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Industry NDE of North Anna 2 RPV Head Penetrations 31 & 59

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Review Meeting for NRC RES NA2
CRDM Program

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Main Topics

- Project Background
- NDE Activities
- Geometry and References
- Demonstration
- Nozzle 31
- Nozzle 59

Project Background – Fall 2001

- Fall 2001 – North Anna Unit 2 Reactor Pressure Vessel (RPV) Head Penetrations were inspected via bare metal visuals (BMV) of the upper head surface
- Results of BMV
 - Nozzle 51, 62 and 63 potential leaks
- Tested J-Groove welds with Dye Penetrant
 - Several indications on each weld
- Removed the thermal sleeves
- Performed Ultrasonic (UT) and Eddy Current Test (ECT) from the ID of the nozzles
- Dye Penetrant tested all the welds after repairs were completed
- Returned Head to Service

Project Background – Fall 2002

- Fall 2002 – North Anna Unit 2 was inspected via bare metal visual, eddy current testing of all J-Groove welds, and UT/ETC of nozzle inside diameters
 - Bare Metal Visual
 - 6 potential leaks
 - ECT of the J-Groove Welds
 - 63 of 65 J-Groove welds had indications
 - 42 J-Groove welds would require repair
 - UT/ECT of nozzle ID
 - 6 nozzles with UT OD circumferential indications
- Utility decided to replace the Reactor Vessel Head
 - Agreed to allow EPRI to remove samples form head

Harvesting and Selection of CRDMs

- Harvested six (6) selected CRDM Penetrations for the RPV Head
 - Based on selected damage mechanisms
 - Axial or Circ indications
 - Parent tube or J-Groove weld indications
 - Potential primary coolant leakage
 - Penetrations selected
 - 10, 31, 51, 54, 59 and 63
- Shipped to Pacific Northwest National Laboratories
- Decontaminated four (4) penetrations at PNNL
- Fabricated stand to hold penetrations for vendor inspections

NDE Project Goals

- Perform examinations that were applied in the field
 - Ultrasonic TOFD and PE Straight beam form the tube inside diameter
 - Surface scan of the tube inside diameter with eddy current from 2" above the J-Groove weld to the tube end wet side
 - Surface scan the J-Groove wetted surface weld with eddy current to include any buttering associated with the weldment from the attached tube interface out to and beyond the weld into the cladding
 - Scan the ID surface of the tubing from the upper weld interface to the dry side of the vessel head with available technology to detect possible leakage path of primary coolant
- This is a technology evaluation project; not vendor comparison

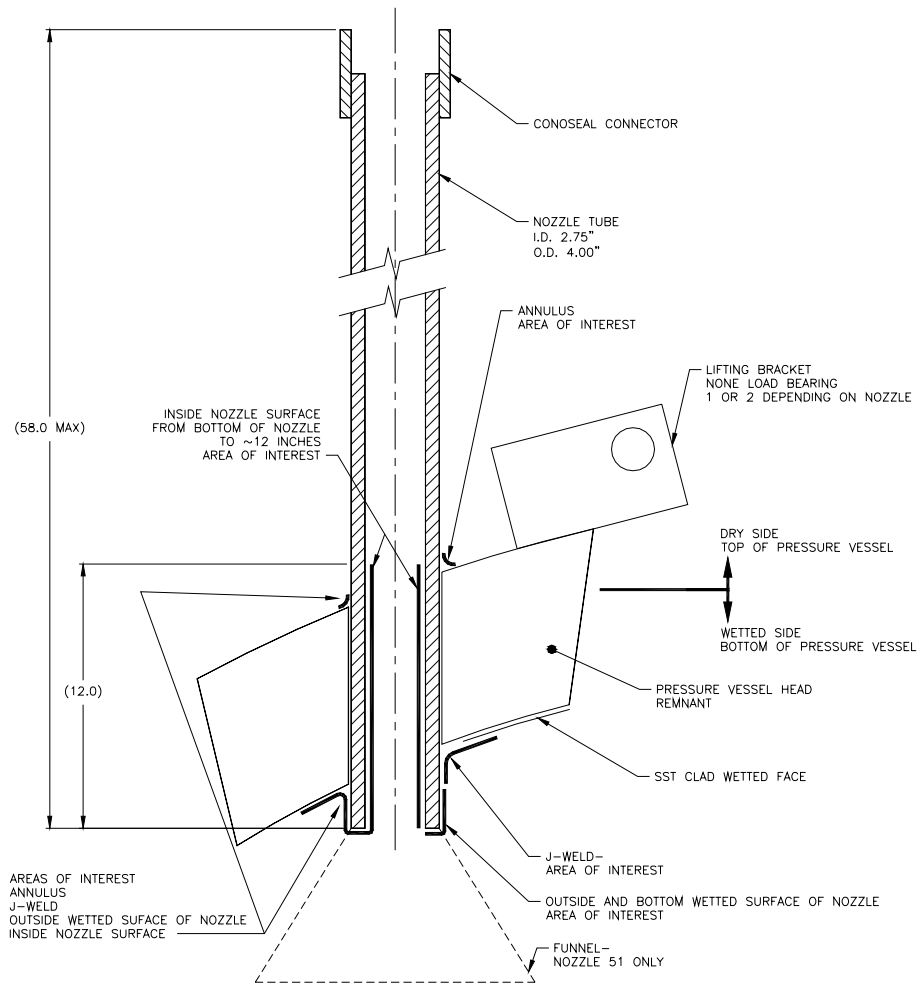
Vendor Examinations by Technique

- Vendors developed their own examination programs that included the following:
 - Ultrasonic scanning of the tube ID from the tube end wet side to above the dry side of the vessel head using:
 - TOFD and Pulse echo straight beam
 - Pulse echo shear wave
 - Electromagnetic Acoustic Transmission (EMAT) from the tube OD above the reactor head
 - Eddy Current surface scan with plus point / driver pick-up technology from the tube end wet side to above the J-Groove ID of the tubing
 - Some low frequency data was collected tube ID above the J-Groove
 - Specialized eddy current scans of the tube ID and OD accessible surfaces and the J-Groove weld
 - Array driver/pick up probes on the wetted surface of the J-Groove weldment
 - Hall effect probes for magnetic residual field detection

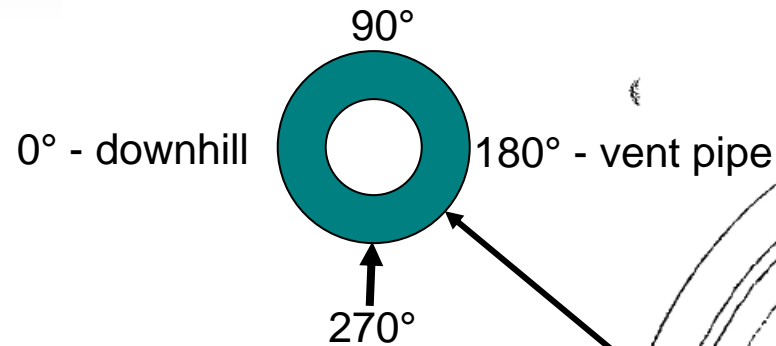
NDE Examination Activities

- RPV CRDM NDE Examination Activities
 - December 2003 to March 2004
 - At Pacific Northwest National Laboratories
 - Vendor Invitations
 - 7 Vendors were invited to participate
 - 4 Vendors accepted
 - R Brooks & Associates Inc.
 - Areva (Framatome-ANP)
 - Pacific Gas & Electric Inspection
 - WesDyne International Inc.

Areas of Interest



Geometry of the Area of Interest of the Samples

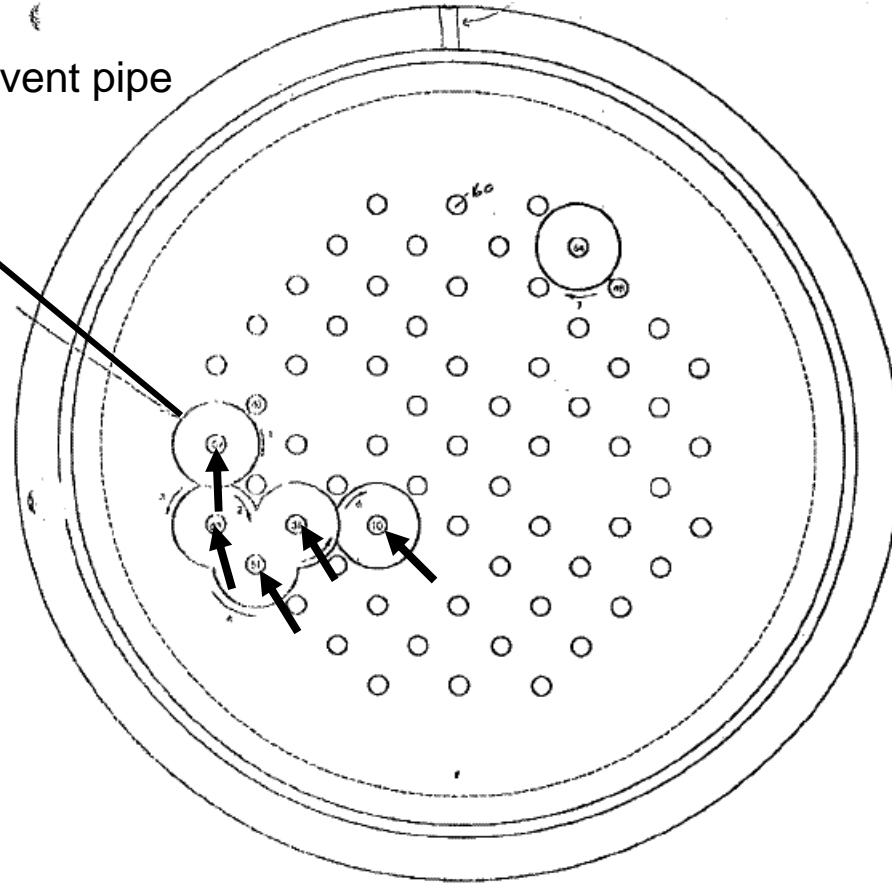


The head as
seen from
above

References

Angles: 0° =
downhill; the arrow
points to the 270°
location of the
penetration

Elevation: 0 " =
penetration bottom
end



Establishing Reference Points

- Reference points for reporting indications
 - Angular ZERO is lowest point of OD of head and CW (+) is looking down from the Adaptor
 - Tube end was notched for ZERO reference location

Zero Axial
Reference

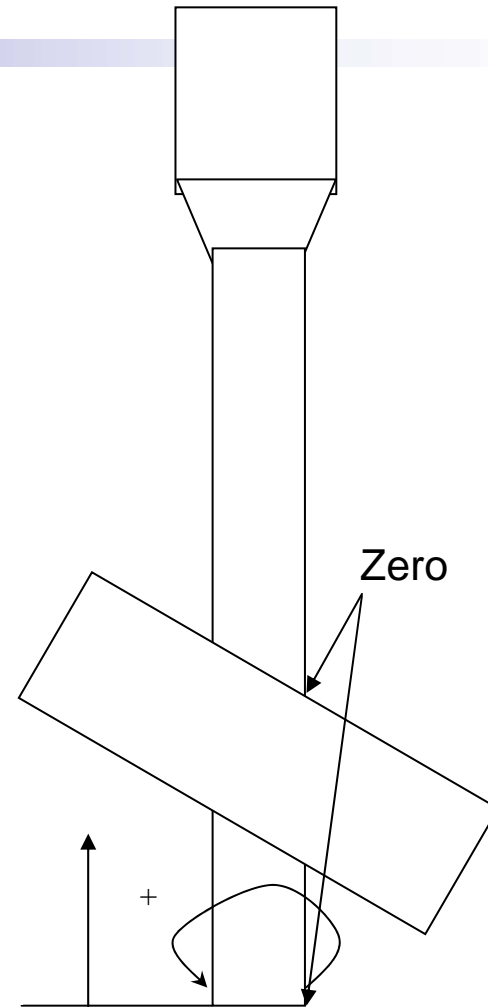


Photo of a Penetration at PNNL



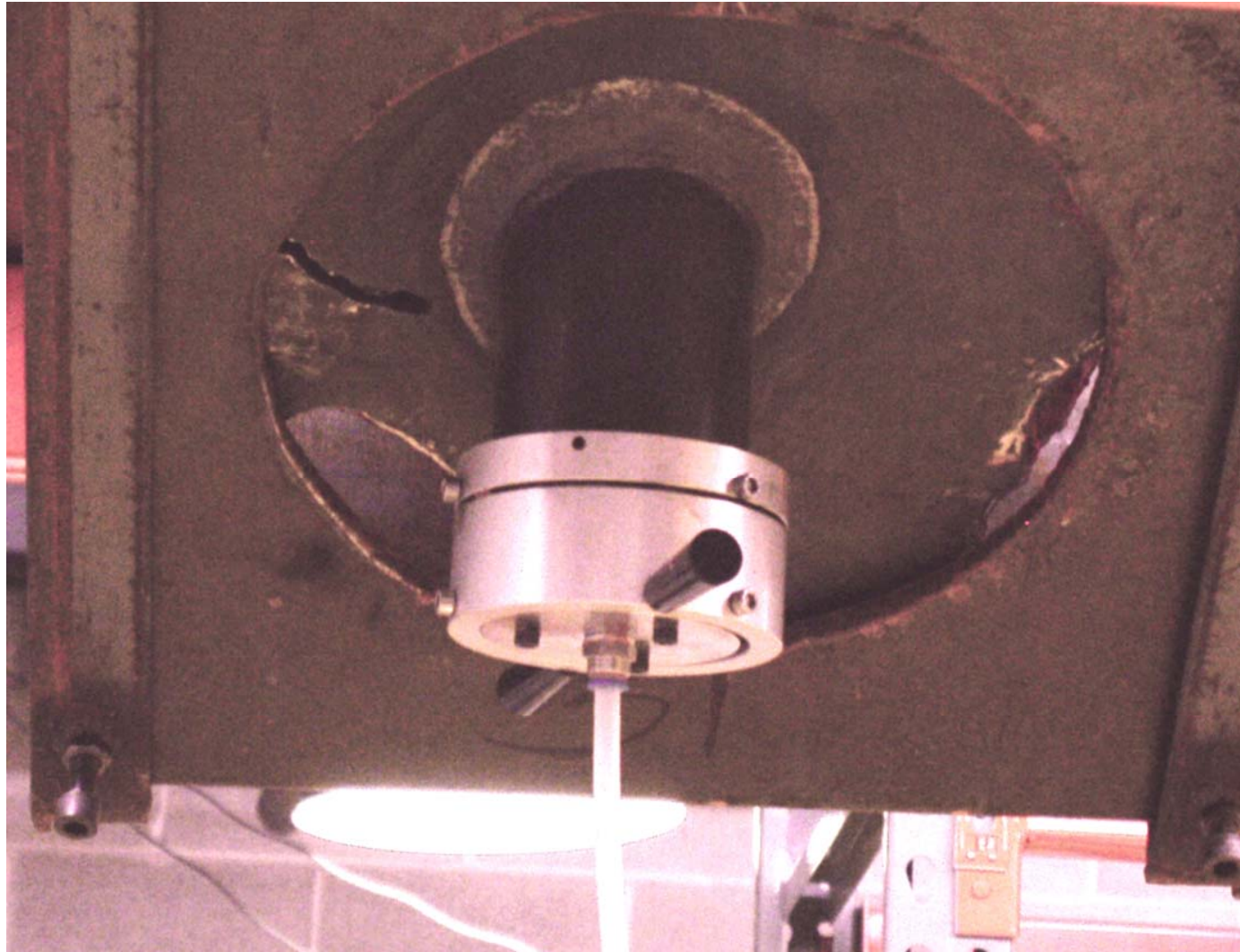
EMATS Guide Wave Examination



Photo of Pallet Stand



Pallet JIG to hold Penetrations



Penetration Nozzle 31

- Three vendors inspected the nozzle to various degrees
 - UT & ET tube ID and EMATS
 - EMATS data was inconclusive due to upper end adaptor signal interference
 - J-Groove weld wet surface not inspected
 - A new technology (ET) identified a possible leak path
 - UT reported intermittent Weld Interface Indications (WII) 360° around the interface of the J-Groove to tube

Penetration Nozzle 31 Summary

• *2002 Field Results*

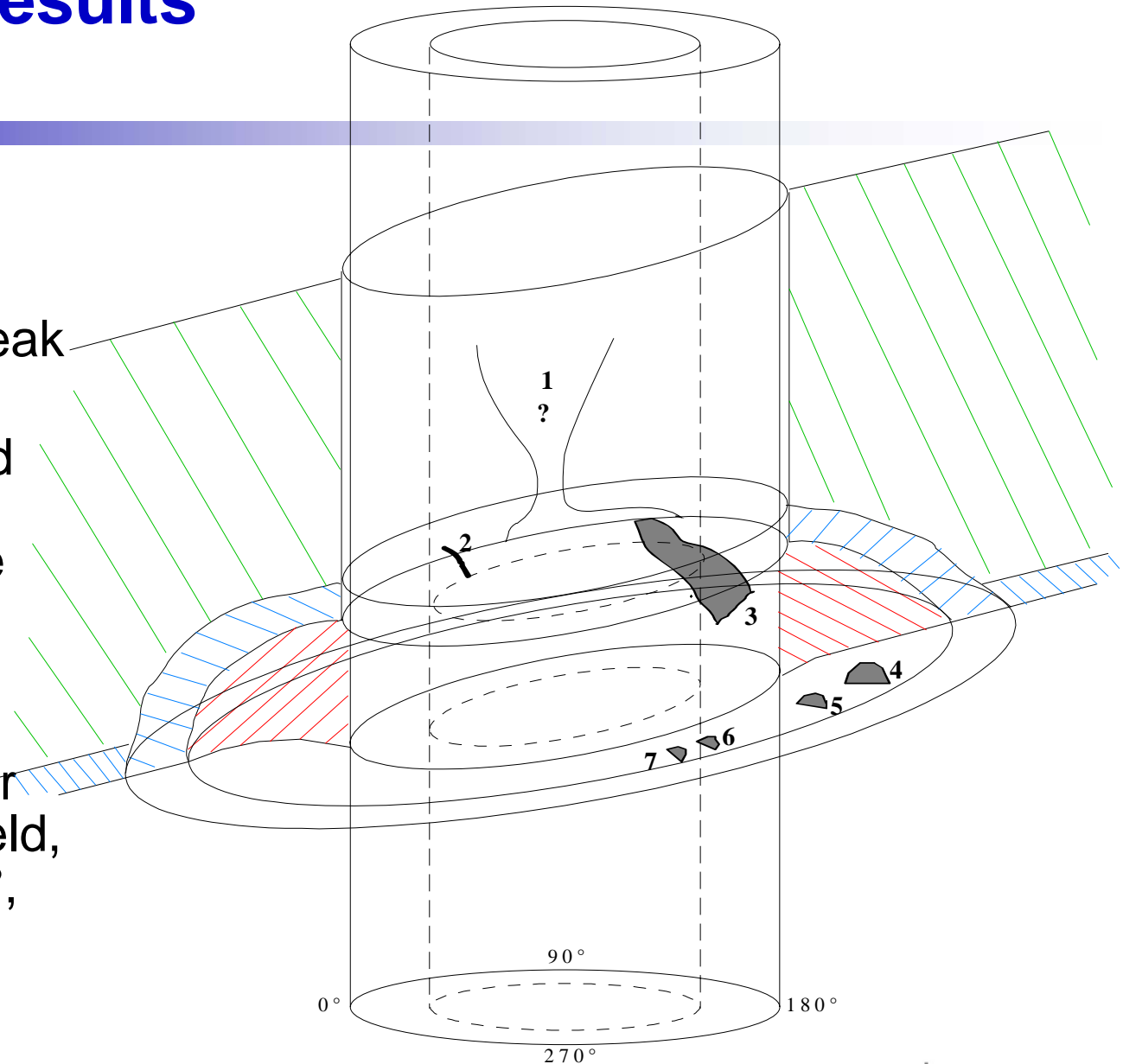
- BMV Visual: Leak indicated
- **UT 1:** possible leak path, 80/120°
- **UT 2:** nozzle mid wall indication, 0.28", above the weld, 300/304°
- **ET 3 to 7:** weld surface axial indications, outer portion of the weld, 154°, 209°, 235°, 264°, 265°

• *Vendors Inspection Results*

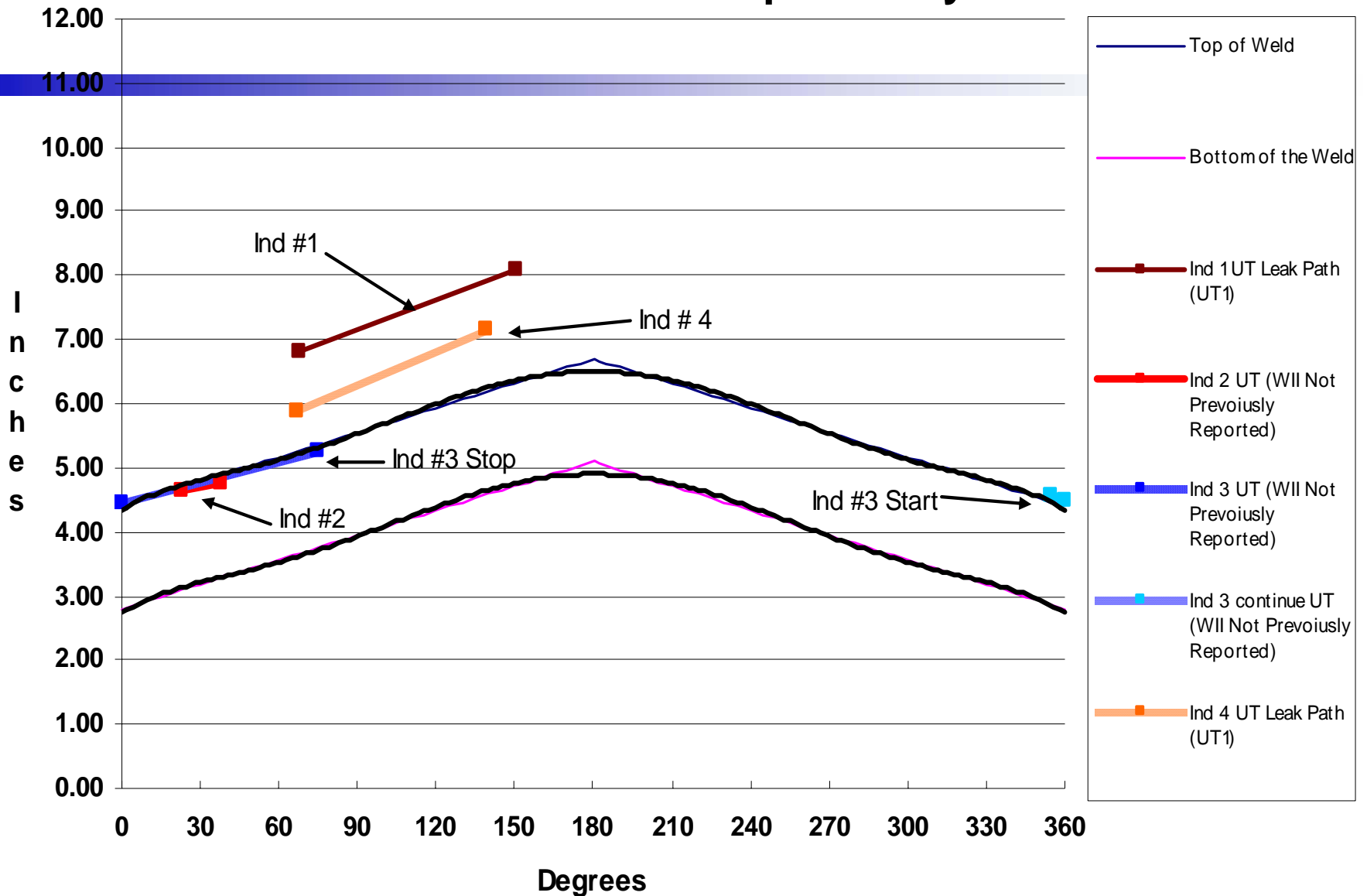
- Visual: Not Applicable
- **UT 1:** Two vendors reported possible leak path
- **UT 2:** Mid wall indication not reported
- **ET 3 to 7:** No vendor examined this region
- ***Newly reported UT LOF intermittent around weld, ET Permeability Variation (PV) indications above weld and ET (Low Freq) possible leak path***

Field NDE Results

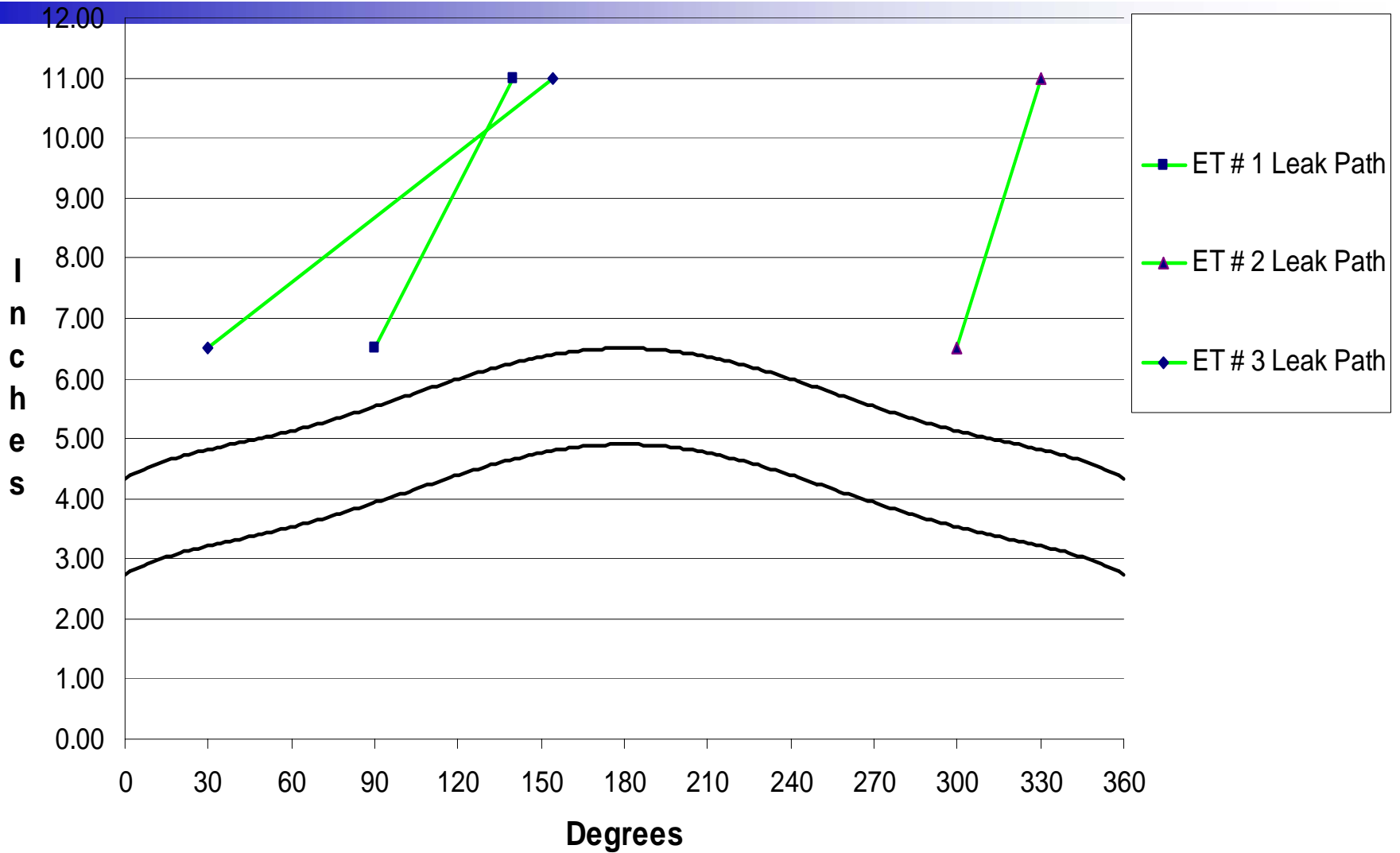
- **Penetration 31:**
- **Visual: leaking**
- **UT 1:** possible leak path, 80/120°
- **UT 2:** nozzle mid wall indication, 0.28", above the weld, 300/304°
- **ET 3 to 7:** weld surface axial indications, outer portion of the weld, 154°, 209°, 235°, 264°, 265°



Nozzle 31 UT Indications Reported by Vendors



Nozzles 31 ET Indications Reported by Vendors



Penetration Nozzle 59

- Three Vendors inspected the nozzle
 - UT, ET, and EMATS
- J-Groove weld wet surface not inspected at PNNL
 - Indications 2 and 4 in the weld wetted surfaces were reported in the original field NDE. These were not re-inspected
- UT reported one additional axial indication, not reported during field NDE
- This penetration has indications to penetration 54

Penetration Nozzle 59 Summary

- **2002 Field Results**

- **Visual : masked**

- **UT 1:** circumferential indication at the nozzle OD, middle of the weld, 347/63°
- **ET 2:** multiple weld surface circumferential indications, outer portion of the weld, 49/136°
- **UT 3:** OD circumferential indication, top of the weld, 156/206°
- **ET 4:** multiple weld surface circumferential indications, outer portion of the weld, 256/306°
- **UT 5:** axial indication on the nozzle ID, above the weld, 159°
- **ET 7:** axial nozzle ID indication, opposite middle of the weld, extends above the weld, 146°

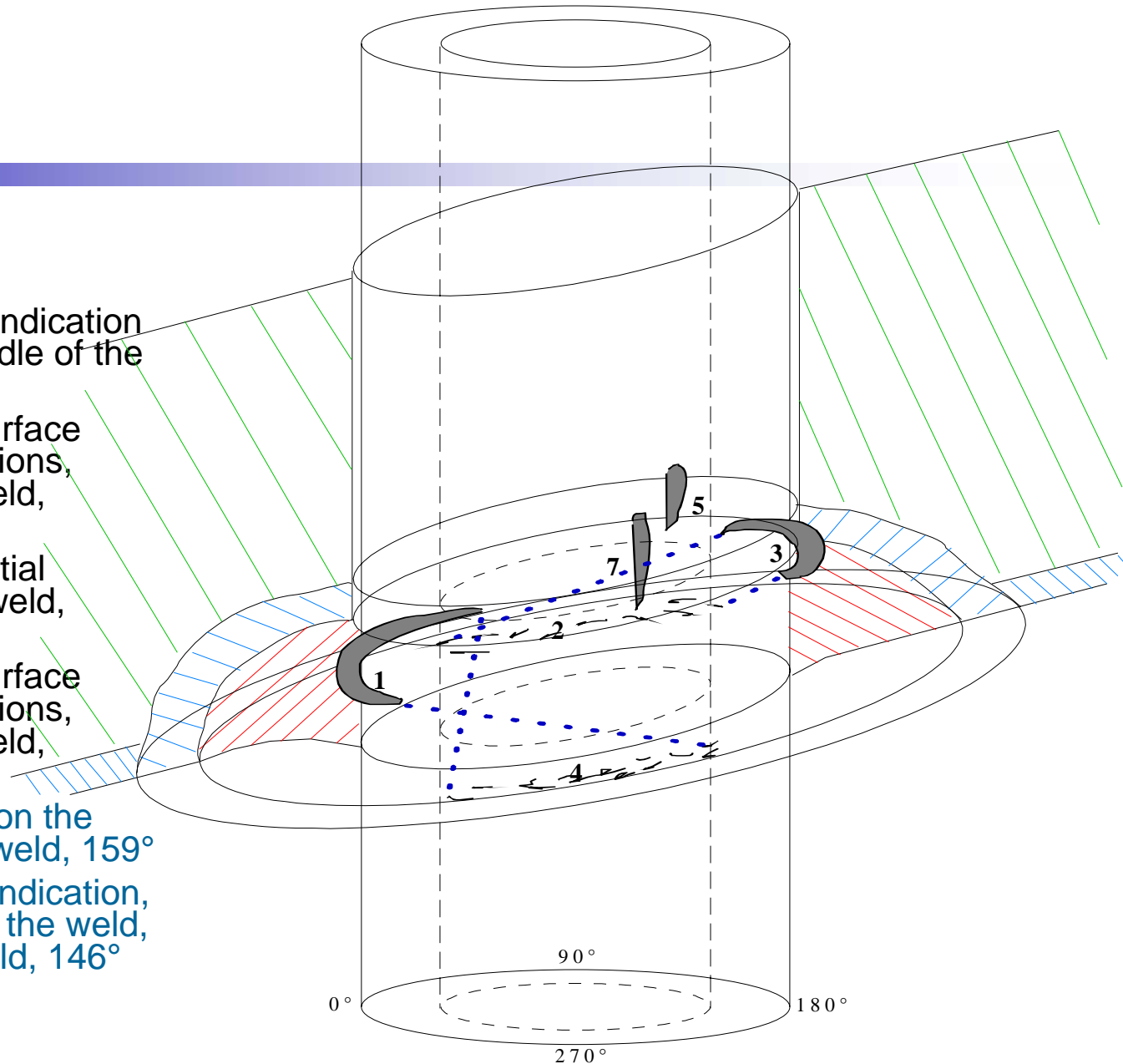
- **Vendors Inspection Results**

- **Visual: Not Applicable**

- **UT 1:** One vendor reported same indication
- **ET 2:** No vendor inspected this region
- **UT 3:** One vendor reported same indication
- **ET 4:** No vendor inspected this region
- **UT 5:** One vendor reported same indication
- **ET 7:** One vendor reported indication with ET and one vendor with UT
- ***One new axial indication was reported using UT***

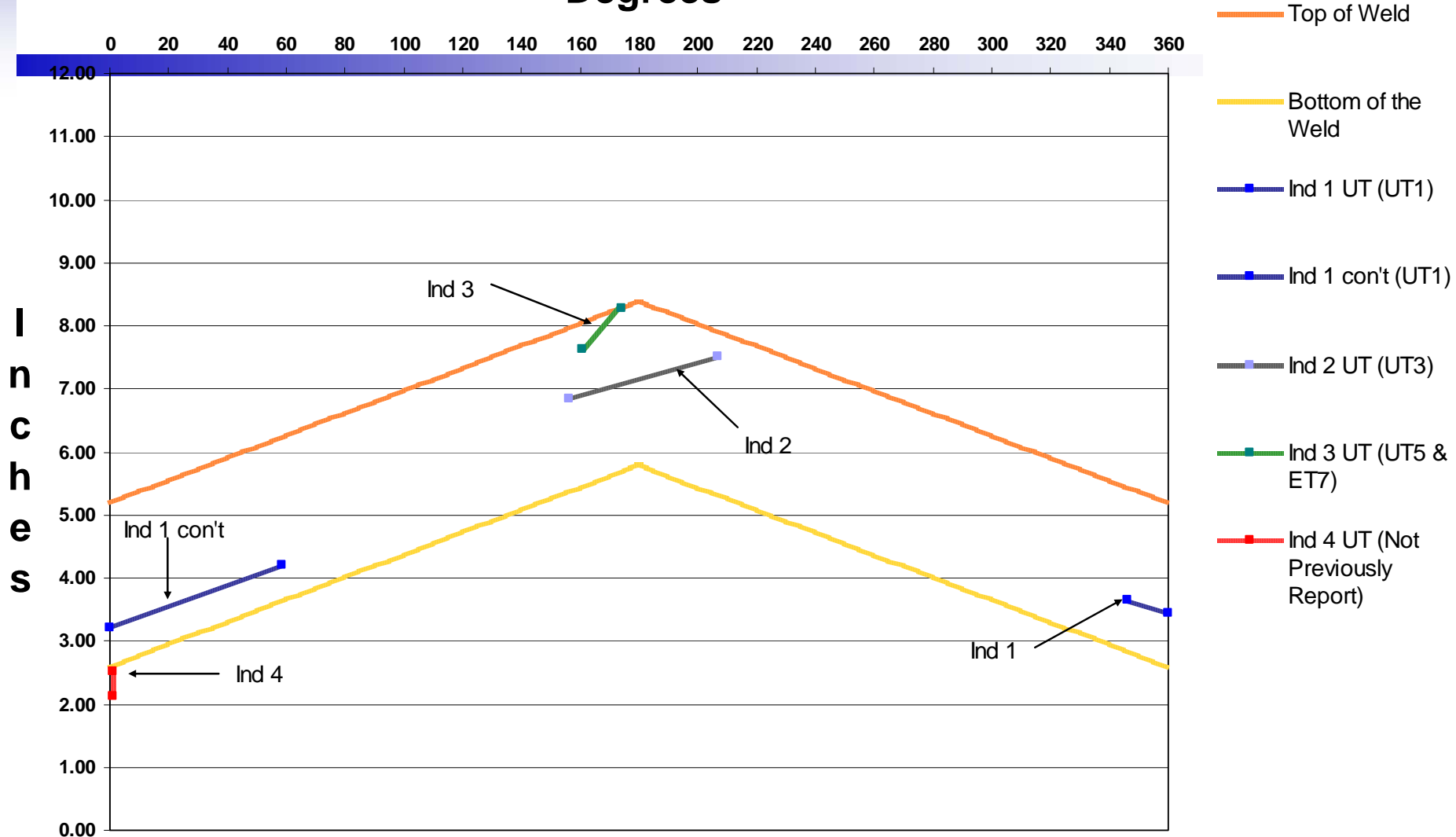
Field NDE Results

- **Penetration 59:**
- **Visual : masked**
- **UT 1:** circumferential indication at the nozzle OD, middle of the weld, 347/63°
- **ET 2:** multiple weld surface circumferential indications, outer portion of the weld, 49/136°
- **UT 3:** OD circumferential indication, top of the weld, 156/206°
- **ET 4:** multiple weld surface circumferential indications, outer portion of the weld, 256/306°
- **UT 5:** axial indication on the nozzle ID, above the weld, 159°
- **ET 7:** axial nozzle ID indication, opposite (?) middle of the weld, extends above the weld, 146°

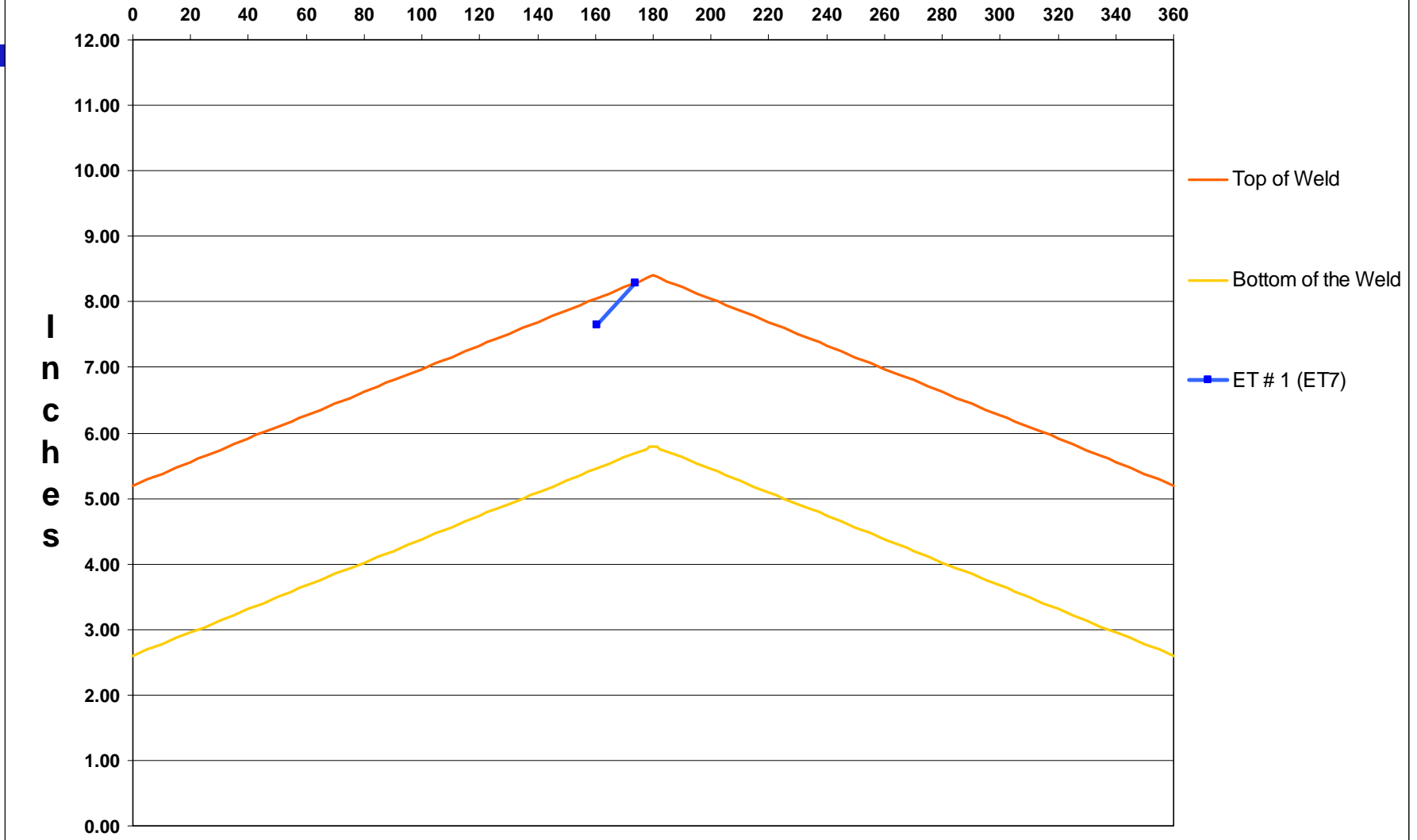


Nozzle #59 UT Indications Reported by Vendors

Degrees



Nozzle #59 ET Indications Reported by Vendors Degrees



Summary

- Awaiting final destructive analysis on penetrations 54, 31 and 59 before final report on NDE performance
- Many flaws located in the weld material not re-examined due to configuration of penetration support jig not allowing for tools to properly access the J-Groove weld
- Some vendors had equipment problems and did not complete their planned inspections
- Some new equipment and probe designs show inspection improvements
- Some activities were truly research and development of new equipment and inspection techniques