

11/14

# ***Nuclear & Environmental Operations***

## ***Davis Besse Reactor Vessel Head Examination***



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# ***Completed Work Scope Items***

- Nozzle 2
  - Visual Inspections
  
- Nozzle 3
  - Visual Inspections / Penetrant Test on OD
  - Sectioning (1" and 2.5" rings)
  - Penetrant Test on 1" ring
  - Ship 2.5" Ring to ANL



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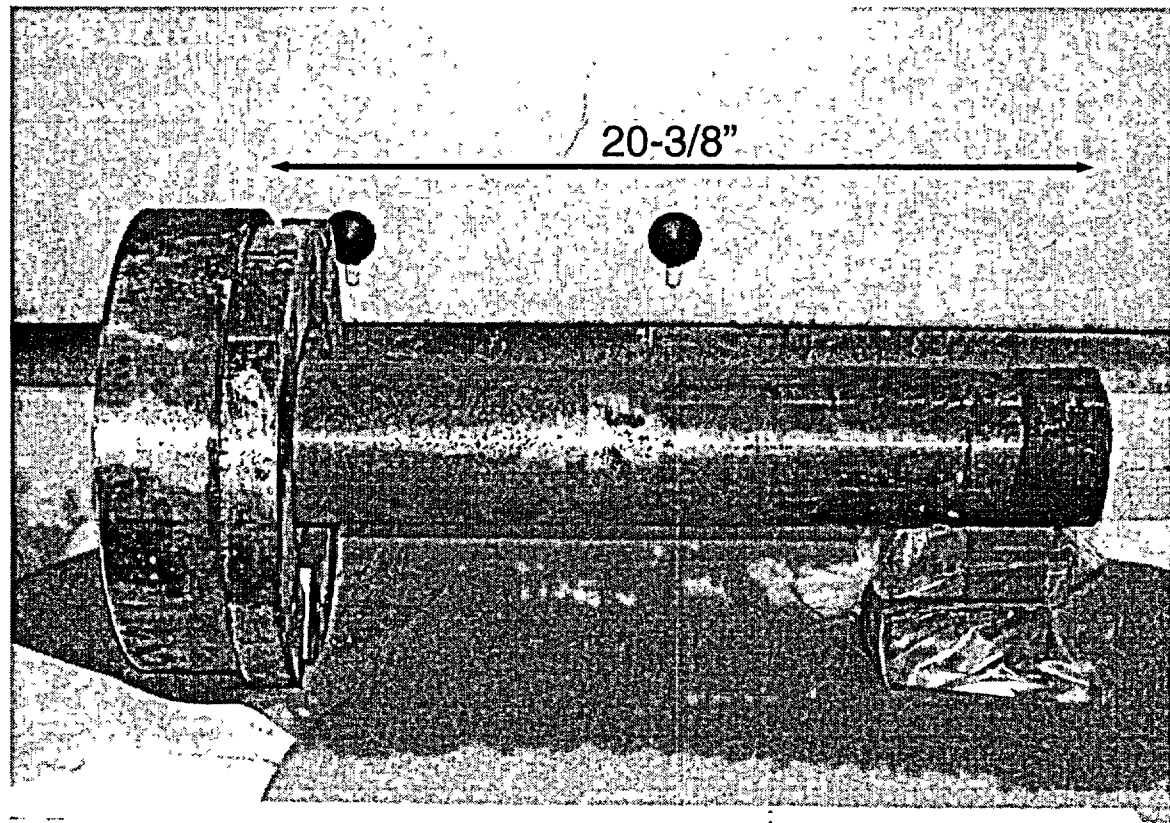
# ***Completed Work Scope Items***

- Nozzle 3 Corrosion Area
  - Cavity and Cladding Molds
  - Sectioning/Machining
    - Cuts #1 through #5
    - Metallography, Microhardness, and Tensile Samples
    - Ship Piece D-2 to ANL
  - Penetrant Tests
    - Surfaces of Cuts #1, #2, and #3
    - Nozzle 3 J-Weld
  - Cladding Thickness Measurements/Visual Inspections
  - Metallography/Microhardness
  - Tensile Testing



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## Nozzle 2 – Side View



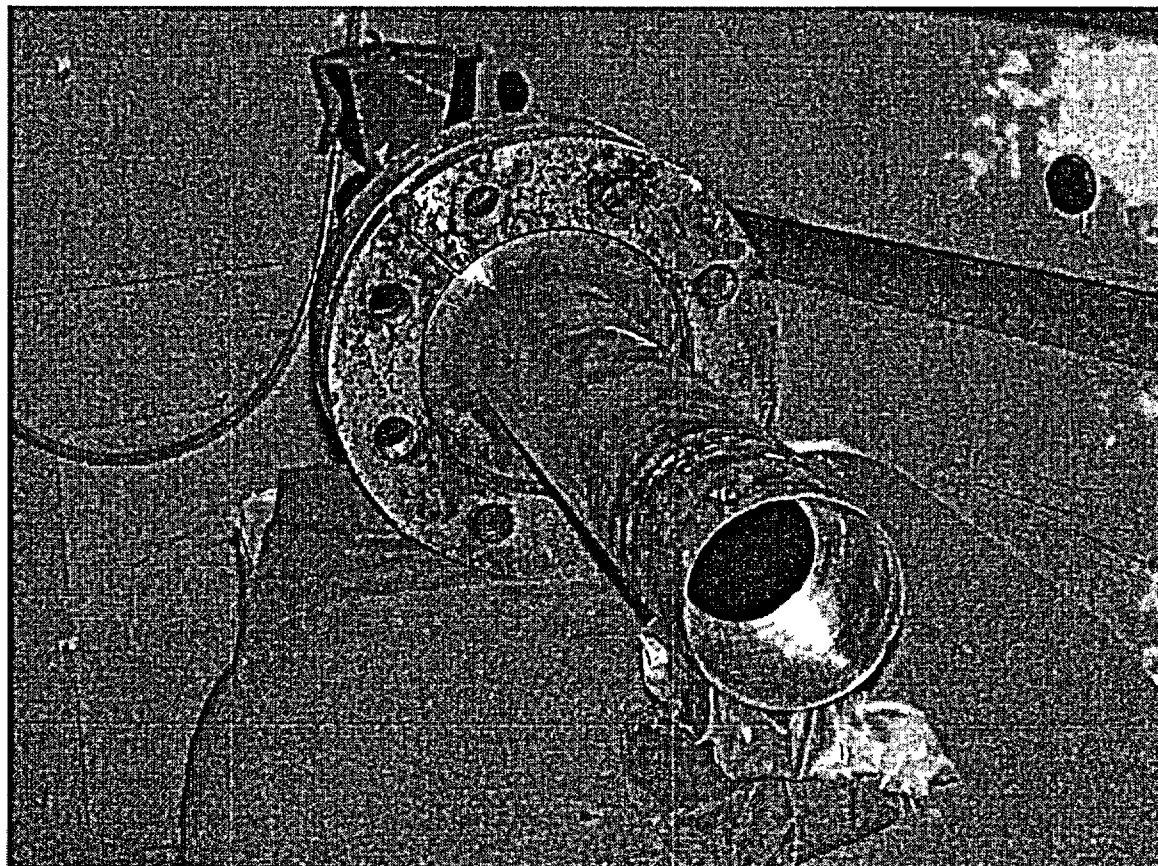
~7-5/8" Bored Away During Removal



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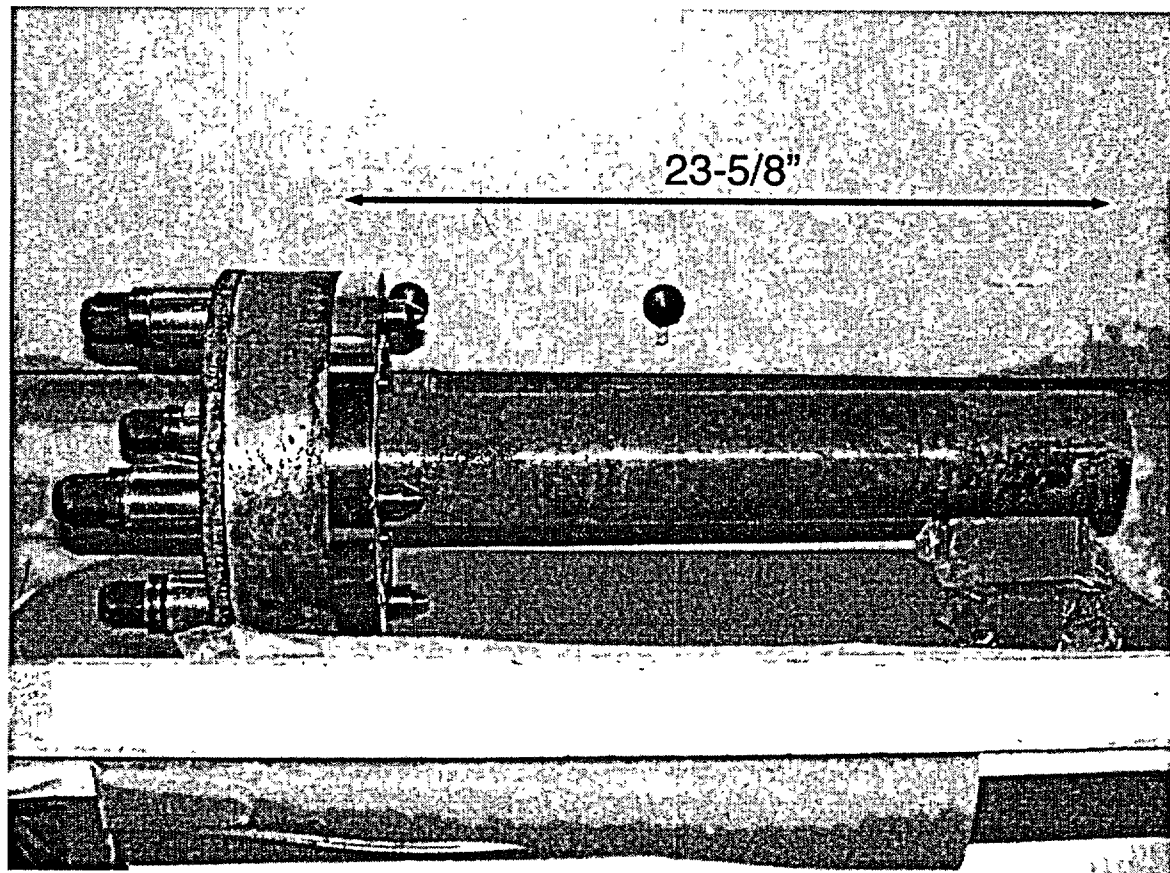


## *Nozzle 2 – End View*



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## ***Nozzle 3 – Side View***

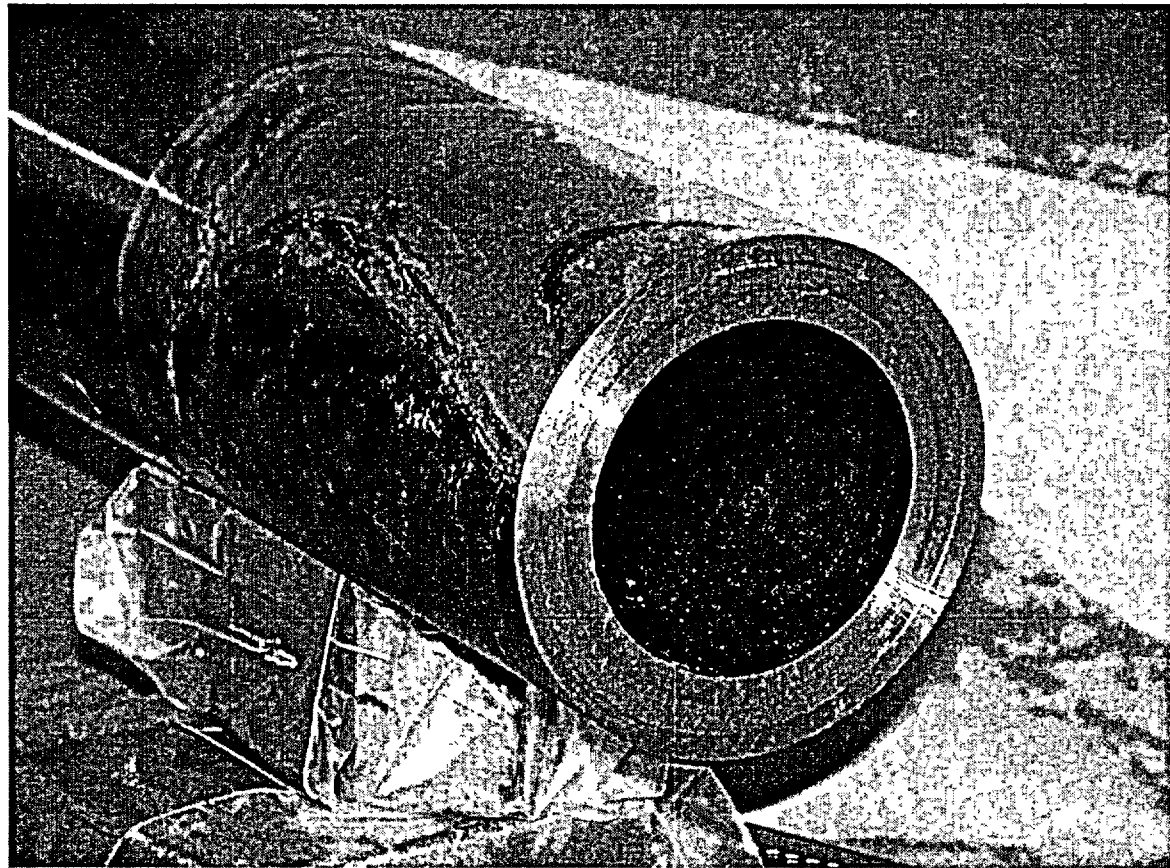


~4-1/2" Bored Away During Removal



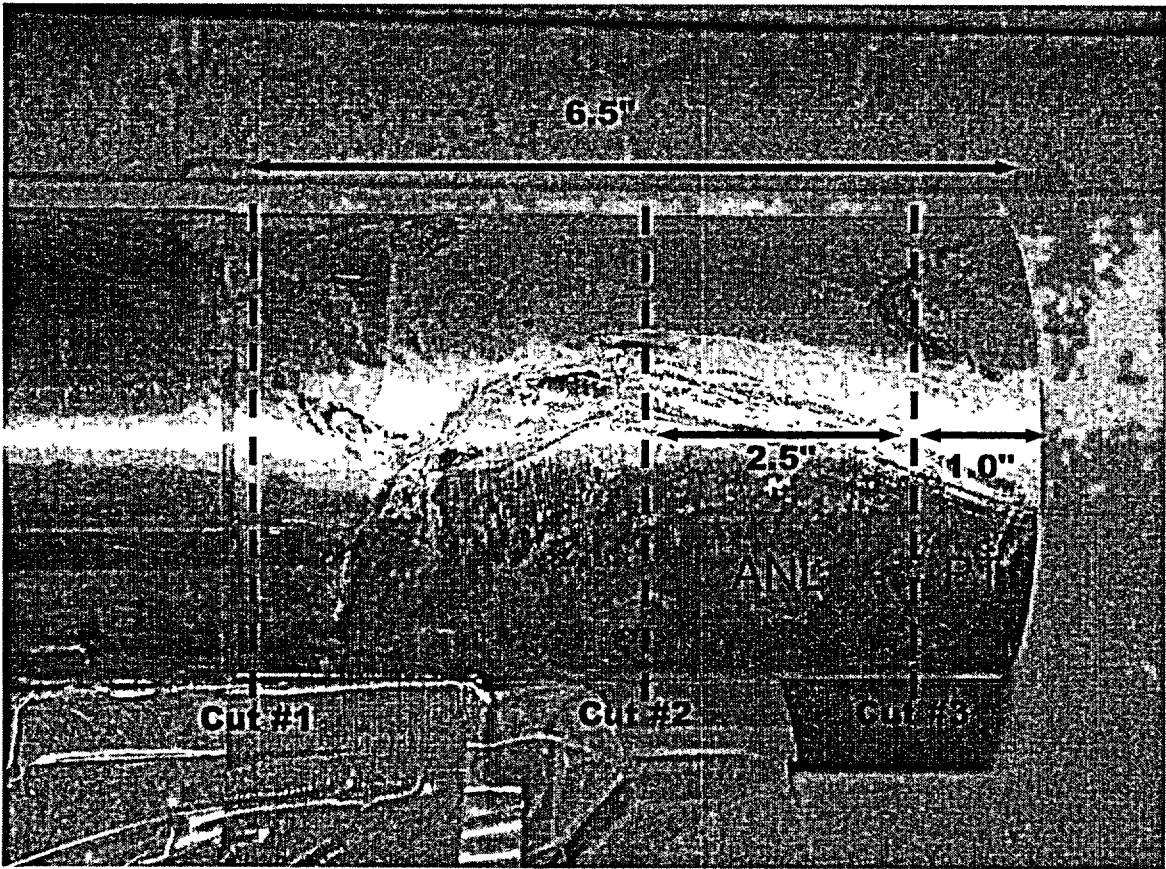
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## ***Nozzle 3 – End View***



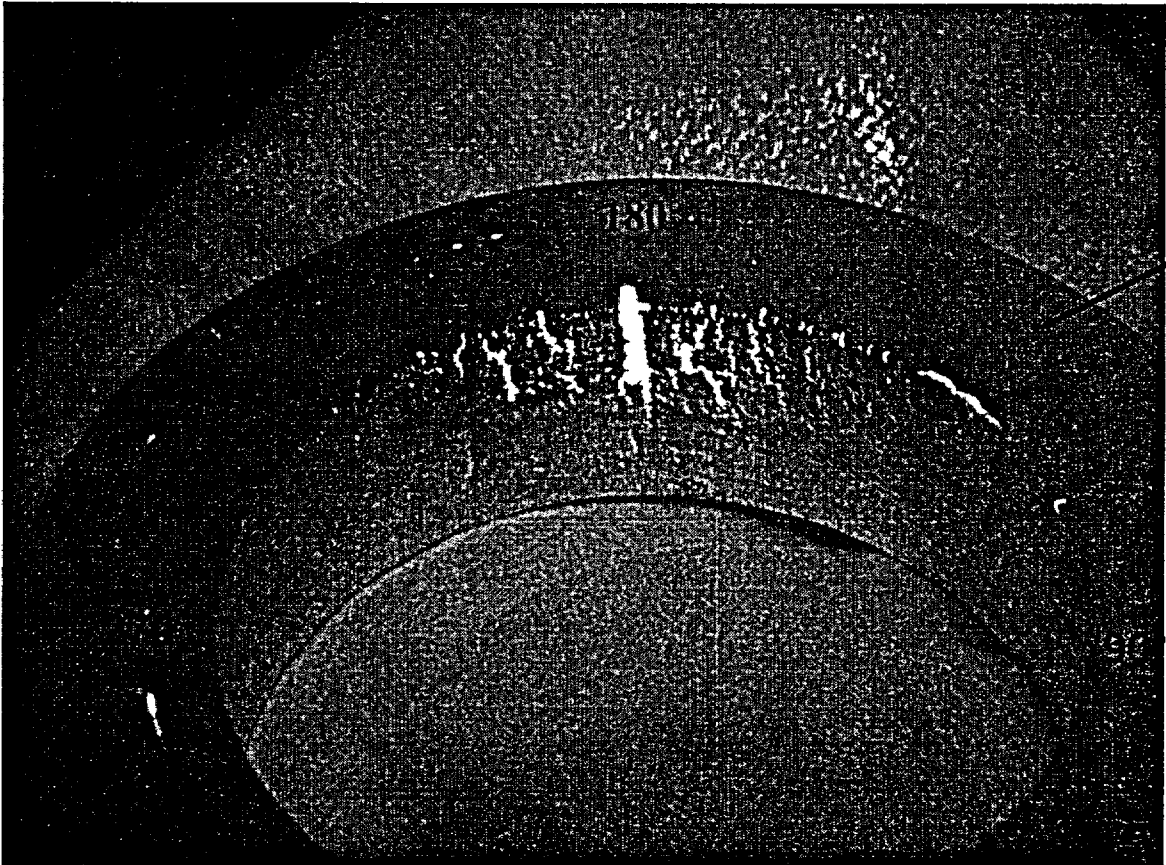
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# Nozzle 3 Sectioning



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**Nozzle 3 – PT on 1” Ring**



Lower  
Surface

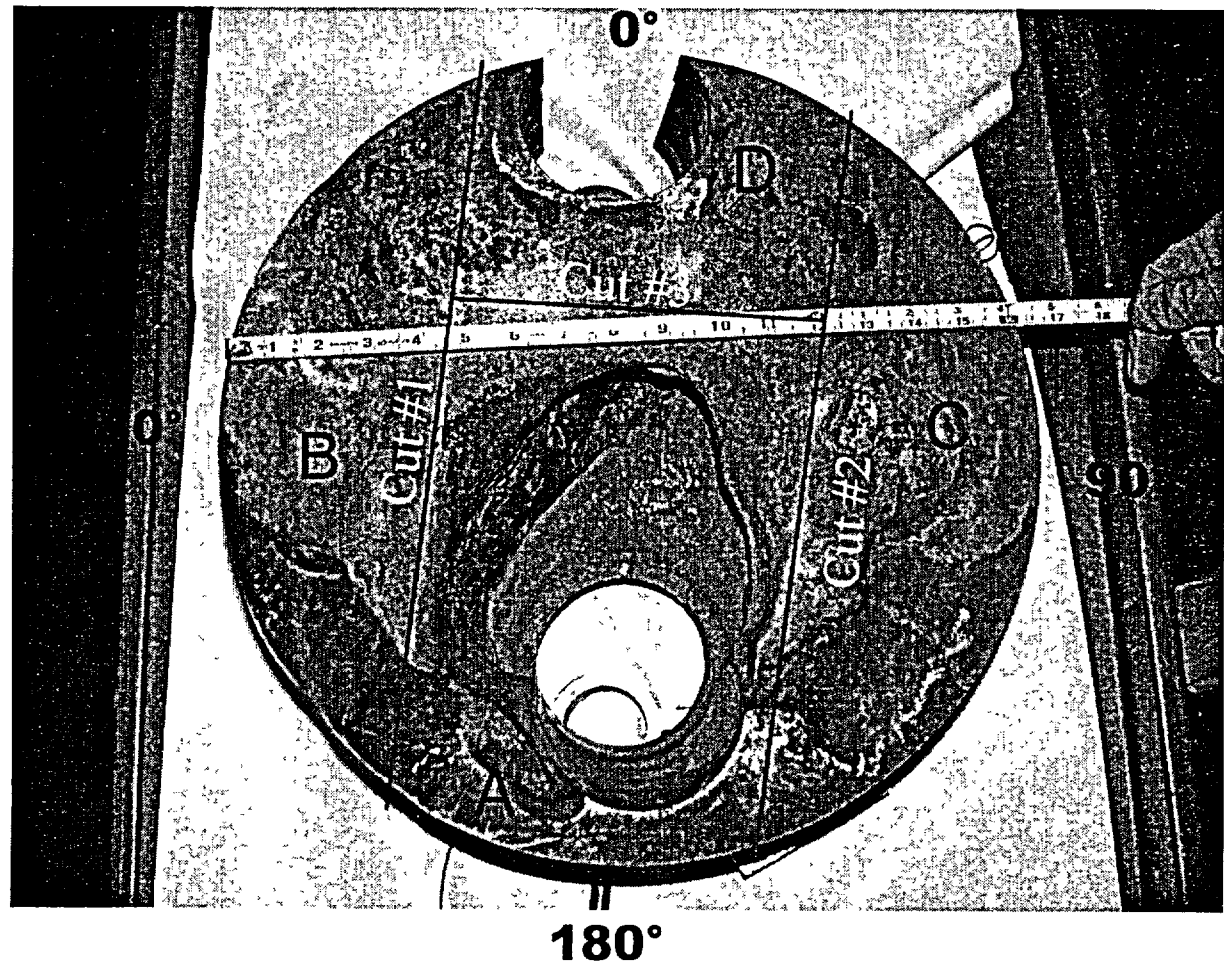
0°



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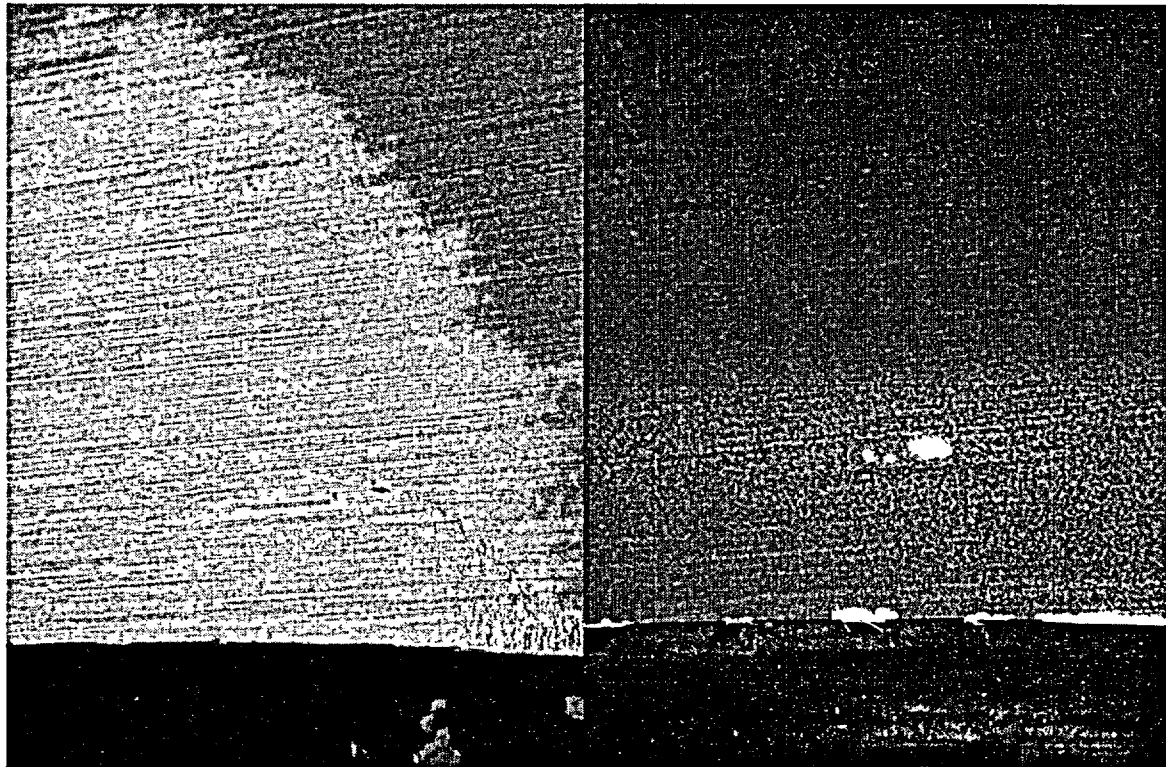


# Sectioning – Corrosion Area



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# ***Penetrant Test – Cuts #1, #2, & #3***

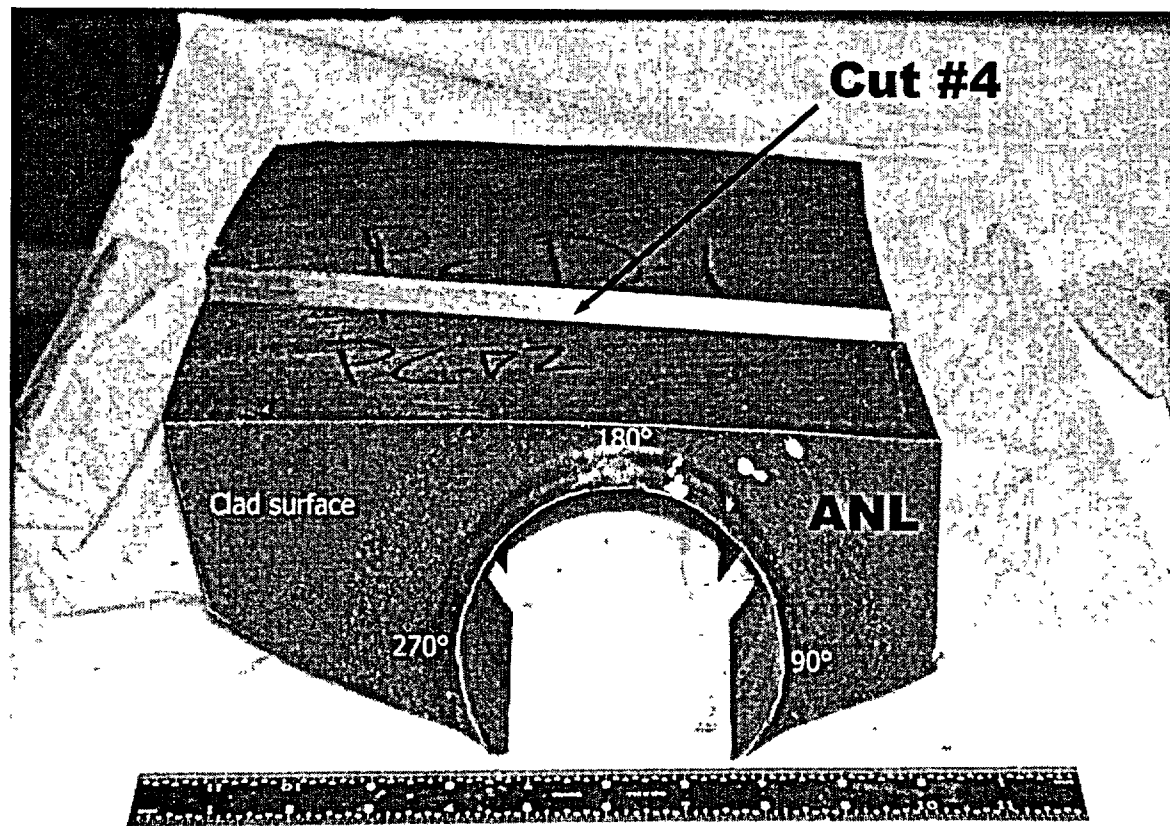


**Small void near nozzle 11 J-weld root (Cut #3). No evidence of cladding disbond on any cut surfaces.**



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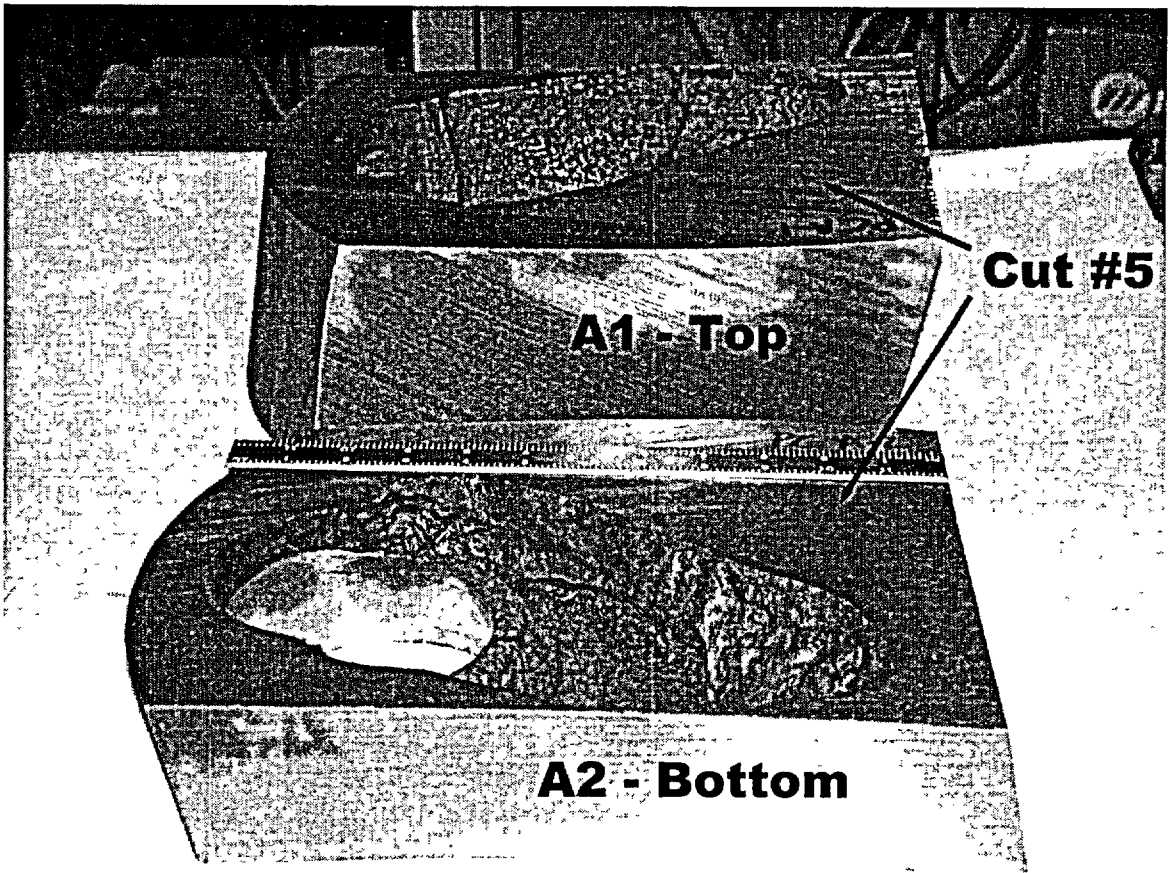
# Sectioning - Block D



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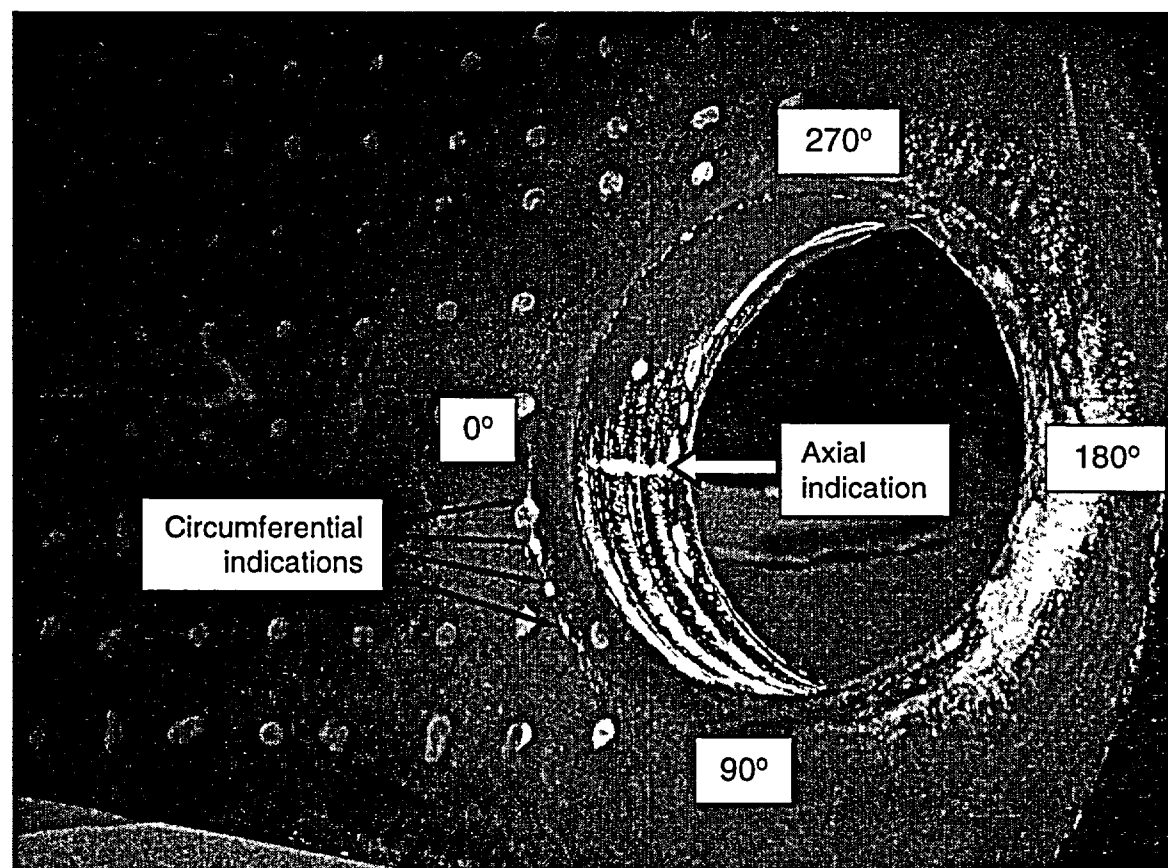


# Sectioning – Block A



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# ***Penetrant Test – Nozzle 3 J-Weld***

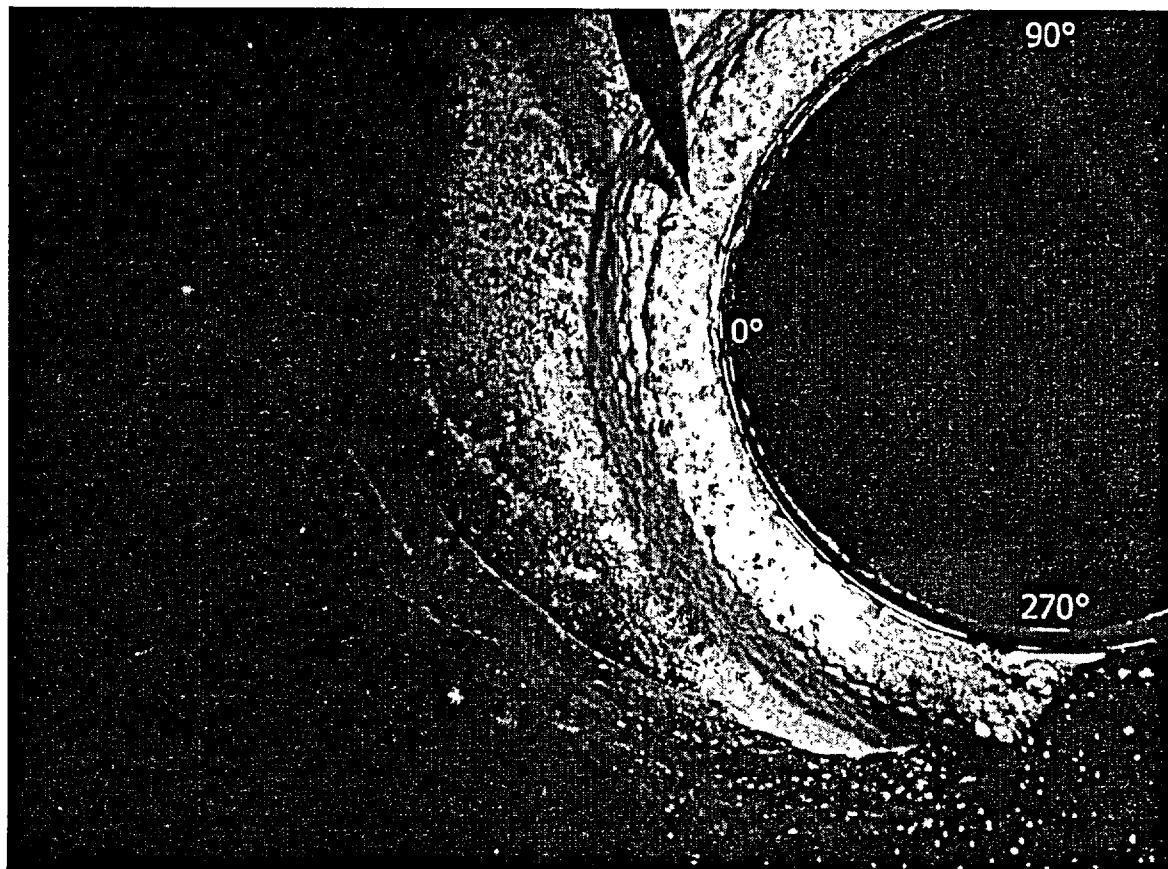


**Looking at RCS Side**



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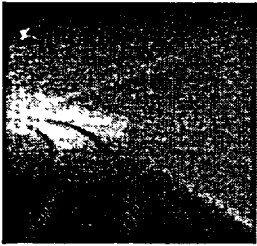
# ***Penetrant Test – Nozzle 3 J-Weld***



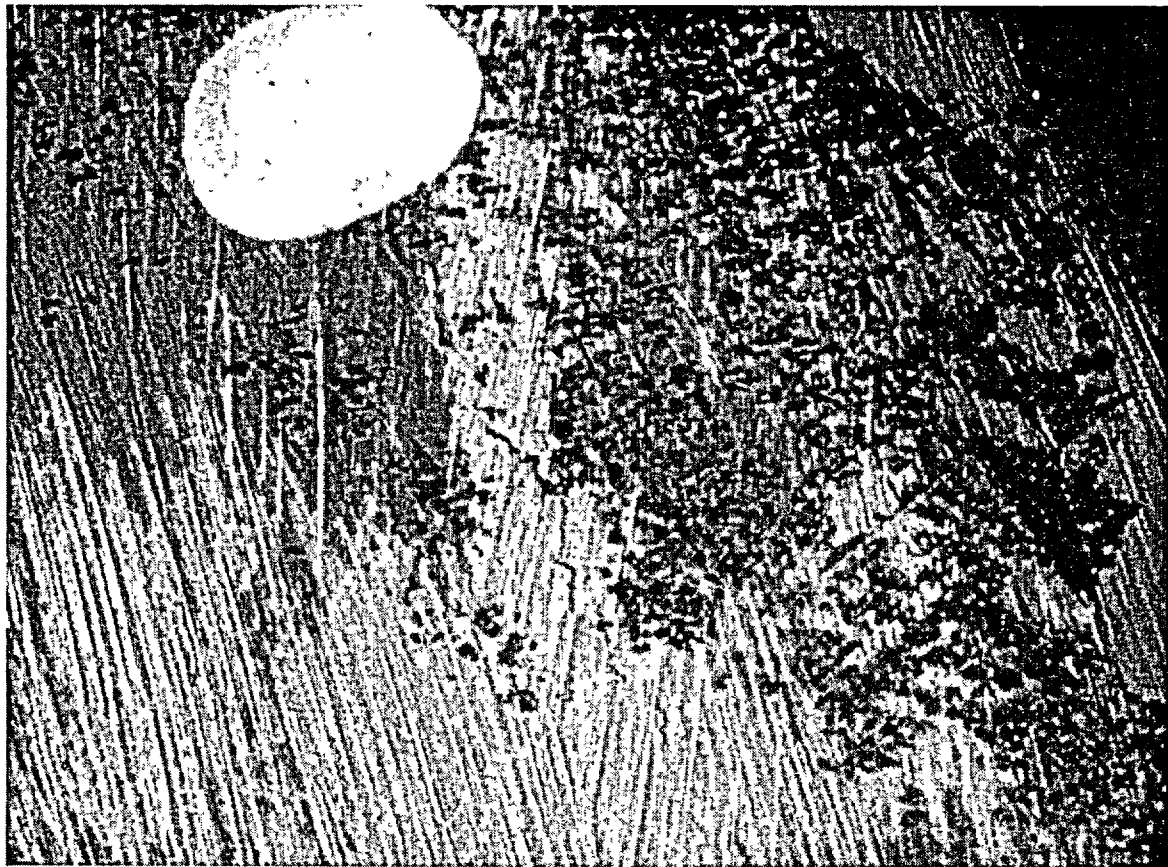
**Looking at Top Side**



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## ***Nozzle 3 J-Weld Cracking***

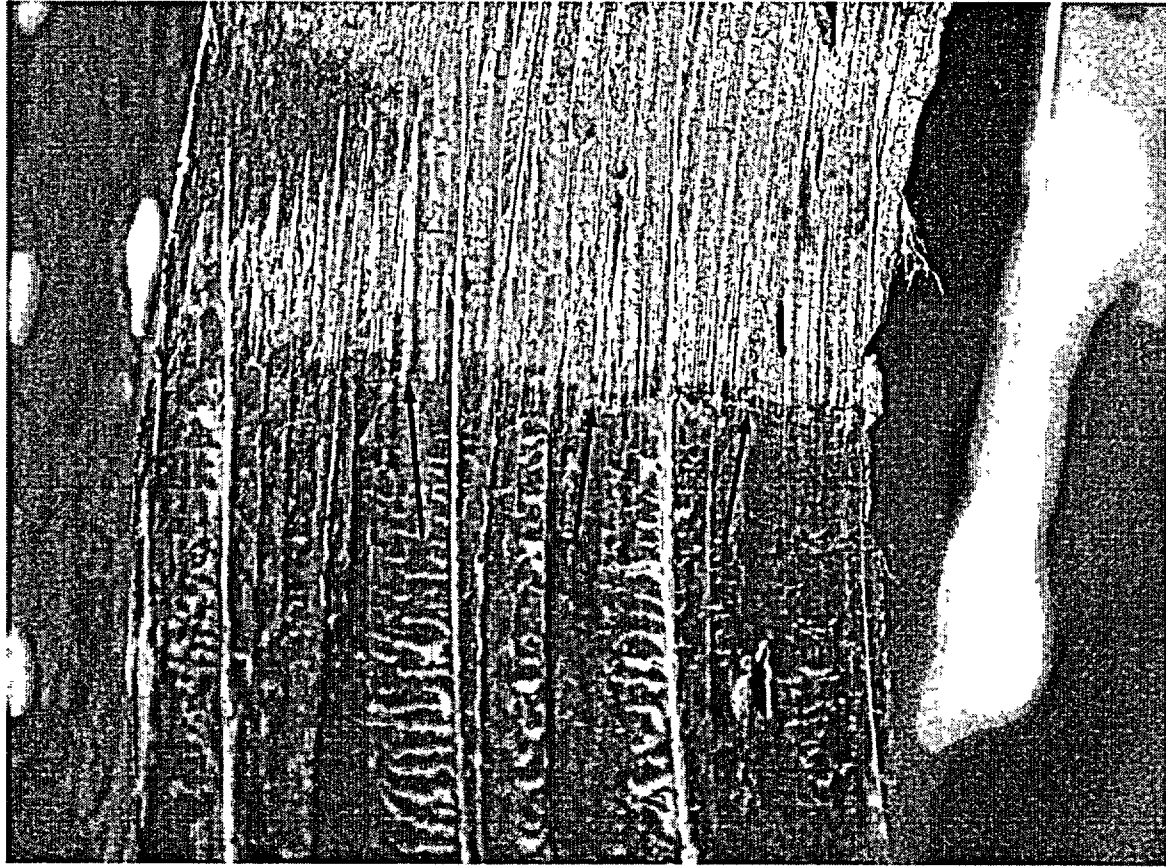


**Circumferential cracks on RCS side of nozzle 3 J-weld  
between 0° and 45°. 6X**



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# ***Nozzle 3 J-Weld Cracking***



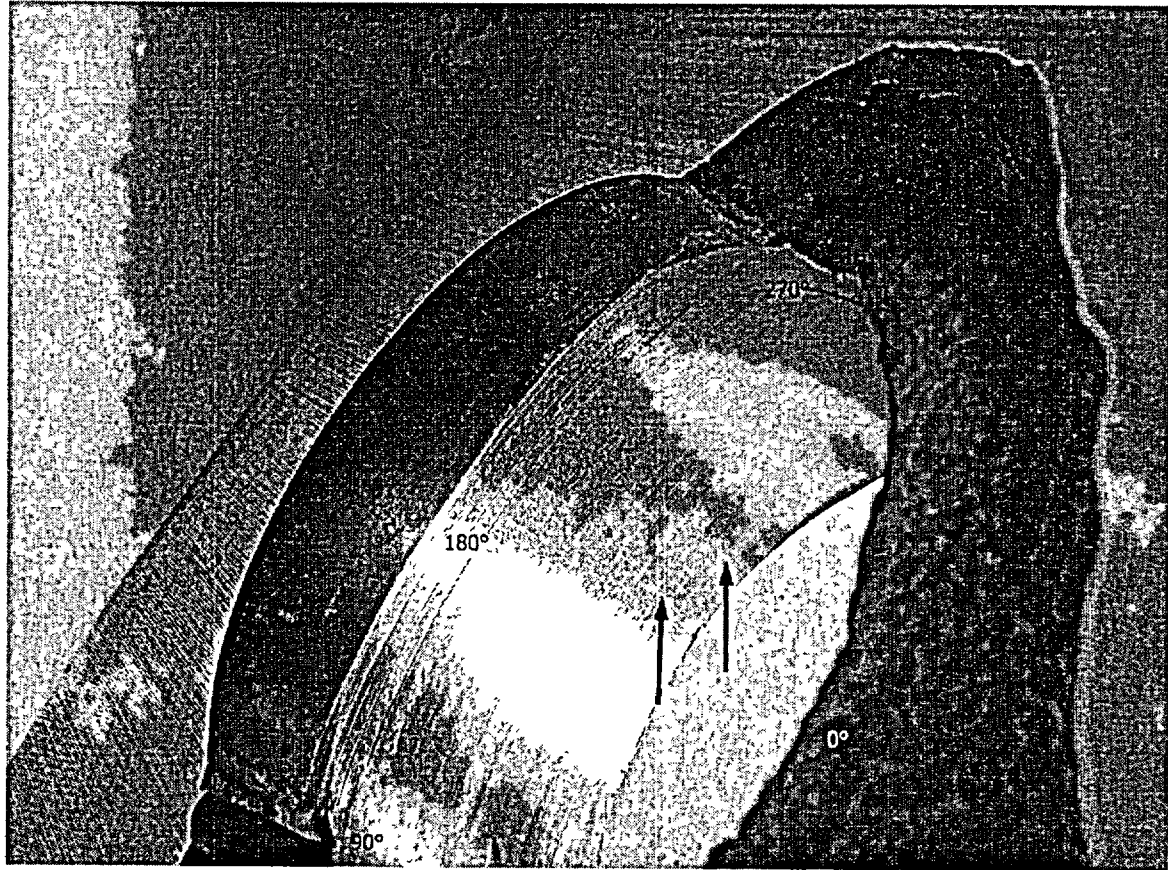
**Axial crack on bored surface of nozzle 3 J-weld near 10°.**



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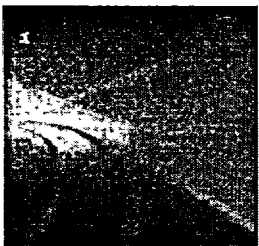
# ***Nozzle 3 J-Weld Cracking***



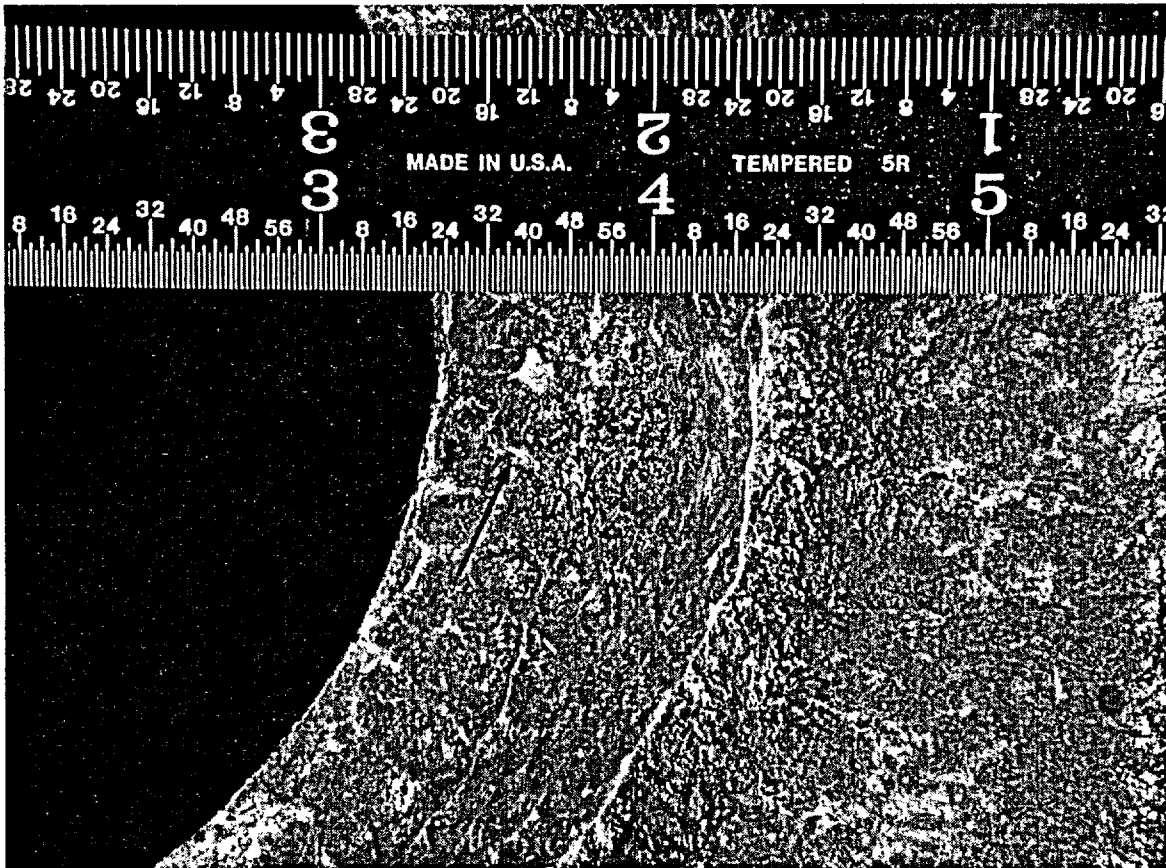
**Axial crack on bored surface of nozzle 3 J-weld near 180°.**



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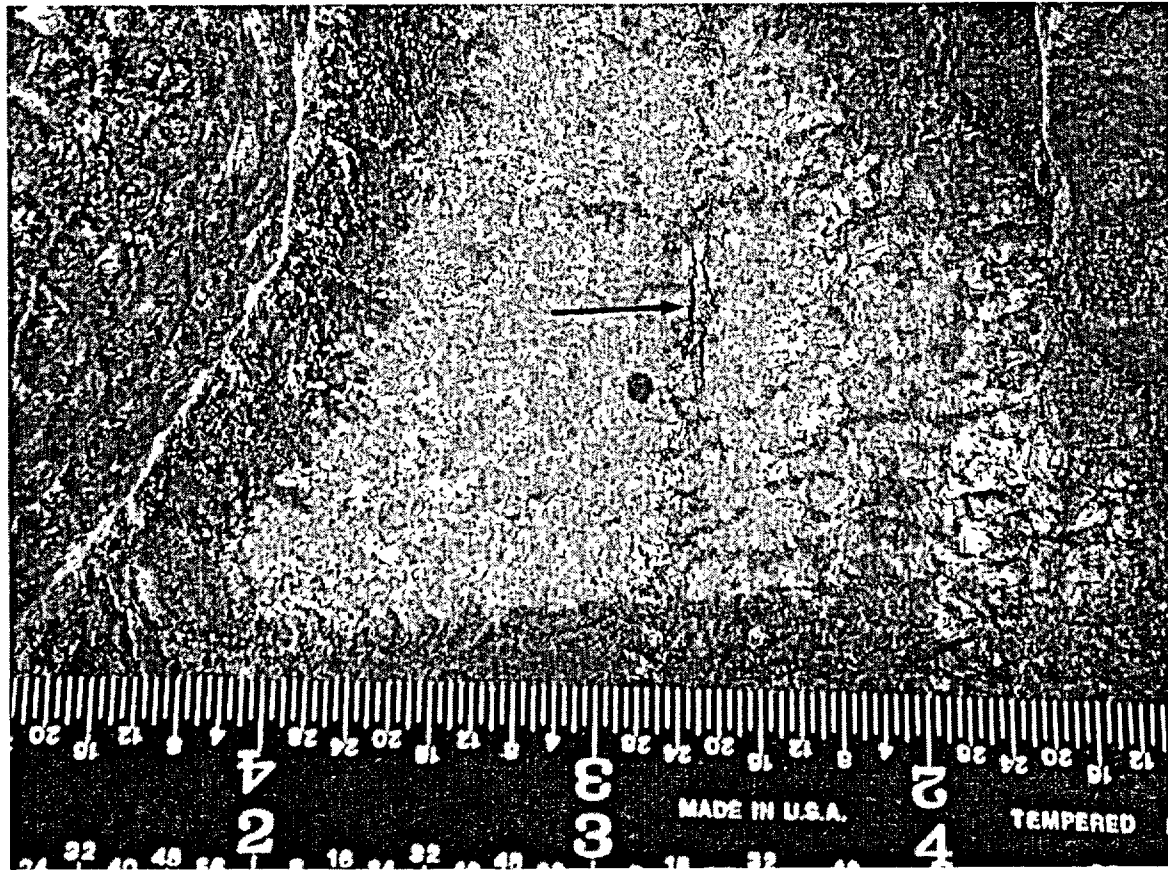


# Nozzle 3 J-Weld Cracking

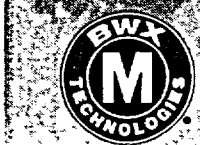


Axial crack on top surface of nozzle 3 J-weld near 10°.

# ***Cladding Cracking***



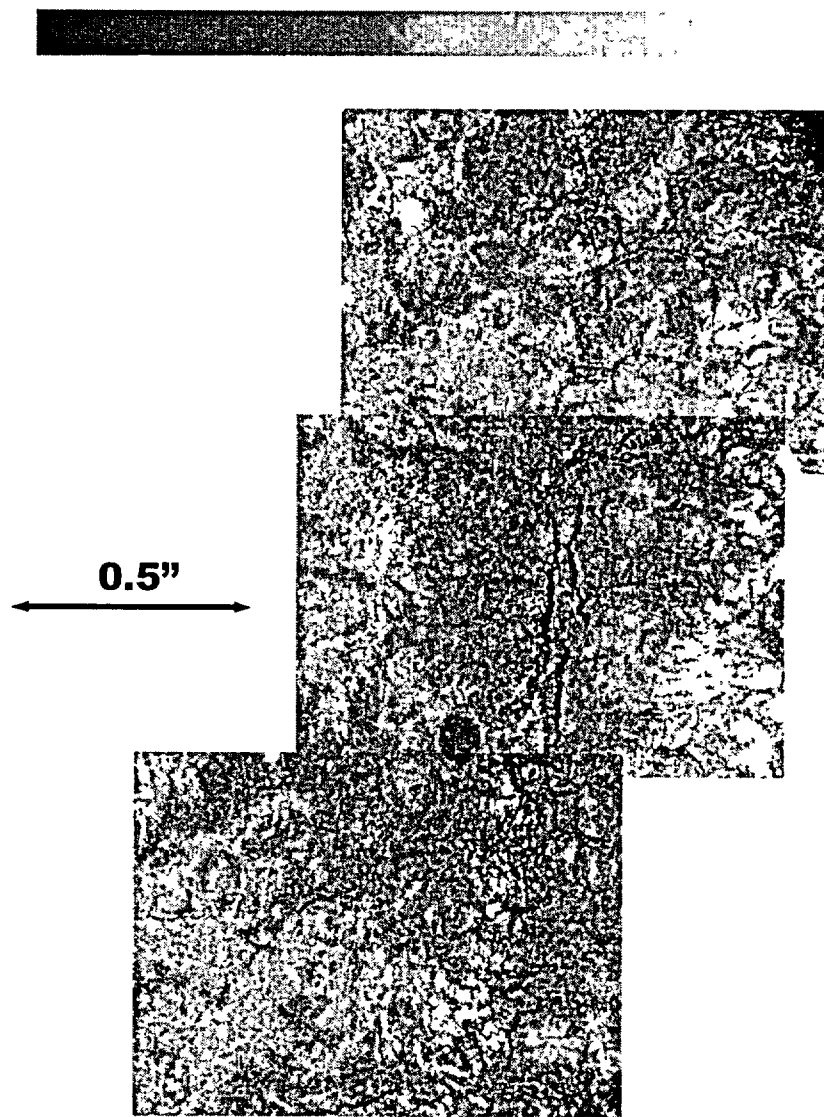
**Crack on exposed surface of cladding.**



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# Cladding Cracking



Crack on exposed surface of cladding. Red dot denotes (0,0) for cladding thickness measurements and was located in area of maximum upward deflection of cladding.



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# ***Cladding Thickness Measurements***

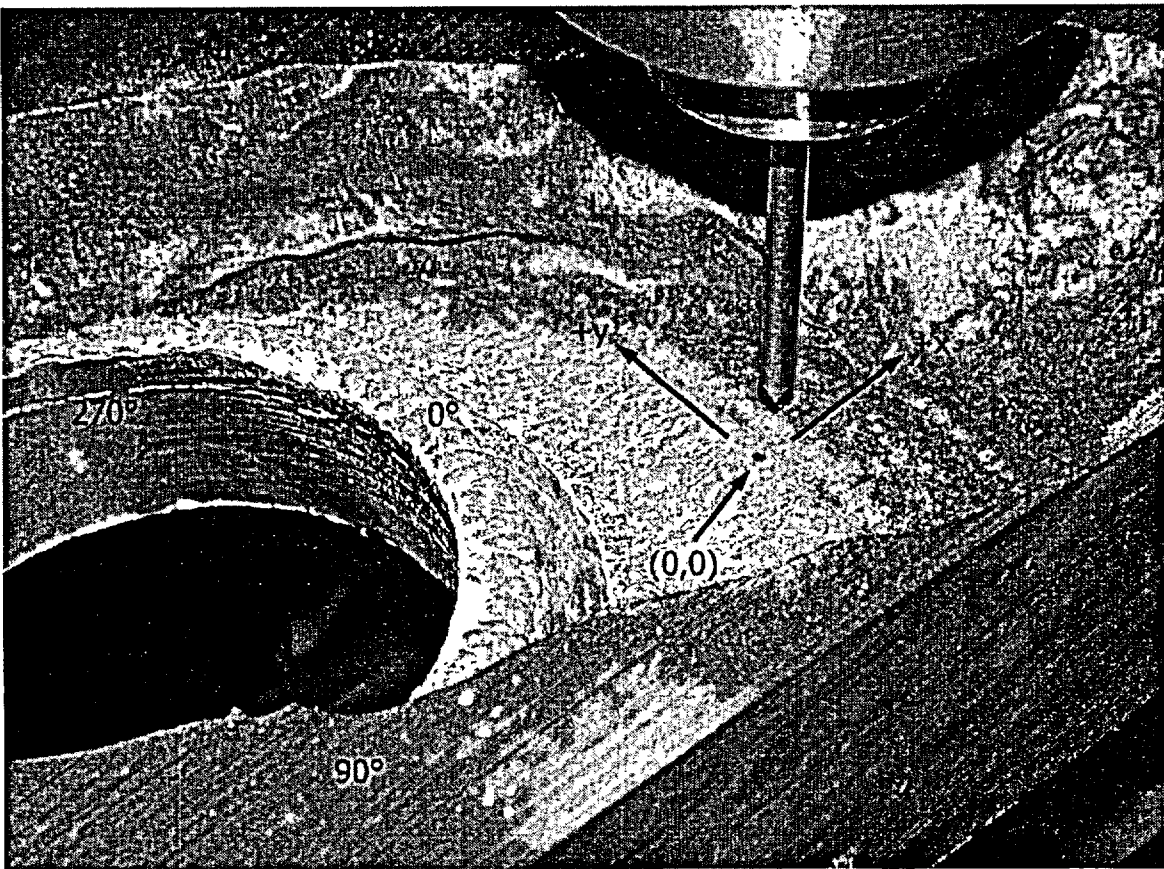


**Test setup for cladding thickness measurements.**



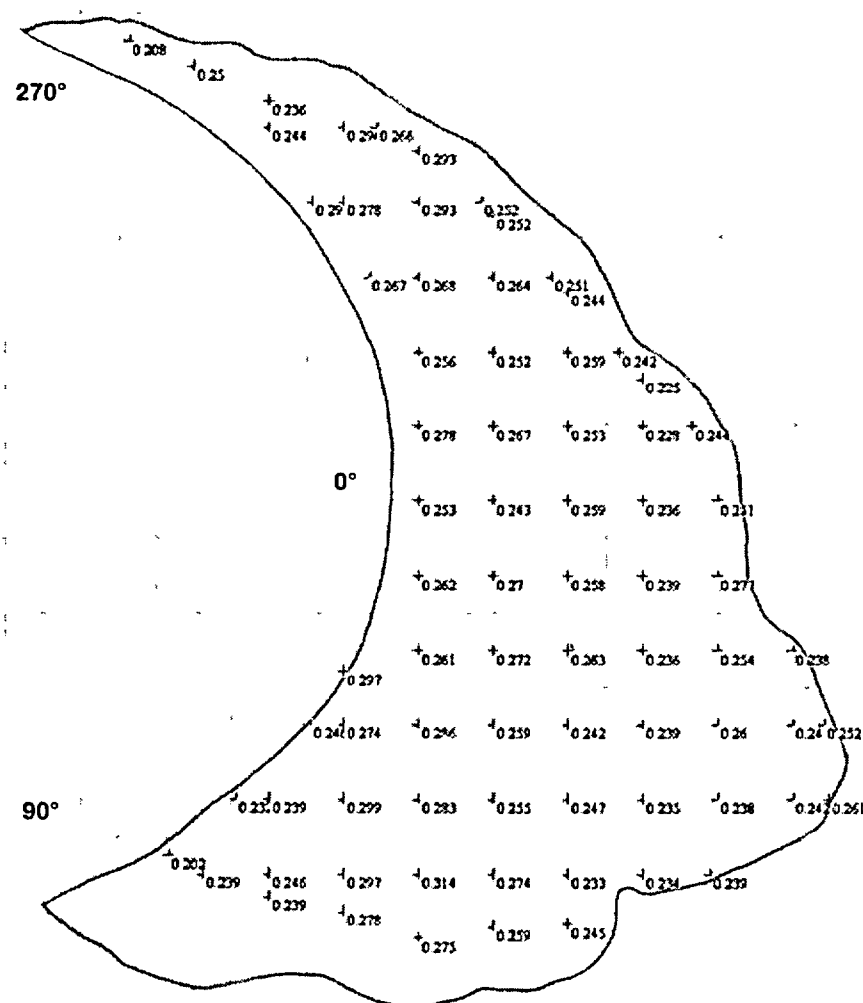
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# Cladding Thickness Measurements



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# Cladding Thickness Measurements



Exposed Cladding: ~17 in<sup>2</sup>  
Average Thickness: 0.256"  
Minimum Thickness: 0.202"  
Maximum Thickness: 0.314"

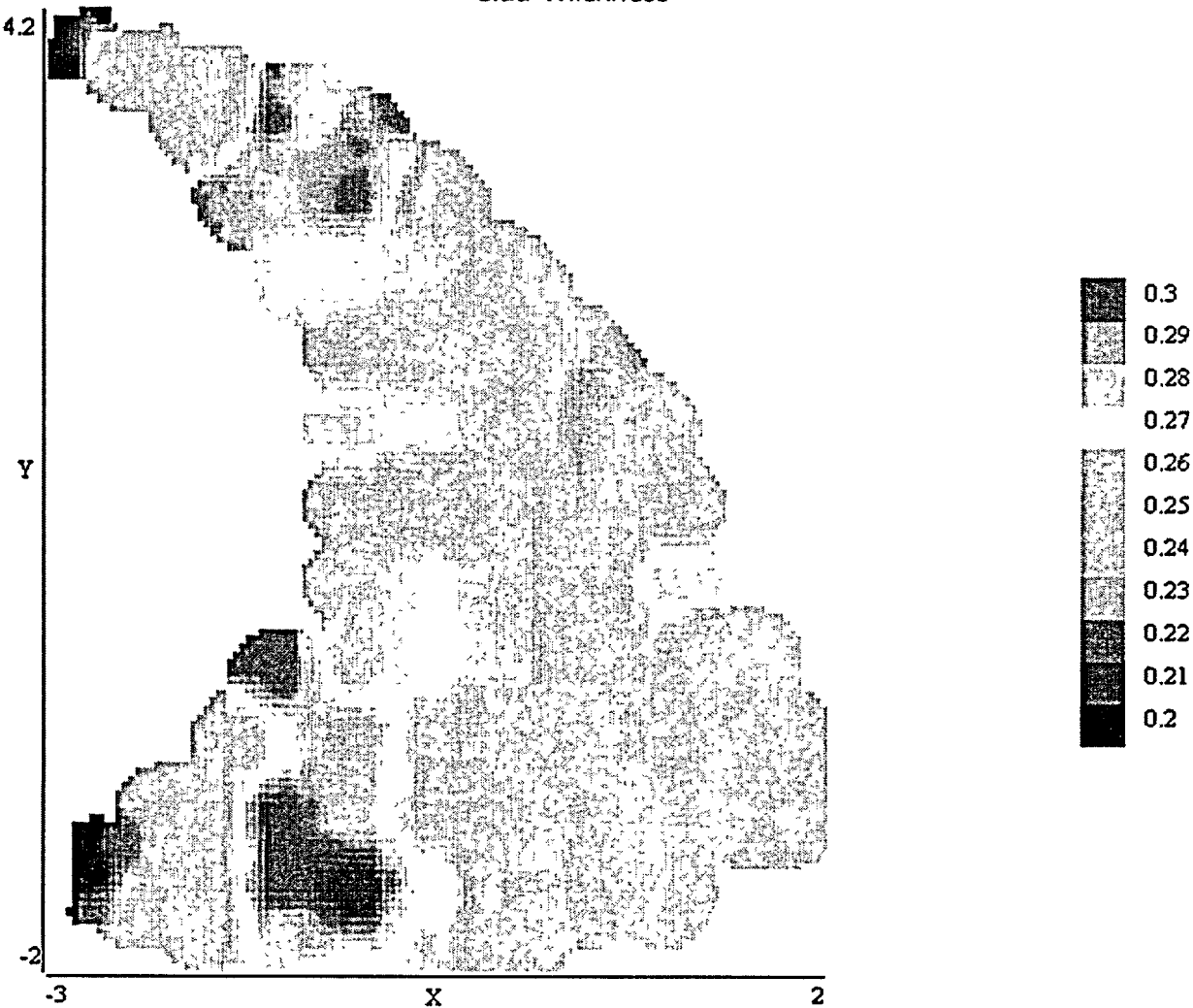


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# Cladding Thickness Measurements



Clad Thickness



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# ***Cladding Thickness Measurements***



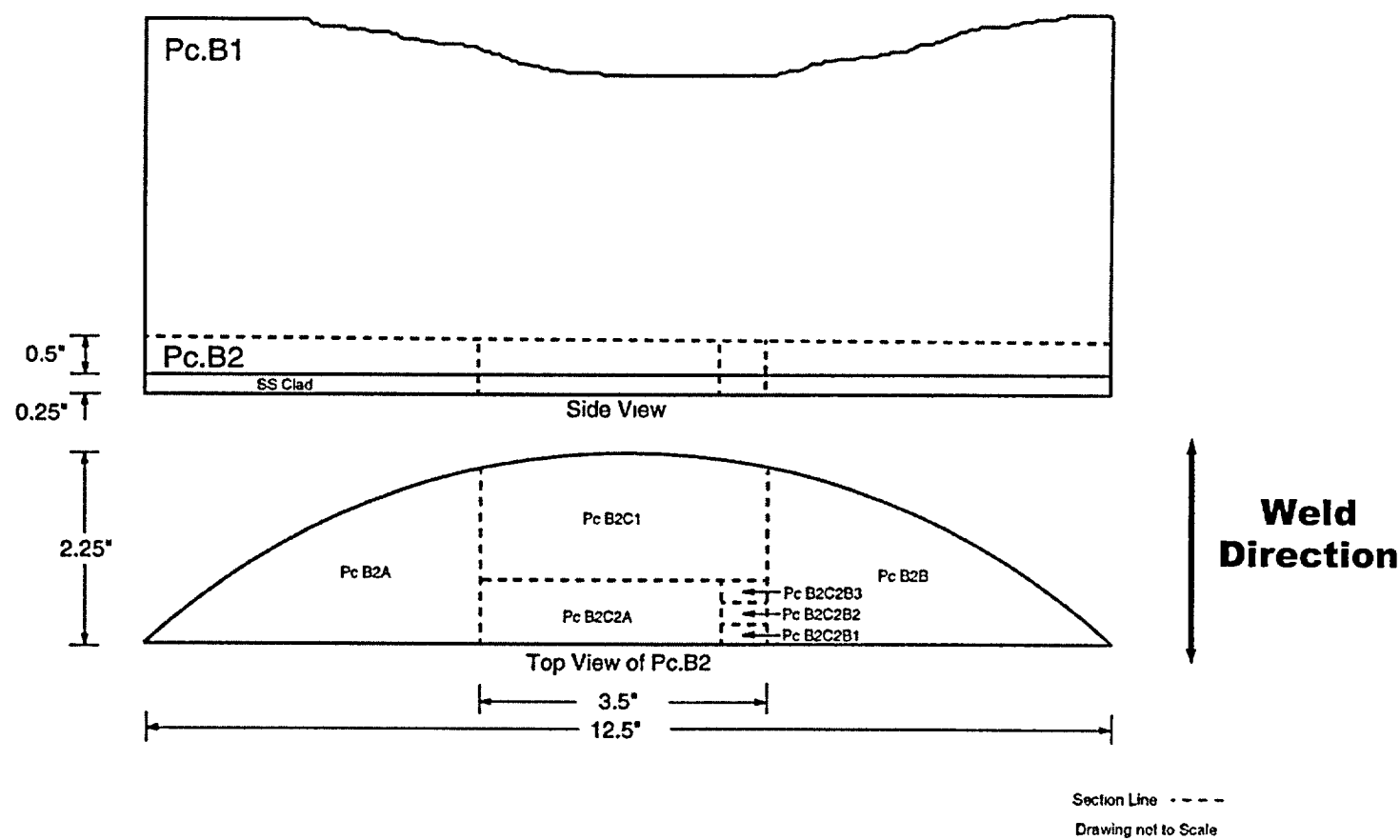
**Crack**

**Crack on exposed surface  
of cladding with cladding  
thickness overlay.**



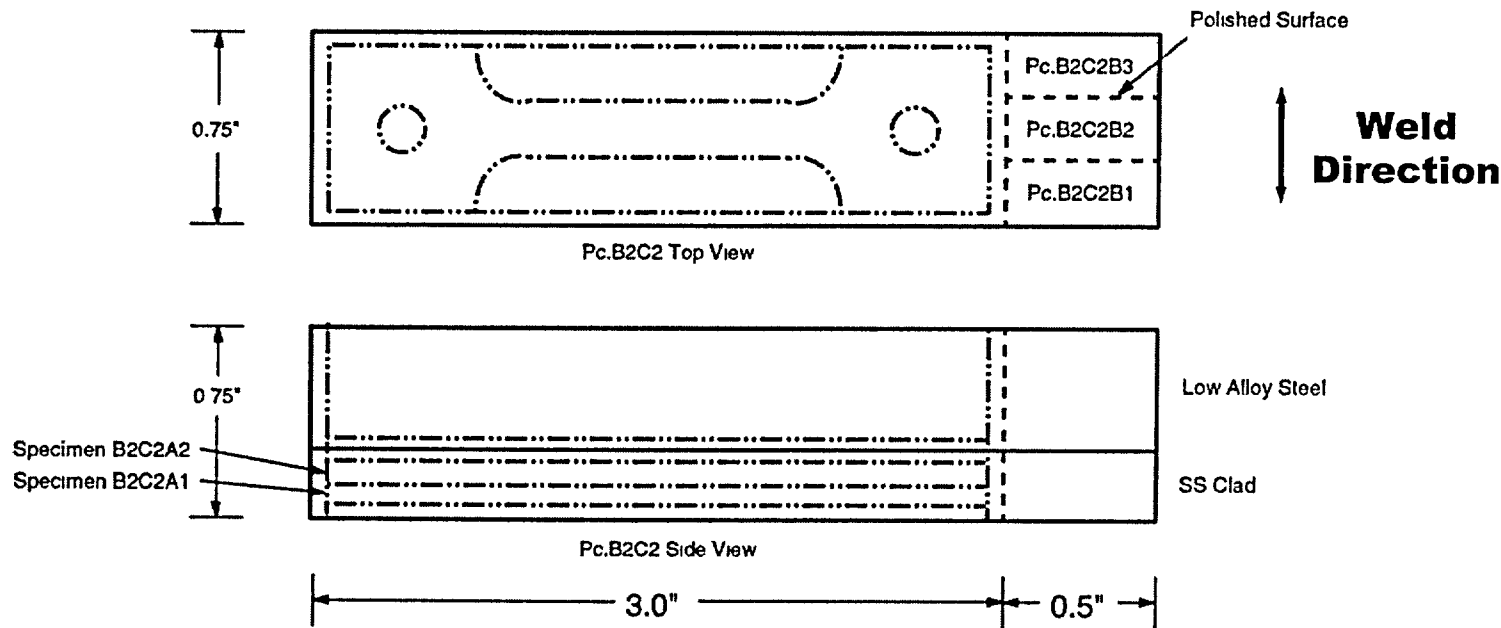
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# Sectioning – Block B



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# Sectioning – Block B



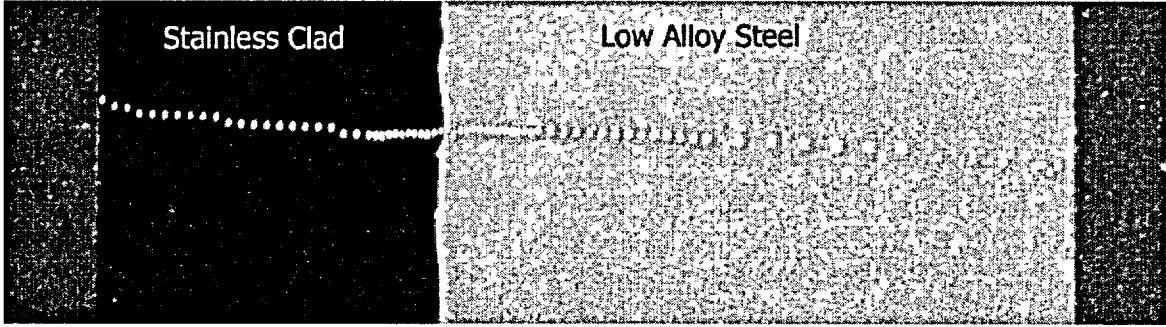
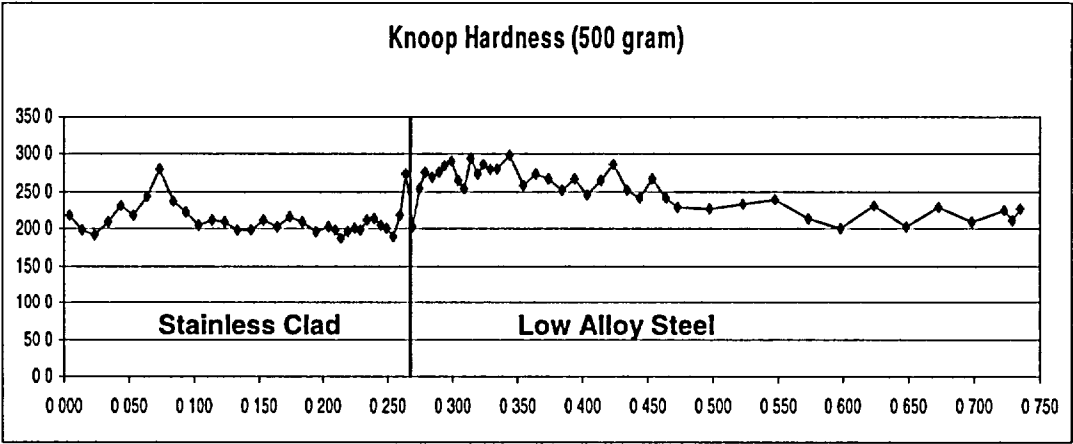
Section Line - - - -  
EDM Section - · - · -  
Drawing not to Scale



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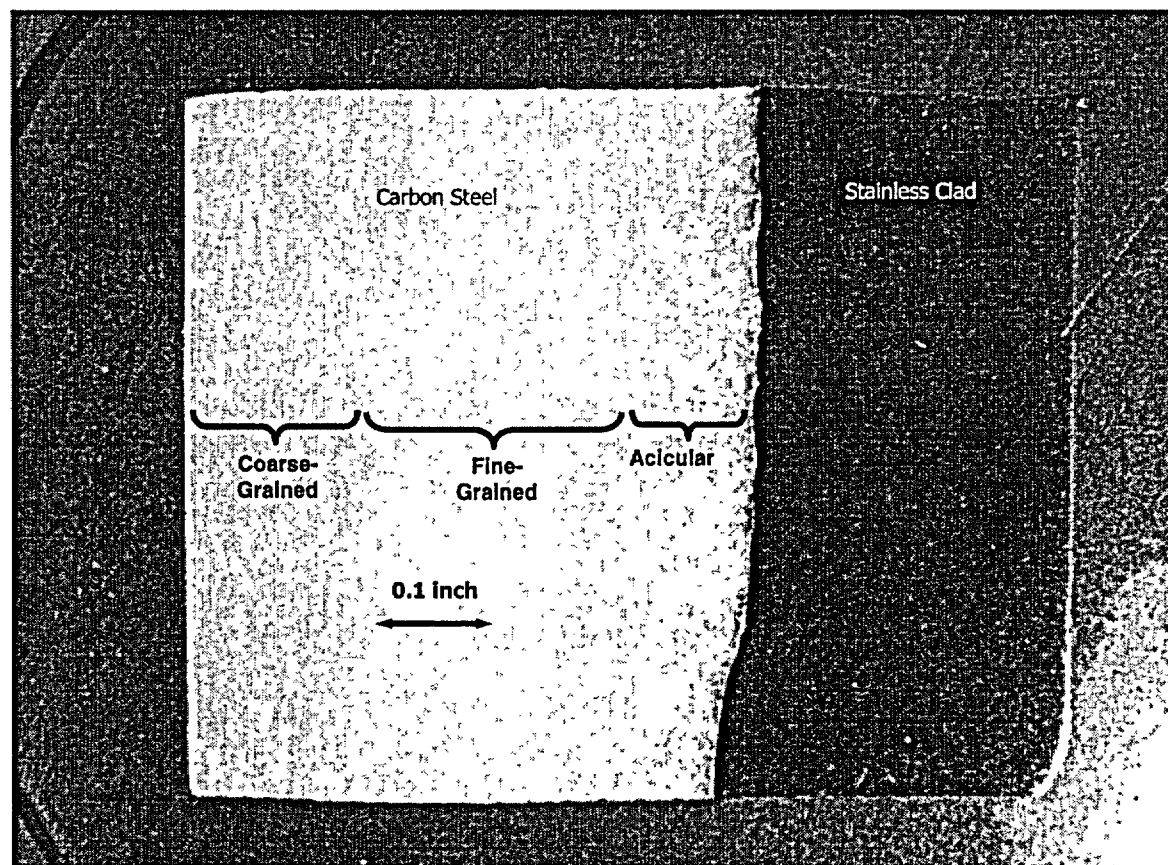


# Knoop Microhardness



Knoop microhardness data (500 gram load).

# Metallography

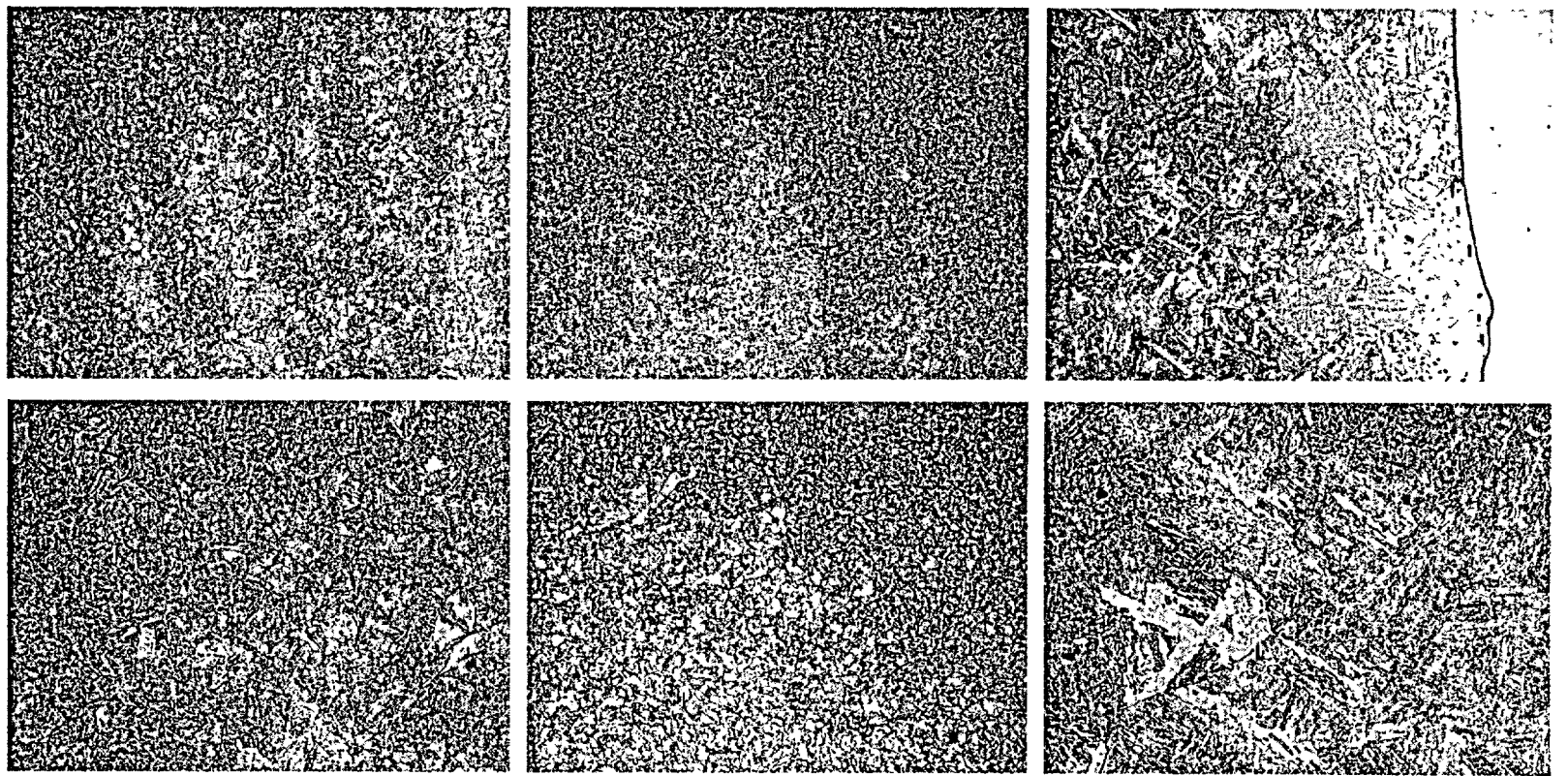


Photograph of mounted sample (B2C2B3).



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# ***Low Alloy Steel Metallography***



**$\frac{1}{2}$ " from Clad**

**$\frac{1}{4}$ " from Clad**

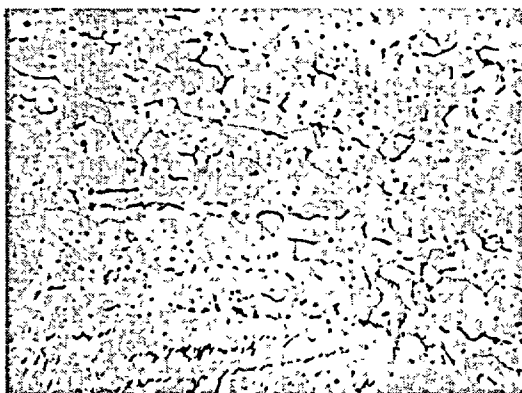
**Near Clad**

**Low alloy steel metallography (100X top; 475X bottom). 2% nital**

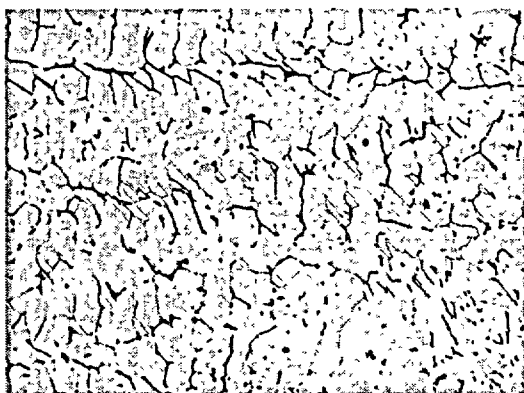
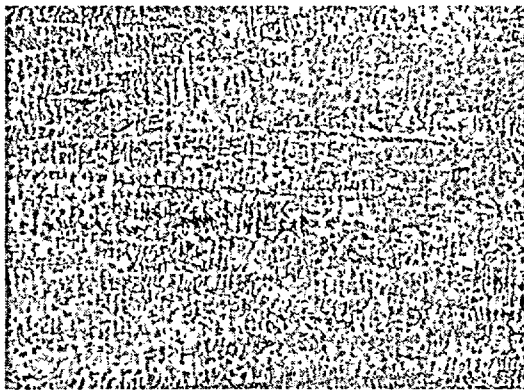


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# Cladding Metallography



Near Low Alloy Steel



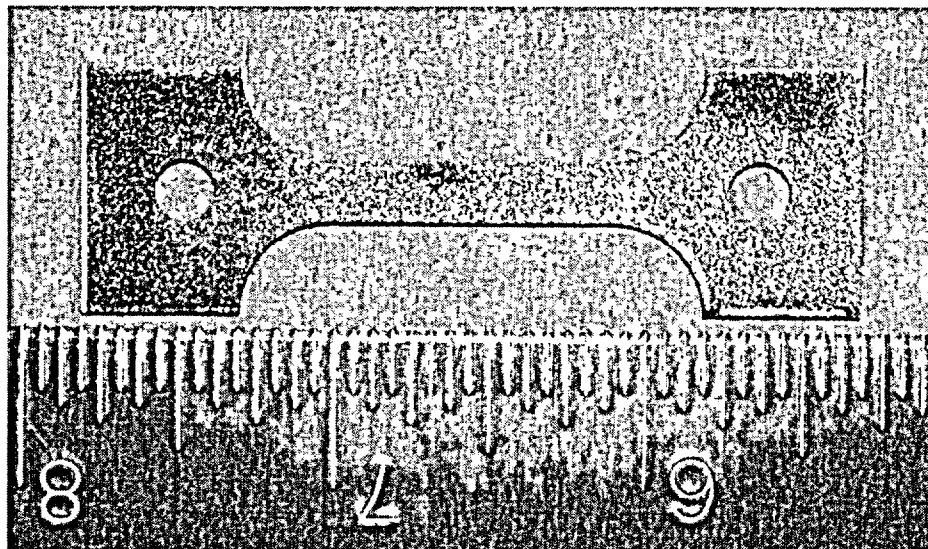
Typical Cladding

Cladding metallography (100X top; 475X bottom). Ferrite number between 5.0 and 7.5 (Severn). Acetic, nitric, hydrochloric etch



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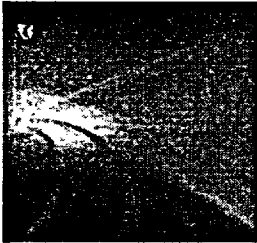
# ***Tensile Testing***



**Tensile Specimen Design (Dummy Shown)  
Overall Length 2.5"; Nominal 0.080" thick**



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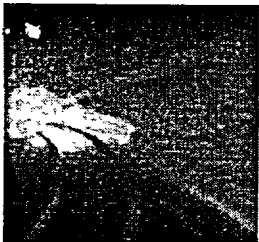
# Tensile Test Results



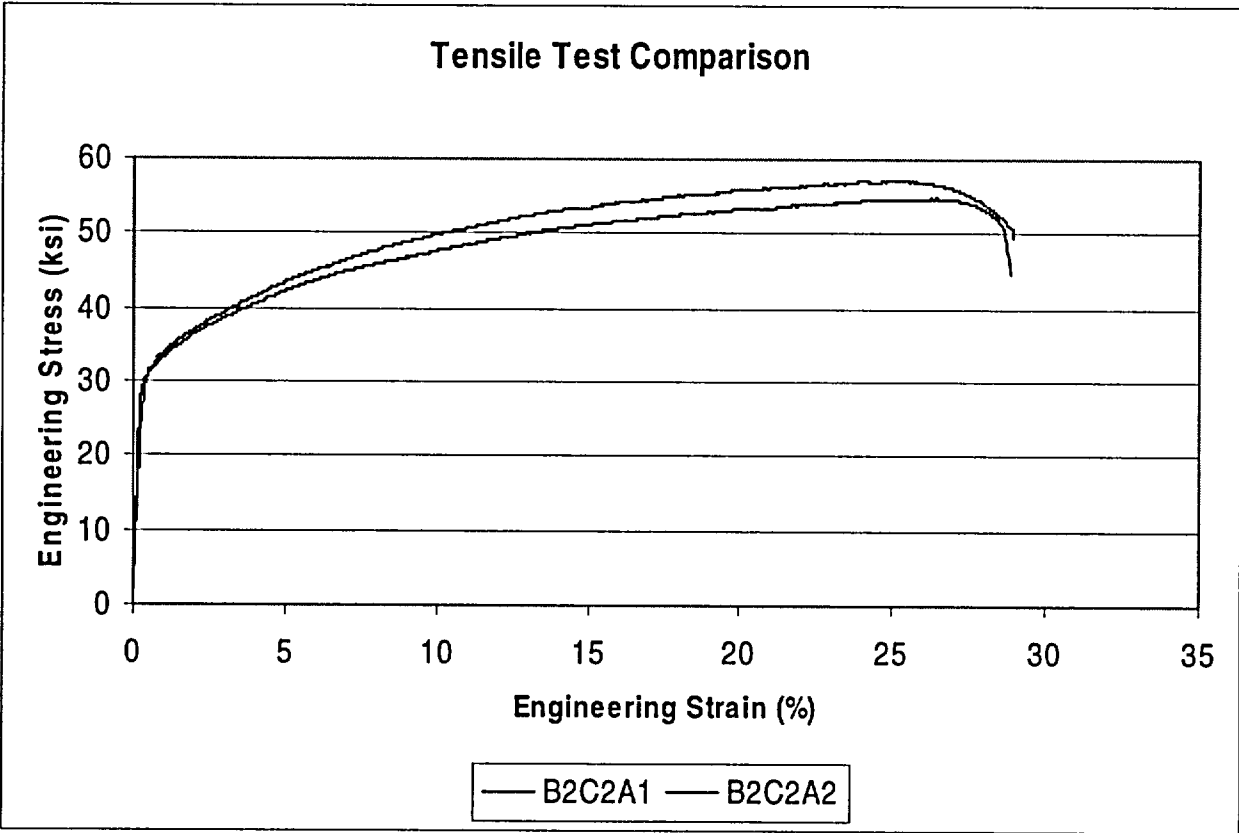
	Specimen B2C2A1 (near RCS)	Specimen B2C2A2 (near low alloy steel)
UTS	54,800 psi	57,100 psi
2% Offset YS	30,500 psi	31,300 psi
Elongation	28.7%	28.7%
RA	39.3%	34.3%



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# Tensile Test Results

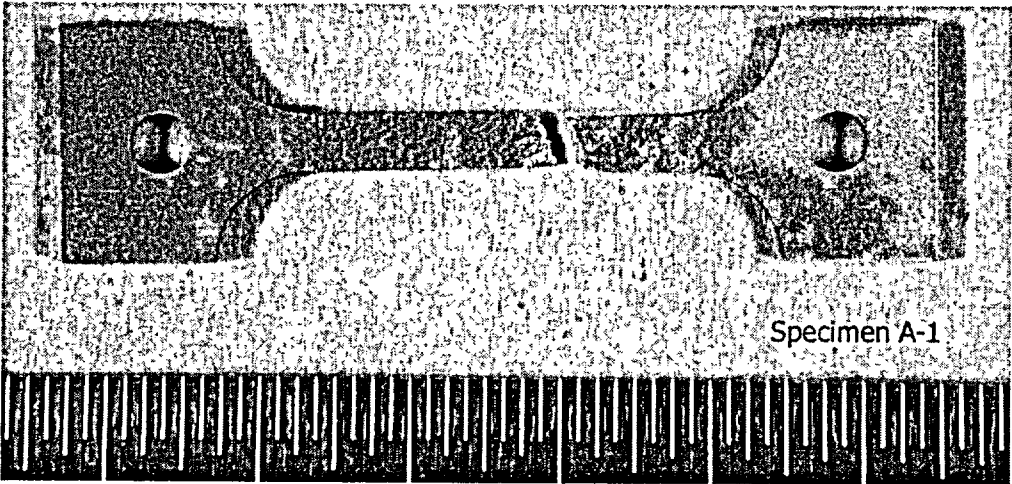


**B2C2A1 – Near RCS      B2C2A2 – Near Low Alloy Steel**

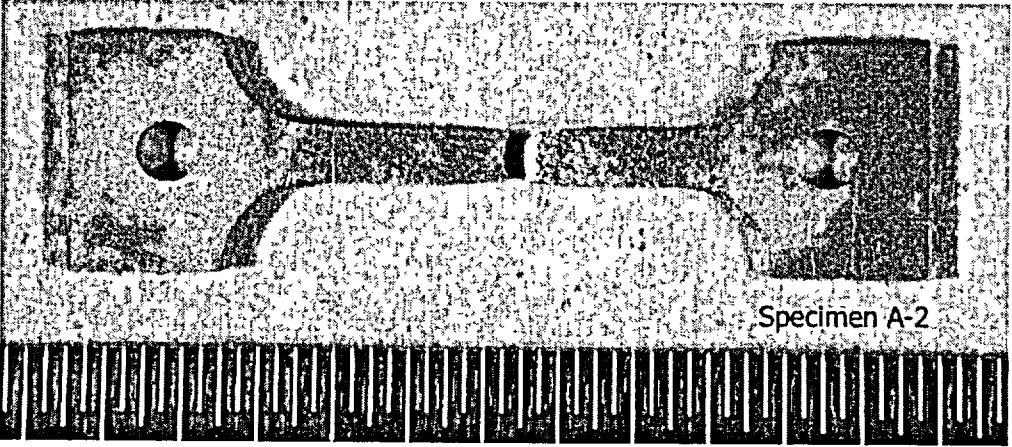




# Tensile Test Results



Specimen A-1



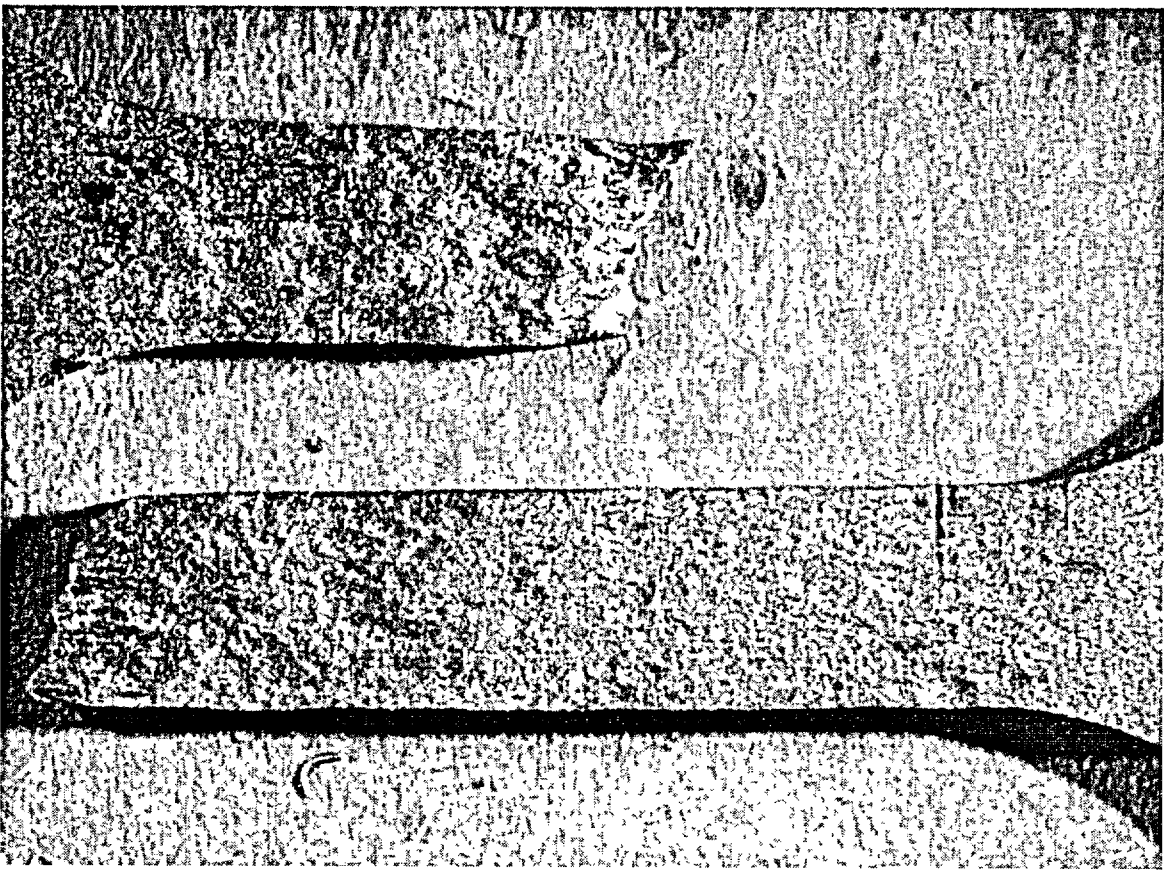
Specimen A-2



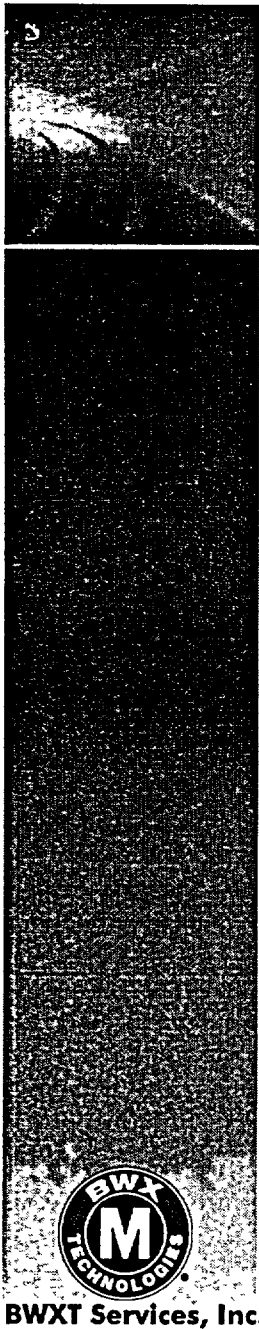
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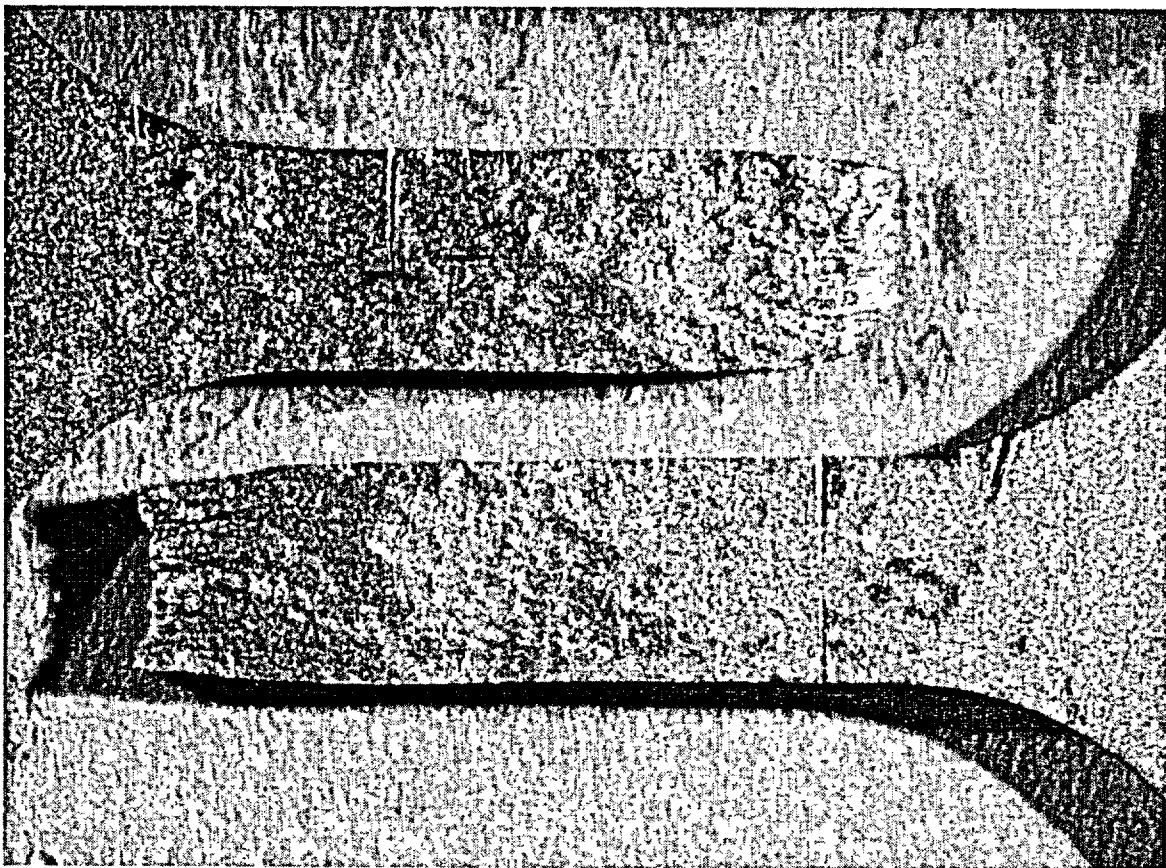
# ***Tensile Test Results***



**Specimen A-1 6X**



# ***Tensile Test Results***



**Specimen A-2 6X**

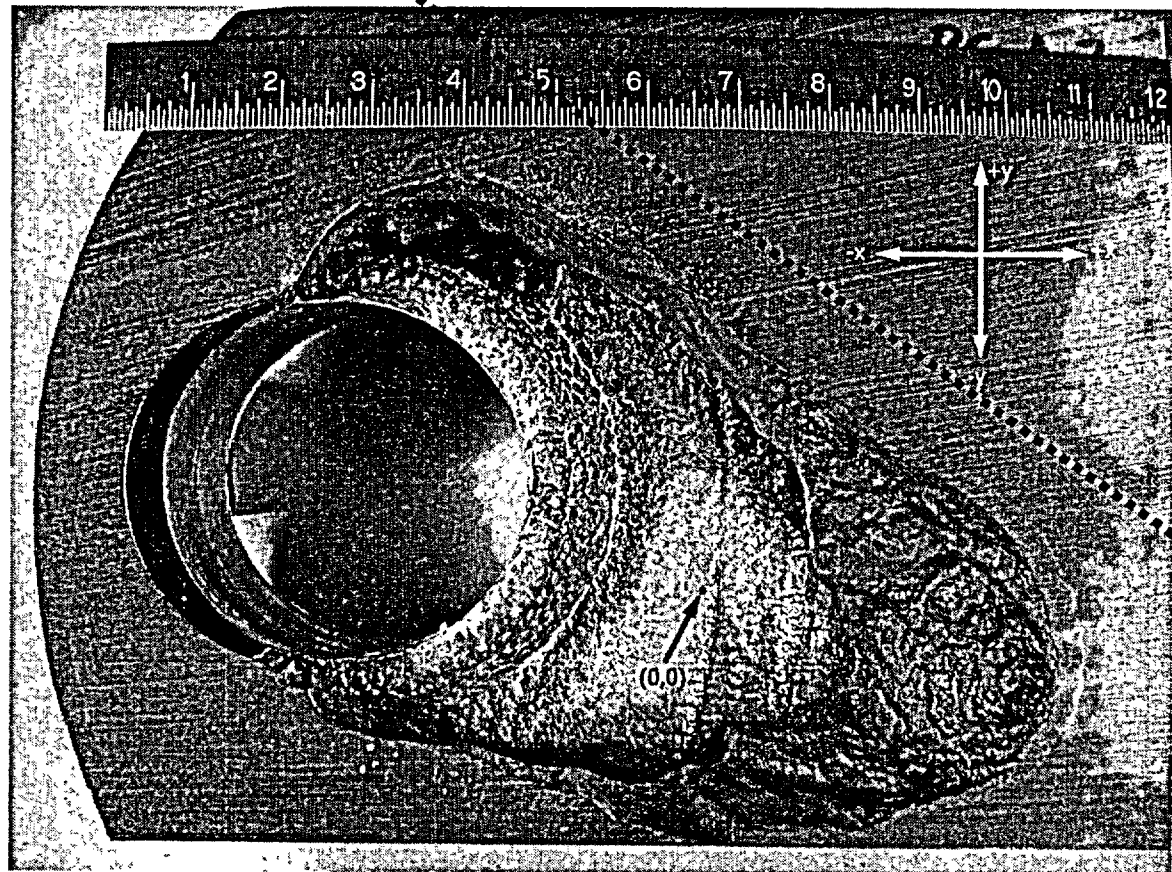
# ***Proposed Work Scope Items***

- Penetrant Test on RCS Side of Clad in Deflected Region (No cracks observed under stereo scope) - *Approved*
- Trim Corner Off Block A-2 to Facilitate Stereo Exam - *Approved*
- Perform Detailed Stereo Exam on Exposed Cladding Cracks and Cavity Side Walls in Block A-2 - *Approved*
- Characterize Cladding Crack Depth and Morphology at Several (~3-4) Locations by Metallography/Microhardness
- Determine Cr Content Through Clad Thickness (EDS Dot Mapping)
- Open Portion of Cladding Crack for SEM/EDS
- Examine Undercut Regions of Cavity by Metallography (Evidence of Cracking or Disbond?)
- Section Block A-1 in 0° to 180° Direction; Examine Side Walls
- Examine Unique Cavity Side Wall Features by SEM/EDS (Cavity Growth Due to Water Level or Microstructure?)



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# ***Proposed Work Scope Items***



Proposed  
Section



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# ***Proposed Work Scope Items***

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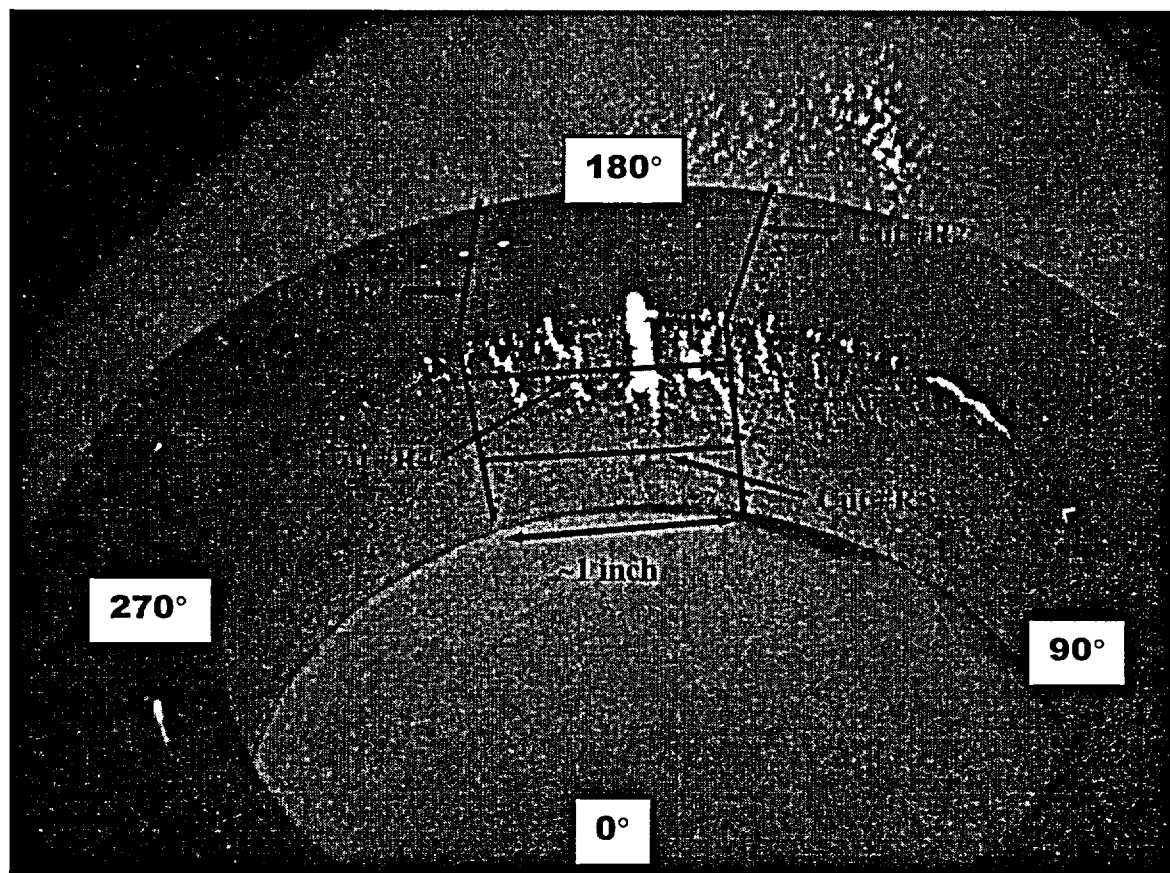
- Examine J-Weld Cracks (Axial at 10° and 180°; Circumferential at 0°- 45°) by Metallography/ Microhardness (Depth and Morphology)
- Open Portion of a J-Weld Crack for SEM/EDS
- Examine Nozzle 3 Cracking by Metallography/ Microhardness (Depth and Morphology)
- Open Portion of Nozzle 3 Crack for SEM/EDS



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# ***Proposed Work Scope Items***

## ***Nozzle 3 Cracks***



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