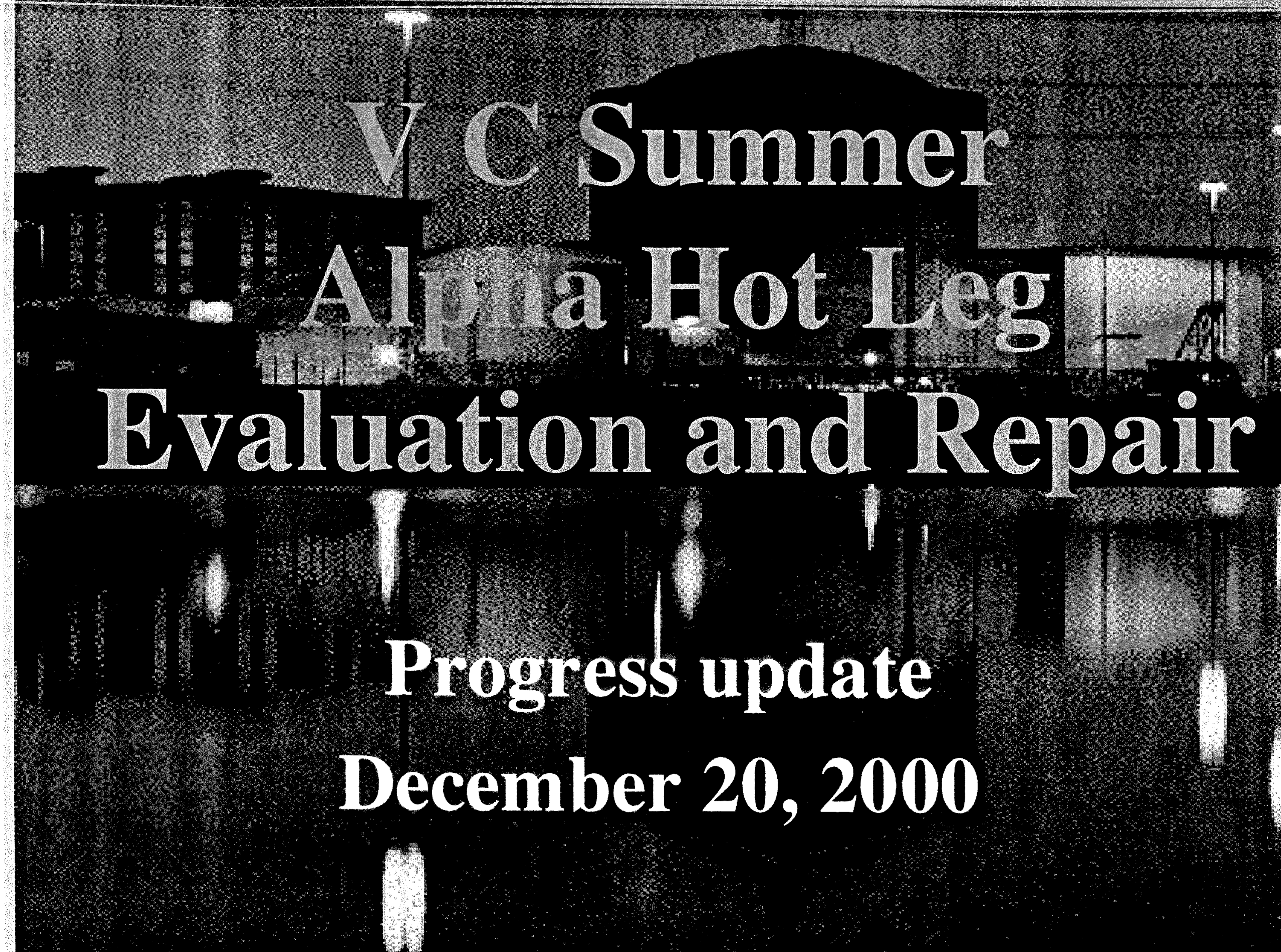
V C Summer
Alpha Hot Leg
Evaluation and Repair
Progress update
December 20, 2000

Enclosure 2

V. C. SUMMER NUCLEAR STATION
Alpha Hot Leg
Evaluation and Repair

Progress report to NRC RII
12-20-2000

Agenda

• Introductions	S. Byrne
• A Hot Leg Disposition & Extent of Condition	G. Halnon
• NDE & Generic Issues	B. Waselus
• Path Forward	M. Browne
• Summary	G. Halnon

Summary of Significant Hot Cell Results

- Crack followed interdentritic morphology
- Hot cracking in weld suggested by micro-fissuring
- Circumferential crack found intersecting main axial crack initiated in cladding and progressed to CS interface
- No cracking of carbon steel, minor wastage at boundary
- No cracking of SS pipe, some minor cracking in HAZ
- Only exit of main crack was through weep hole

Summary of Significant Hot Cell Results

- Alloy 82 was predominate deposit in the weld
- A few ET indications could not be confirmed with destructive examinations
- One ET indication was subsurface, iron-rich compound.
- Three extremely small, shallow indications were found by PT and visually were not seen by ET
- Original 4" crack found by PT was determined to be acid cutting.

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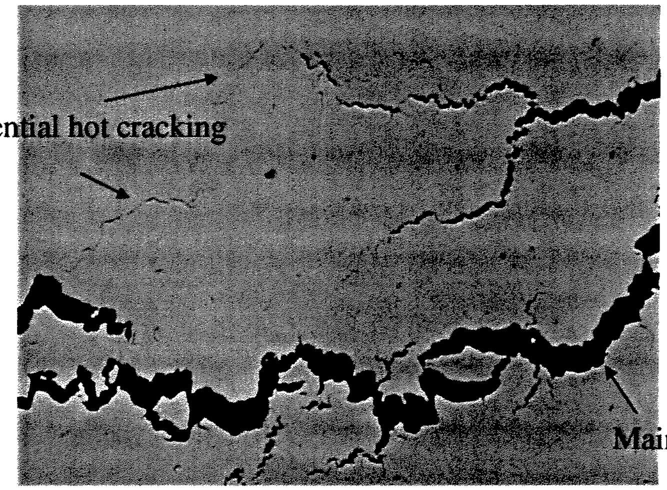
Morphology of Crack 25X



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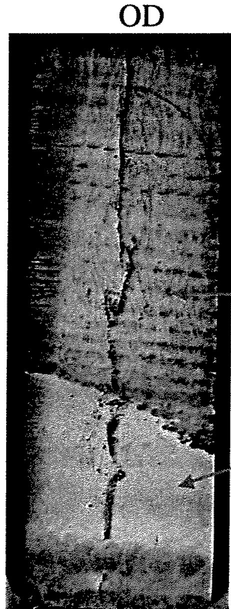
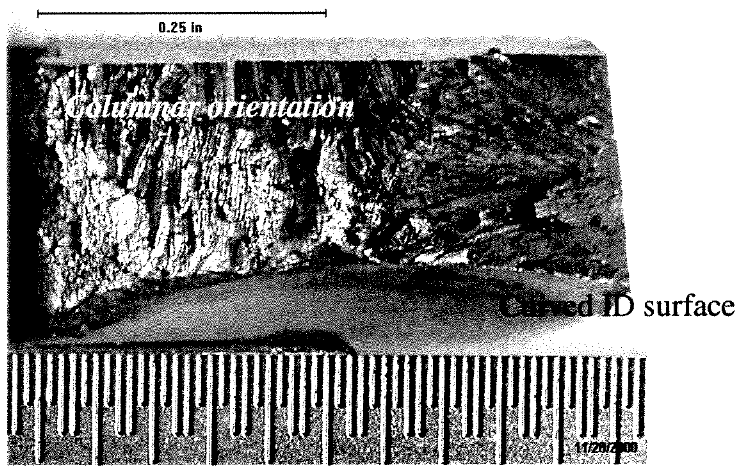
Cross Section of Weld

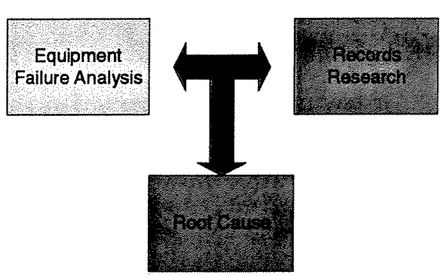


Interdentritic Morphology



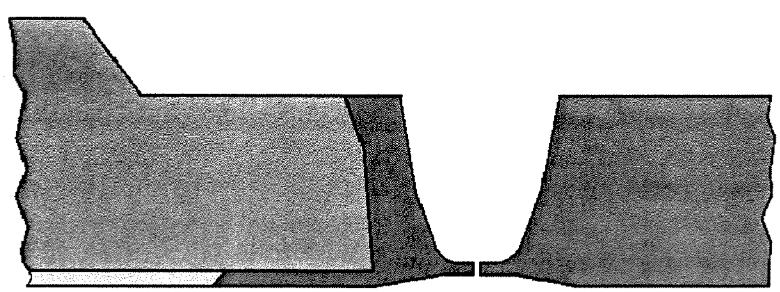
Root Cause

- Equipment Failure Analysis
  - Crack Initiation
  - Crack Propagation
  - Organizational and Programmatic Effects

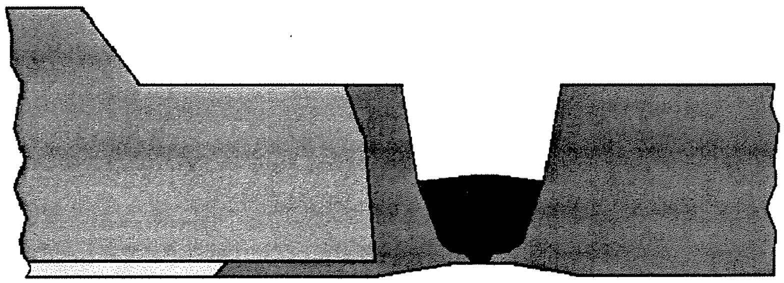


Primary Root Cause

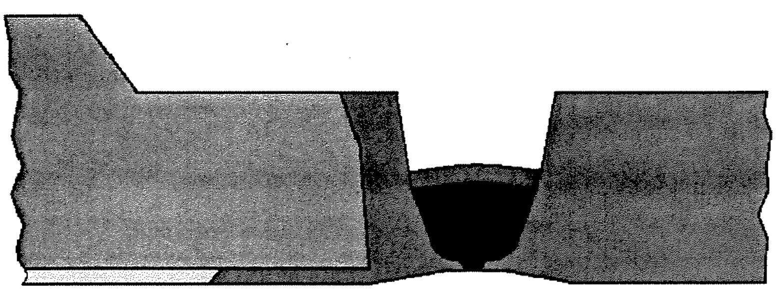
The construction weld process of grinding out the inside of the weld with a bridge pass on the VC Summer reactor vessel "A" hot leg nozzle to pipe weld created high welding residual stresses in a material (Alloy 182/82) and in an environment known to cause Pressurized Water Stress Corrosion Cracking (PWSCC).



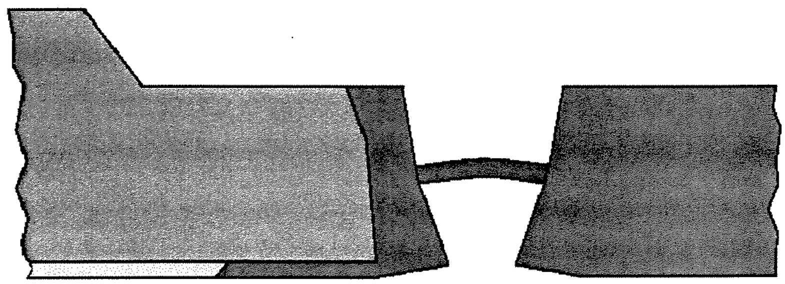
This is the start of the original weld it was designed to be filled from the ID out toward the OD



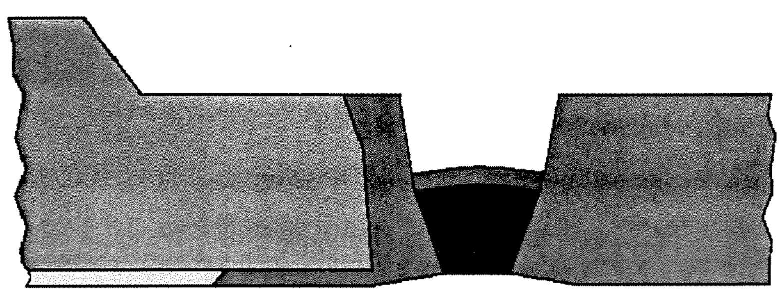
The first pass was made per design but rejected



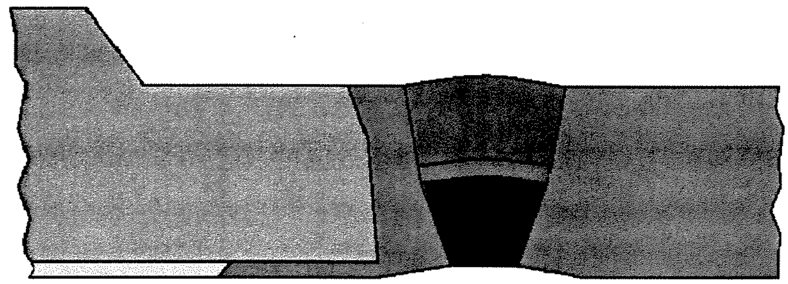
A bridge was laid in to stabilize the pipe



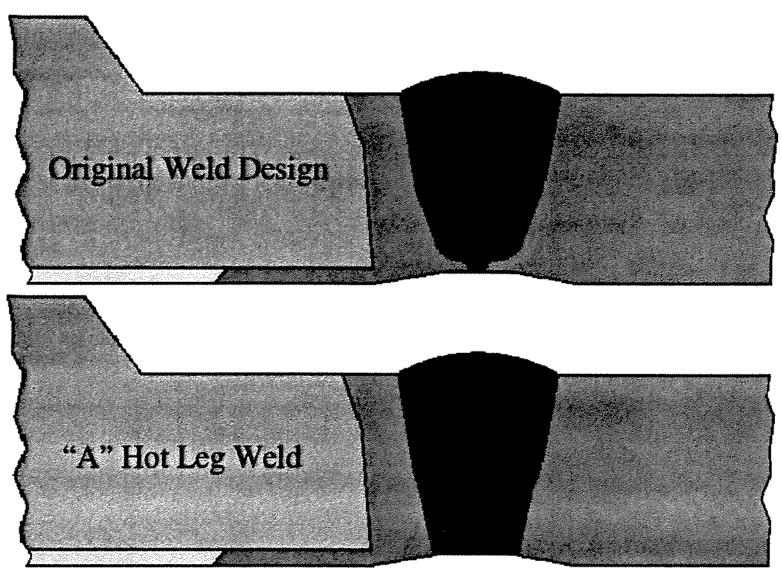
The rejected area was removed



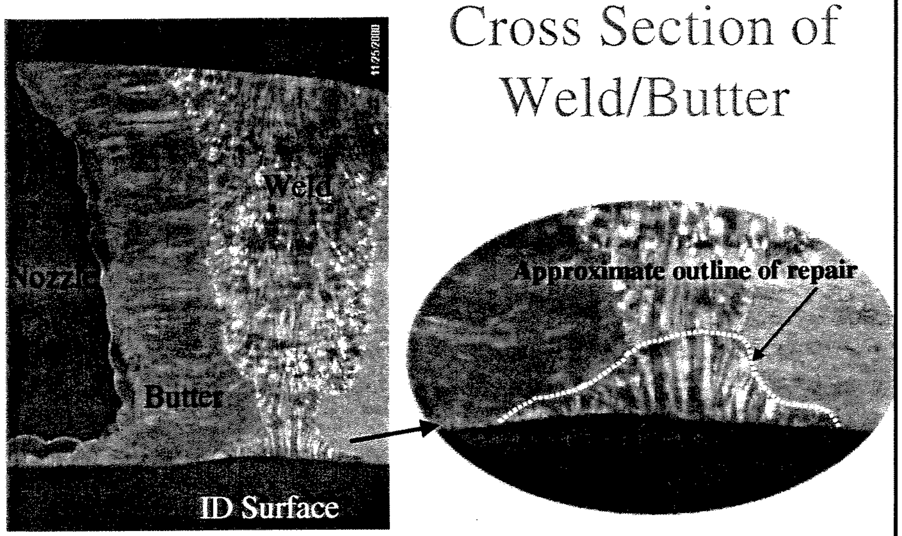
Weld was reapplied from the ID to the bridge



The weld was then completed from the bridge to the OD



Cross Section of Weld/Butter



Supporting Failure Analysis

- Crack Initiation
  - Pressurized Water Stress Corrosion Cracking from high residual stresses
    - Metallurgical investigations
    - Review of construction weld history
    - Finite element analysis-2D
    - Similarities with Ringhals
- Crack Propagation
  - PWSCC
  - Assisted by Hot Cracking and residual stresses in weld

Summary of Root Cause Effort

- Root Cause team composition
- Considered 22 unique modes of crack initiation
  - Refuted 18
  - Supported 4
    - Extensive repairs, grind out of entire ID
    - Performance of Inconel
    - Opportunities to detect
    - PWSCC

Summary of Root Cause

- Considered 13 modes of crack propagation
  - Refuted 10
  - Supported 3
    - PWSCC
    - Hot cracking
    - Extensive repairs
- Considered 11 Organizational/ Programmatic
  - Refuted 8
  - Supported 3
    - As-welded buttered design
    - Acceptance Standards of NDE process
    - Qualification of welding process

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Extent of Condition

- A Hot Leg weld is unique
  - Weld repairs on other legs were local in nature
  - Original weld joint configuration maintained
  - 2-D FEA generally confirms higher stresses for as welded configuration
  - Ringhals double-V weld joint design supports higher frequency of stress corrosion cracking
- Cold legs are of much lower temperature
  - much less favorable for crack initiation

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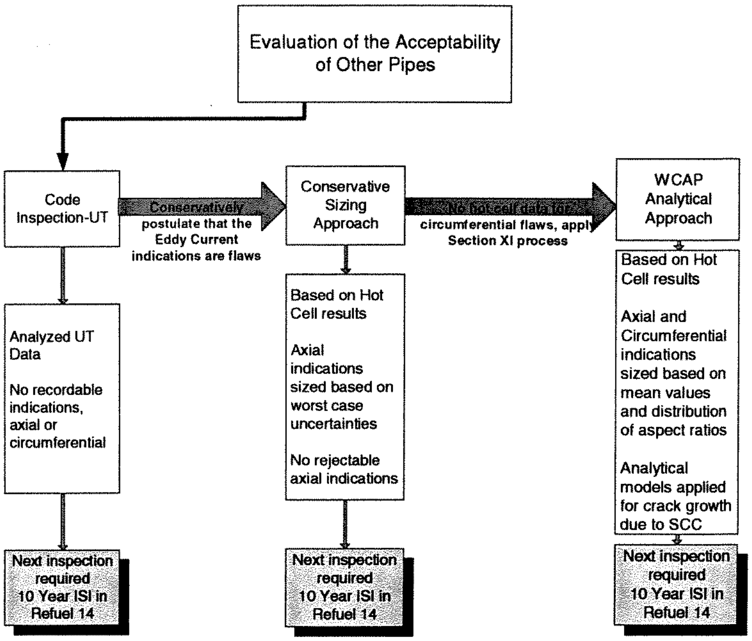
Extent of Condition

- Question: Are the other 5 pipes affected?
- Performed code UT inspection from ID
  - No code recordable indications in other pipes
- Performed eddy current
  - Data in some areas needs evaluation and resolution
    - 2 axial indications in B Hot Leg
    - Circ indications, 1 in each leg except B cold leg



Analytical Approach

- WCAP 15615, Integrity Evaluation for Future Operation Virgil C. Summer Nuclear Plant: Reactor Vessel Nozzle to Pipe Weld Regions
  - Axial Flaw: B Hot Leg; 3.2 years to grow to 75% through wall
  - Circ Flaw: B/C Hot Legs; 3.4 years to grow to 75% through wall
  - Other indications are in Cold Legs and not of concern for the short term
- Results of all three approaches conservatively support operability for at least two cycles of operation (actual operation time: less than 3 years)

NDE and Generic Issues

Bob Waselus
Acting General Manager Strategic Planning

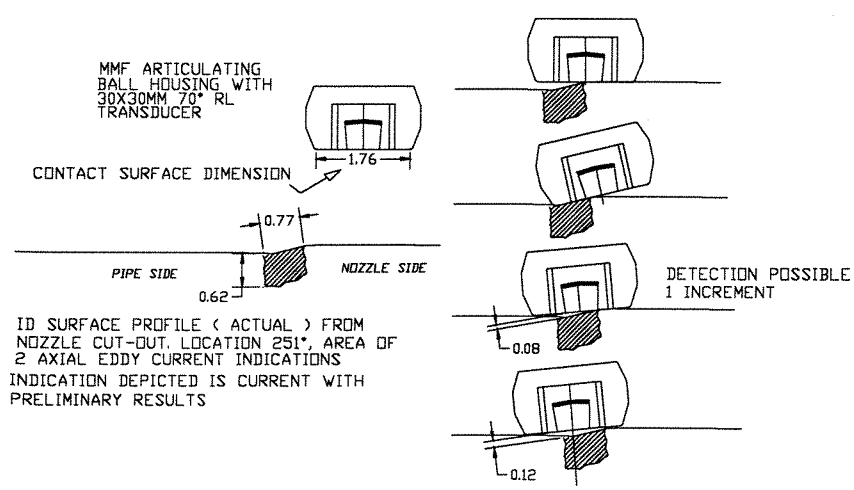
UT Examination Techniques

- UT in 1993 utilized latest available technology.
- UT used in 2000
  - **Accepted by the Code and NRC**
  - **Standard methodology used in industry**
  - **Performance demonstration performed as will be required by the 2002 PDI**
  - **Electric Power Research Institute (EPRI) Non Destructive Examination (NDE) Center participation.**

Points About UT

- "A" Hot Leg Indication (through wall)
  - Was seen and characterized by UT
- The next most significant "A" Hot Leg Indication was not detected.
  - Was initially not seen by UT because:
    - Surface irregularity
    - Orientation and shape of indication
    - Threshold of detection
  - Upon comparison with ET data
    - Indication was noted, but characterized as a non relevant indication
    - RT at Spartanburg, with essentially no background radiation, could see a faint indication, but was not called

Detection Analysis



V.C. SUMER NOZZLE CUT-OUT SECTION AT 251°
UT PROBE ORIENTATION ALONG SURFACE GEOMETRY

Conclusion

- **Irregular surface geometry in area of interest is acceptable for small footprint spring loaded eddy current probes but not flat enough for reliable UT detection using the qualified technique.**

Examination Techniques

- **ET used in 2000**
  - **First time application in this country**
  - **Not recognized by the Code for this application**
  - **Westdyne technology used for this exam**
    - **Plus Point Probes (2)**
    - **250 AND 150 kHz**
    - **No acceptance standard nor sizing capability was set due to the research nature**
  - **On site demo to show ability to detect surface indications under ideal conditions**

ET Examination Techniques

- **Why Eddy Current was performed:**
  - **To build on experience Ringhals had recently encountered**
  - **Assist in developing a full picture of condition of the welds**
  - **We recognized and discussed before starting the risk of not being able to fully explain our findings and that this was research**
  - **Believed it was the right thing to do.**

Points about ET

- Identified the through wall crack.
- Identified over, under, and false calls.
- Not 100% correlation with ID PT.
- Will need R&D to become a reliable and qualified method for this type application.

NRC Generic questions

- Are techniques other than UT appropriate for assessing the integrity of the nozzle to pipe weld? How should these techniques be qualified?
- What qualified UT techniques are used by industry ? Are they capable of assessing the type of flaw found at Summer.

Industry Generic Issues

- EPRI and WOG involved from start.
- NDE center provided continuous support.
- EPRI managed PWR Materials Reliability Project (MRP) will assume industry technical lead on generic issues.
- MRP will coordinate with Vendors, Consultants, Owners Groups and Utility experts.
- NEI will provide regulatory interface.

Industry Generic Issues

- Fleet Assessment (Like VIP-06)
- NDE Capability
- ISI Frequency
- Repair Strategies
- Mitigation Strategies

Industry Generic Issues

- Process has proactively started prior to regulatory action.
- NEI letter of 12-14-2000
- EPRI MRP is pursuing approval and funding.
- V C Summer, with the assistance of NEI, will host an industry briefing early in 2001.

The Path Forward

Mel Browne
Licensing Manager

End Point of This Effort

- Initial Meeting on 10/25…..
- Conclusion will be:
  - "A" Hot Leg is unique OR
  - Commonalties are addressed in other welds
- Plant will be safe for start up:
  - Pipe and weld(s) meet code requirements
  - Repair will bound probable failure scenarios

Operability Requirements

- Technical Specifications
  - Reactor coolant system leakage
    - No pressure boundary leakage
    - Code required pressure test performed prior to start-up.

Operability Requirements

- Technical Specifications
  - Structural Integrity
    - Pipe spool meets or exceeds original specifications
    - Weld repair meets all currently approved Code requirements
    - Weld filler material has improved corrosion resistance and is approved for use by relief request
    - Final inspection meets Code requirements

Other Licensing and Design Basis Considerations

Reactor Coolant System Leakage

- Leakage detection systems meet requirements of RG 1.45
  - Leakage resulting from stress assisted corrosion would demand rapid detection. Alarms at 0.5 to 1.0 GPM unidentified leakage provide acceptable performance.
- Hardware is supplemented by visual inspection
  - Visual inspections proven to be frequent enough to detect a SCC propagating through wall before it meets the 1 gpm threshold

Reactor Coolant System Leakage

- Program under engineering oversight
- Evaluation techniques
  - Radio-isotopic analysis of sumps
  - Radio-isotopic analysis of containment atmosphere
  - Chemical analysis of sumps
  - Analysis of other data

Reactor Coolant System Leakage

- Improvements to provide additional margin
  - Provide additional computer alarms to prompt evaluation
  - Provide additional displays to assist evaluation
  - Include additional detail in visual inspection procedures
  - Instill greater sensitivity to the possibility of pressure boundary leakage

Leak Before Break

- Evaluated in WCAP-15615
- Basic principles remain valid
- Predicts large factor of safety between onset of detectable leakage and critical flaw size
- Principles proven by actual circumstances
  - Leak was discovered visually, even before instrumentation threshold approached
  - Generous margin between actual leak and critical flaw size

Meeting Summary

Greg Halnon

General Manager Engineering Services

SCE&G

Summary

- Root Cause:
  - Weld repair caused high residual stresses which contributed to the existence of PWSCC.
- Corrective Action
  - Remove faulty weld from "A" and repair pipe to meet code requirements.

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Summary

- Extent of Condition
  - Reasonable assurance exists that the other nozzle welds in the RCS are acceptable, with margin for 2 years, 9 months until Refuel 14.
- Monitoring the effectiveness of corrective actions
  - Refuel 14 , Fall 2003 - Full 10 year ISI
  - Other testing when and as determined by MRP industry initiatives.
  - Re-evaluate conclusions after each inspection activity

Open Items

- Approve and Issue WCAP 15615, Integrity Evaluation for Future Operation Virgil C. Summer Nuclear Plant: Reactor Vessel Nozzle to Pipe Weld Regions
- Final ASME Section III acceptance of new welds
- ASME Section XI - ISI Baseline of new welds
  - OD Baseline this outage, if ID baseline done in future, both ID and OD UT will be performed to correlate
- Approve and issue Corrective Action documents*
  - Root Cause report
  - Boric Acid Deposit Disposition
  - Concrete Evaluation

*Includes safety committee reviews

Conclusion

End Point of the Outage will be:

- A Hot Leg returned to operable status
- Extent of condition actions bounds uncertainty in other pipes
- Meet licensing and design basis for instrumentation and LBB principles