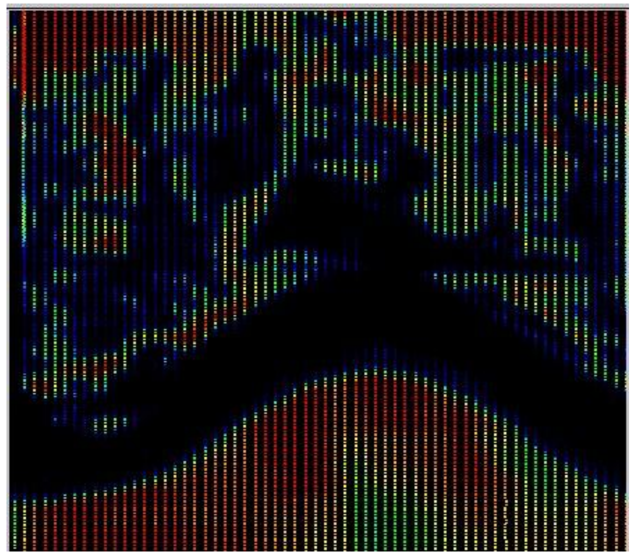


Figure 7: Industry-acquired ISI data taken to detect and characterize the presence of any leakage path in Nozzle 31. The alleged leakage path is shown with the white arrows.



Tight Annulus with "riverbed" (from PNNL results)

- UTLP maps presence/absence of compacted boron entrapped in the annulus
- No wastage, water flow beach marks evident

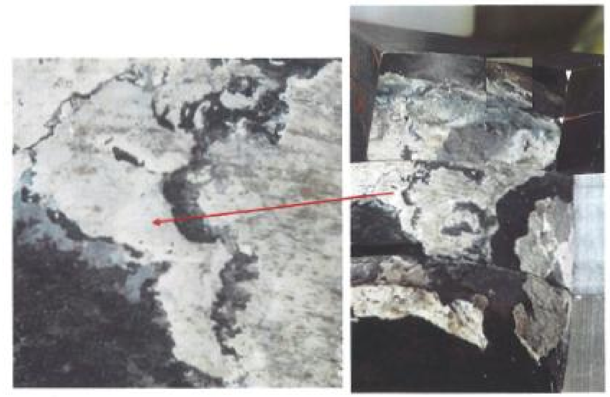


Figure 5: Enlarged region showing damage to the metal in the boric acid-filled region.

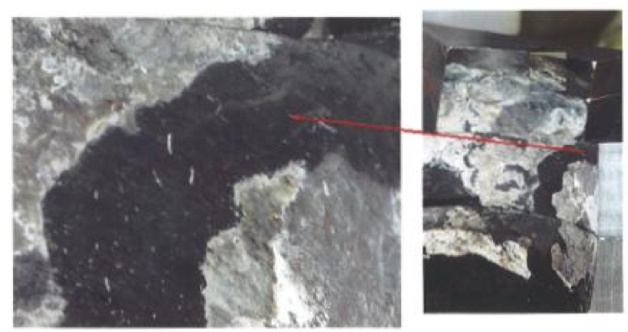
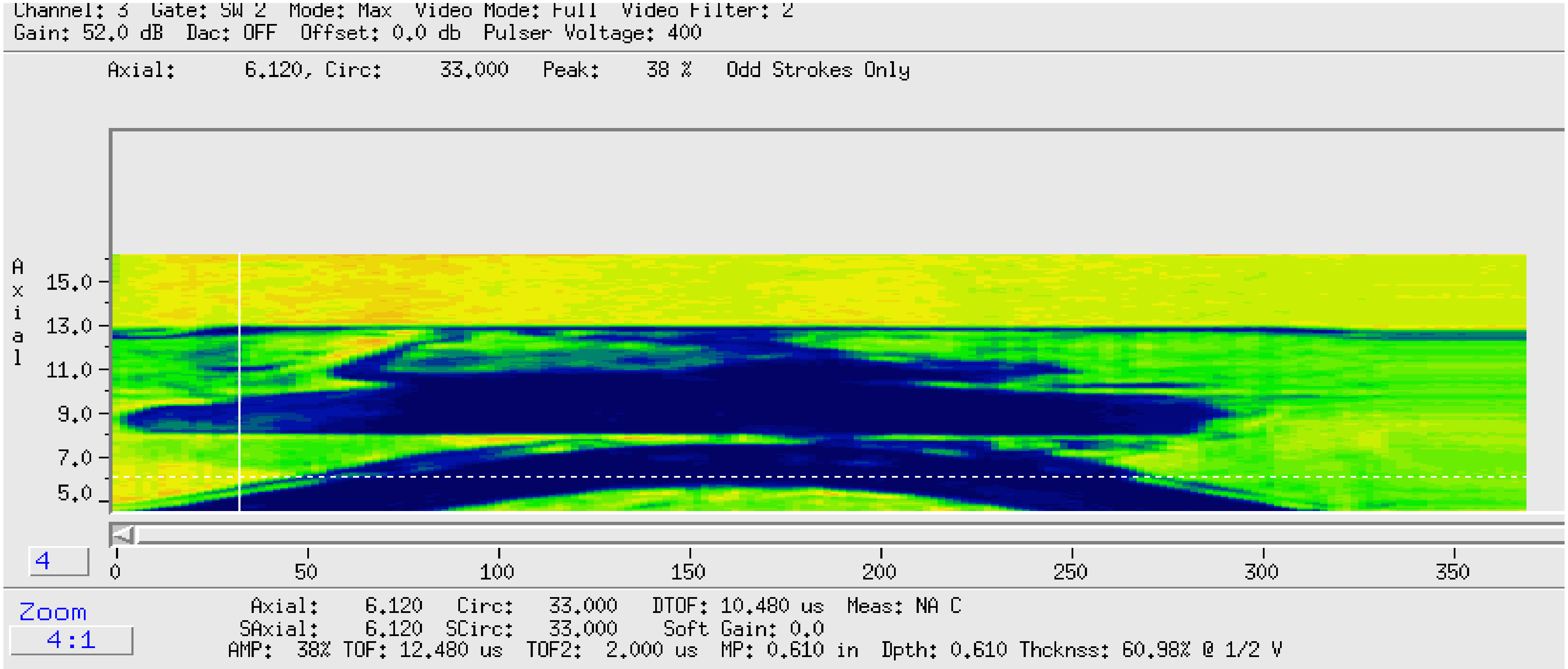


Figure 6: Image showing apparent water flow damage in the "clean" region of the annulus.

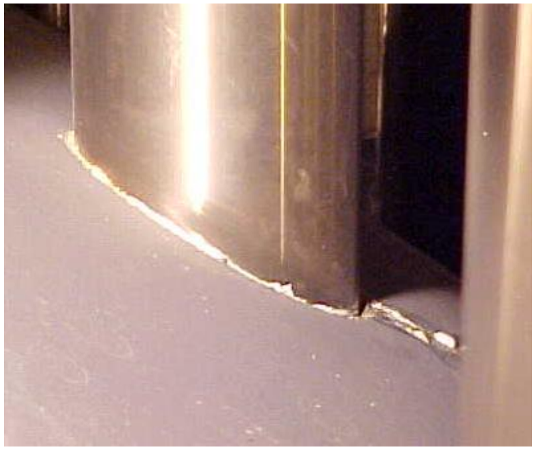
Tight Annulus w/o washed out "riverbed"



Low Amplitude (Reverse) Response

Tight Annulus w/o washed out “riverbed”

- Early stage of leakage
- Detected with BMV
- Crack in weld, no damage to nozzle
- UTLP detected with reduced amplitude riverbed at triple point aligned with weld crack
- Weld crack confirmed by ET, field surface replication and He leak test



Destructive Testing Results vs Leak Path

- Four nozzles removed from North Anna 2 were examined at PNNL
- One nozzle from foreign plant with UTLP detection had in situ metallography and He leak testing
- UT Results
  - UTLP and BMV agreed on all five; 3 leaking-2 not leaking
  - Three confirmed leakers had UTLP response
    - One had the normal high amplitude riverbed response, two had the low amplitude response
    - Analysis procedures modified to add the low amplitude response after PNNL data was available in 2008

Inspection Process for Leak Path

- Leak path inspection process
  - Ensure adequate coverage above J-groove weld is displayed
  - Ensure backwall signal is not saturated
  - Adjust color palette for maximum contrast
  - Analyze for "*meandering*" pattern of contrasting amplitude extending from triple point to top of the interference fit
  - If UTLP detected, look for crack in penetration wall or use additional NDE (e.g., PT, ET, etc.) To confirm crack location within J-groove weld

Current Industry Status

- Initial baseline inspection of ~5000 CRDM/CEDM nozzles for all units
  - Changes in baseline can be used to detect leak path
- All heads cleaned as needed, insulation modified, and access openings provided for qualified BMV
  - Capability to detect small leakage
- Several units have repeated inspections
- Since 2003 ~6000 Inspections with ZERO operational leaks

Conclusion

- Large body of data from plant examinations, mock-up data, and destructive test data demonstrates UTLP is effective
- Combination of vendor demonstrated UTLP and BMV provides defense in depth, overall a very good correlation between UTLP and BMV
- Baseline data is now available for all nozzles for comparison of changes making leak path easier to detect
- All leak path processes are documented in procedures and technical justifications and have been used for over 6 years
- Data analyst training for UTLP detection is provided by both vendors

Position on Leak Path Assessment Requirements

- Vendor demonstrated UT leak path assessment combined with BMV of the head surface provides a defense-in-depth method to ensure reactor coolant pressure boundary integrity through the J-groove weld.
- Spring 2009 plants have reviewed the available demonstration data and determined it meets the intent of the 10CFR 50.55a rule

Position on Leak Path Assessment Requirements

- It is spring 2009 plants understanding, based on previous discussions, that a specific relief request may not be required for the demonstration of UTLP
- There is merit in further pursuit of the Regulator's acceptance of this information as meeting the requirement for a demonstrated leak path process

Position on Leak Path Assessment Requirements

- The PWROG and MRP organizations accept the responsibility for development of this information and subsequent presentation to the Regulator.