



ISG-TIP-2 Task Coordinating Group Meeting
Argonne National Laboratory
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EDDY CURRENT PERFORMANCE DEMONSTRATION for CANDU Steam Generators

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TOPICS COVERED

1. CANDU Steam Generator Specifics:
 - Tube material
 - Tube size
 - Flaw & noise
 - Probes
2. Validation Approach for POD & Sizing
 - Pulled tubes
 - Lab defects and field noise
 - Signal Injection and Signal Subtraction
3. Quantifying ET signals
4. Standardizing probe responses

CANDU Steam Generator Tube Properties

Station	Material	OD	Wall Thickness	Flaws
Pickering	Monel 400 (Ferromagnetic)	12.7 mm (0.498")	1.2 mm (0.049")	Pitting Wastage Erosion/Corrosion
Bruce	Inconel 600	13.0 mm (0.510")	1.1 mm (0.044")	SCC/U-bend/TS Fatigue Cracking Fretting Wear Loose Parts Damage
Pt. Lepreau	Incoloy 800	15.9 mm (0.625")	1.1 mm (0.044")	Wastage/Pitting Fretting Wear
Gentilly	Incoloy 800	15.9 mm (0.625")	1.1 mm (0.044")	Fretting Wear Loose Parts Damage
Darlington	Incoloy 800	15.9 mm (0.625")	1.1 mm (0.044")	Fretting Wear Loose Parts Damage

Probes Used in Canadian CANDU Steam Generator Inspections

Probe	Probe Type	Station	Application
C3	Transmit/Receive Multi-coil Array Probe for Circ. Cracks and Volumetric Flaws	Bruce	IGA, PWSCC, ODSCC at Tubesheet ODSCC at U-Bend Sizing of Fretting Wear ODSCC at tubesheet
Plus-Point MRPC®	Rotating Differential Cross- Wound Tangent Probe	Bruce Darlington	
Bobbin	Bobbin	Bruce Darlington Pt. Lepreau Gentilly 2	Fretting Wear, Pitting Quantify Deposits, Tube Deformations
C5	Transmit/Receive Multi-Coil Array Probe for Circ., Axial and Volumetric Flaws	Darlington Gentilly 2	Accurate Sizing of Fretting Wear, Loose Parts Damage
CTR1	Magnetic Saturating Bobbin	Pickering	Fretting Wear, Pitting, Wastage Erosion/Corrosion Wastage
CTR2-C4	Magnetic Saturating Multi-coil Array Probe for Axial Cracks and Volumetric Flaws	Pickering	Accurate Sizing of Erosion/Corrosion Flaws

Eddy Current Performance Demonstration for CANDU Steam Generators

Date

Work Plan

1998 Dec

Generate POD and Sizing Accuracy Curves for detecting Fretting Wear Scars in Darlington type SG tubes.

1999 Mar

Generate POD and Sizing Accuracy Curves for detecting SCC in Bruce type SG tubes.

1999 Sep

Develop Techniques for generating SCC (axial and Circumferential) in 16 mm (5/8") SG tubes.

2000 Mar

Generate POD and sizing accuracy curves for detecting SCC in 16 mm (5/8") SG tubes.

2001 Mar

Qualify computer algorithms for fast analysis of eddy current signals.

2002 Mar

Incorporate data into the "site-specific" CANDU component of EPRI's Industry Database (IDB)

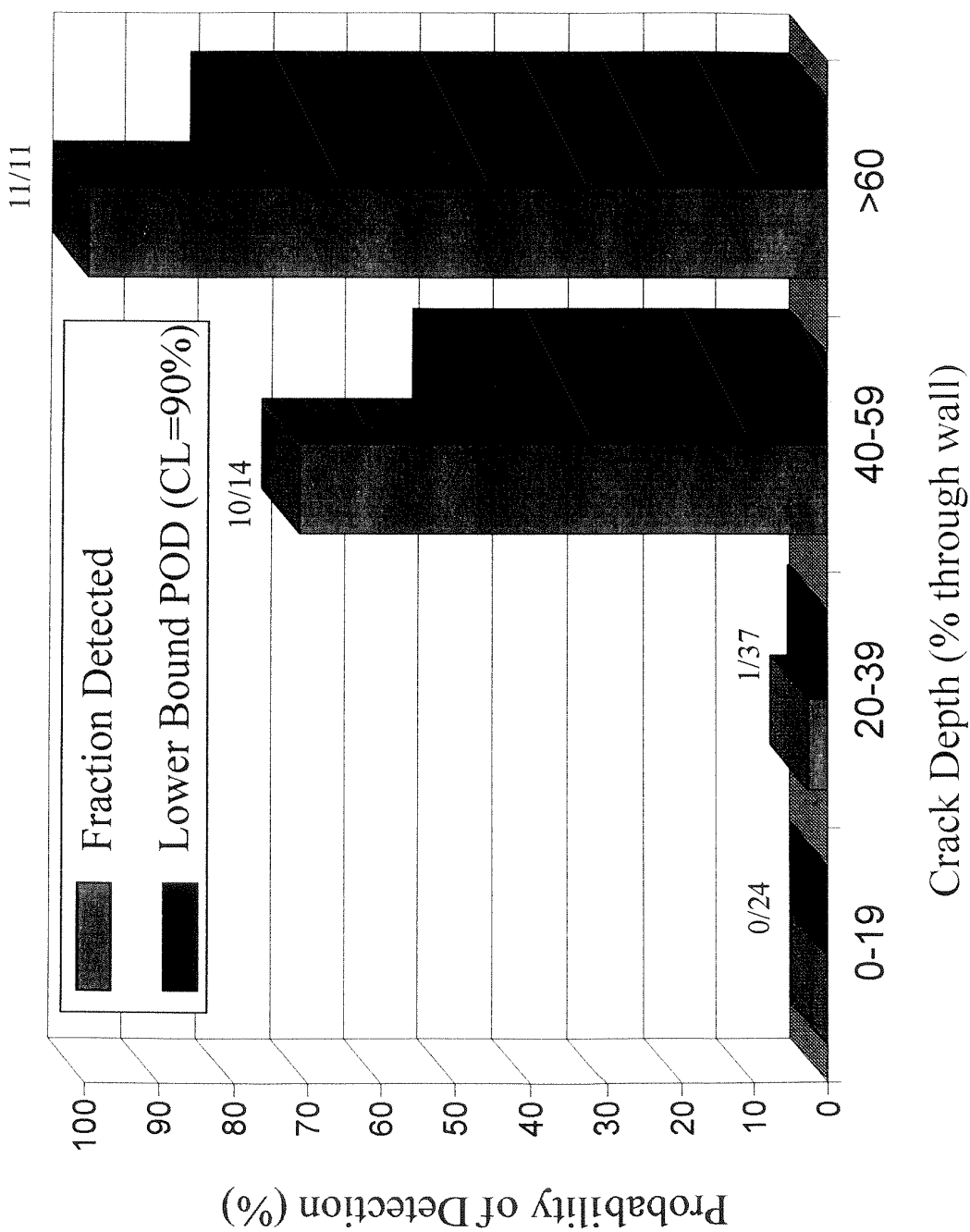
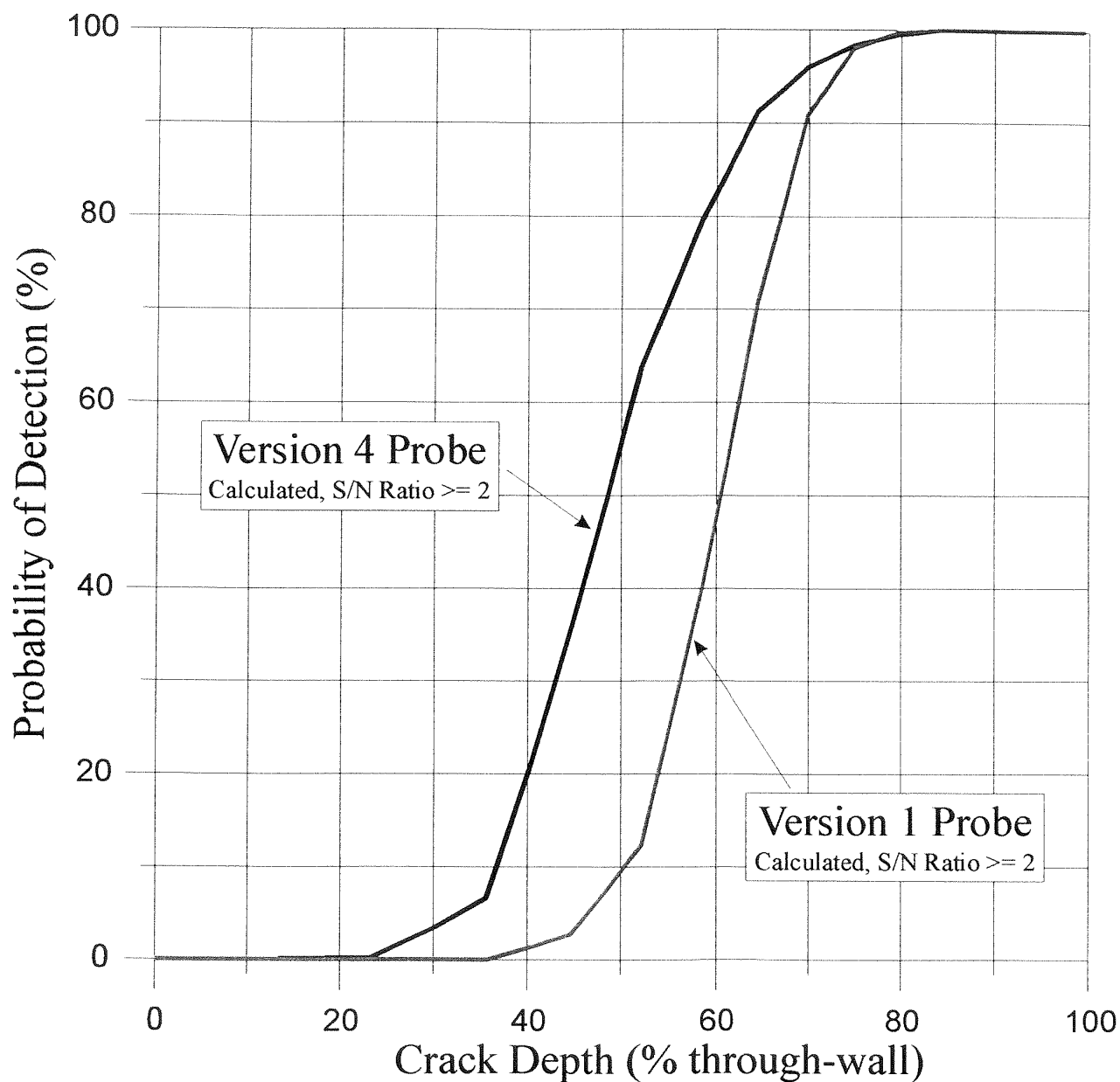
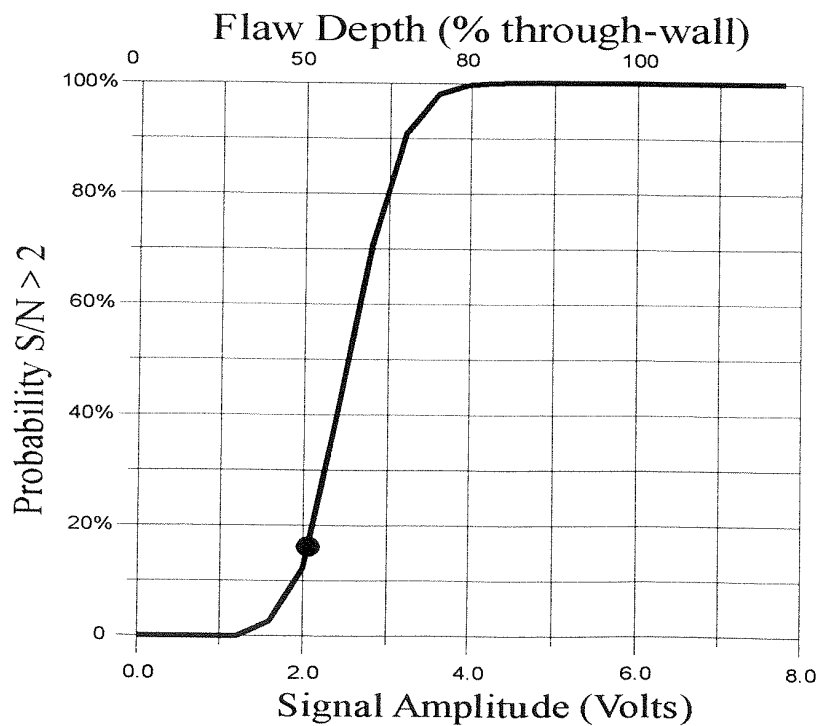
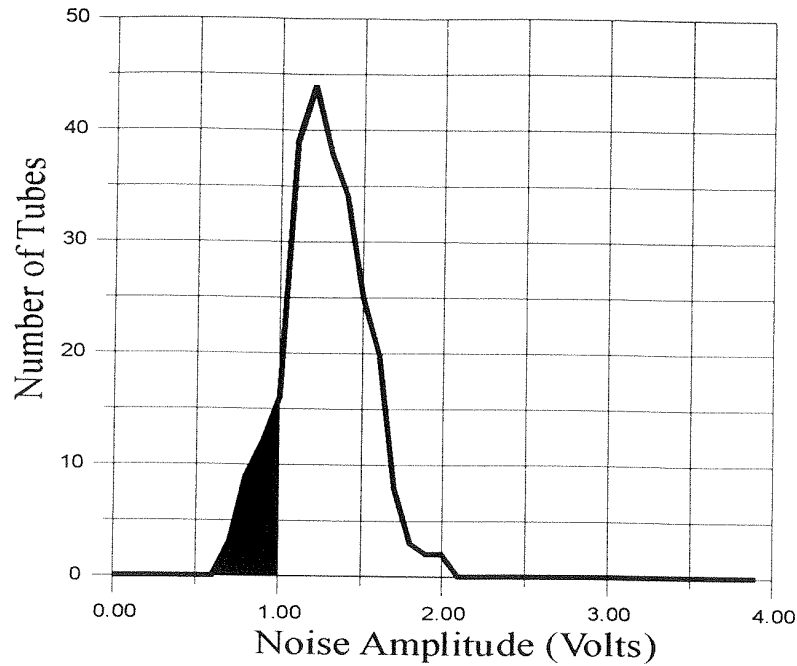


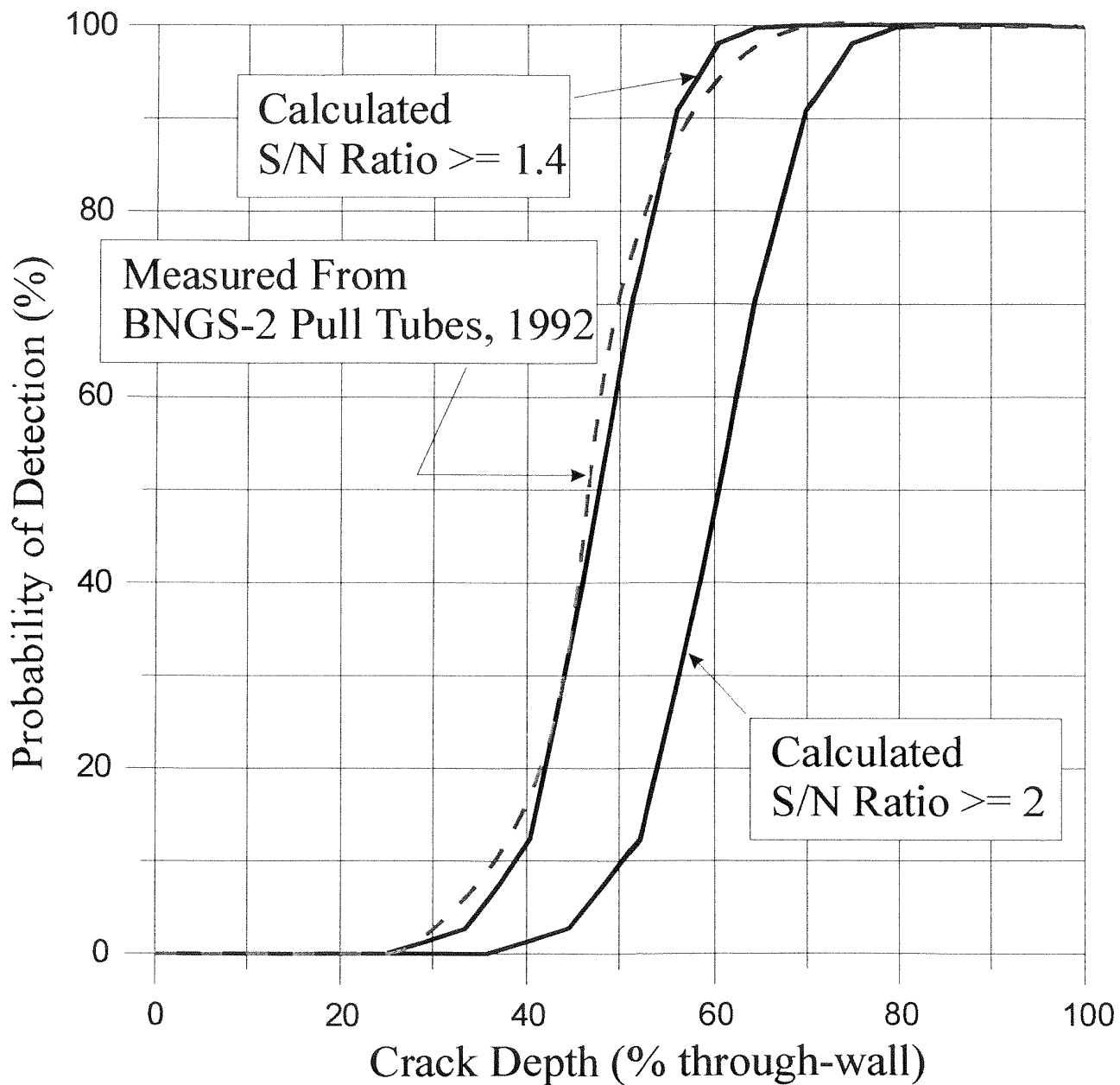
Figure: POD histogram for C3 probe detecting ODSCC in Inconel 600 steam generator tubes. This data is based on pulled tube results.



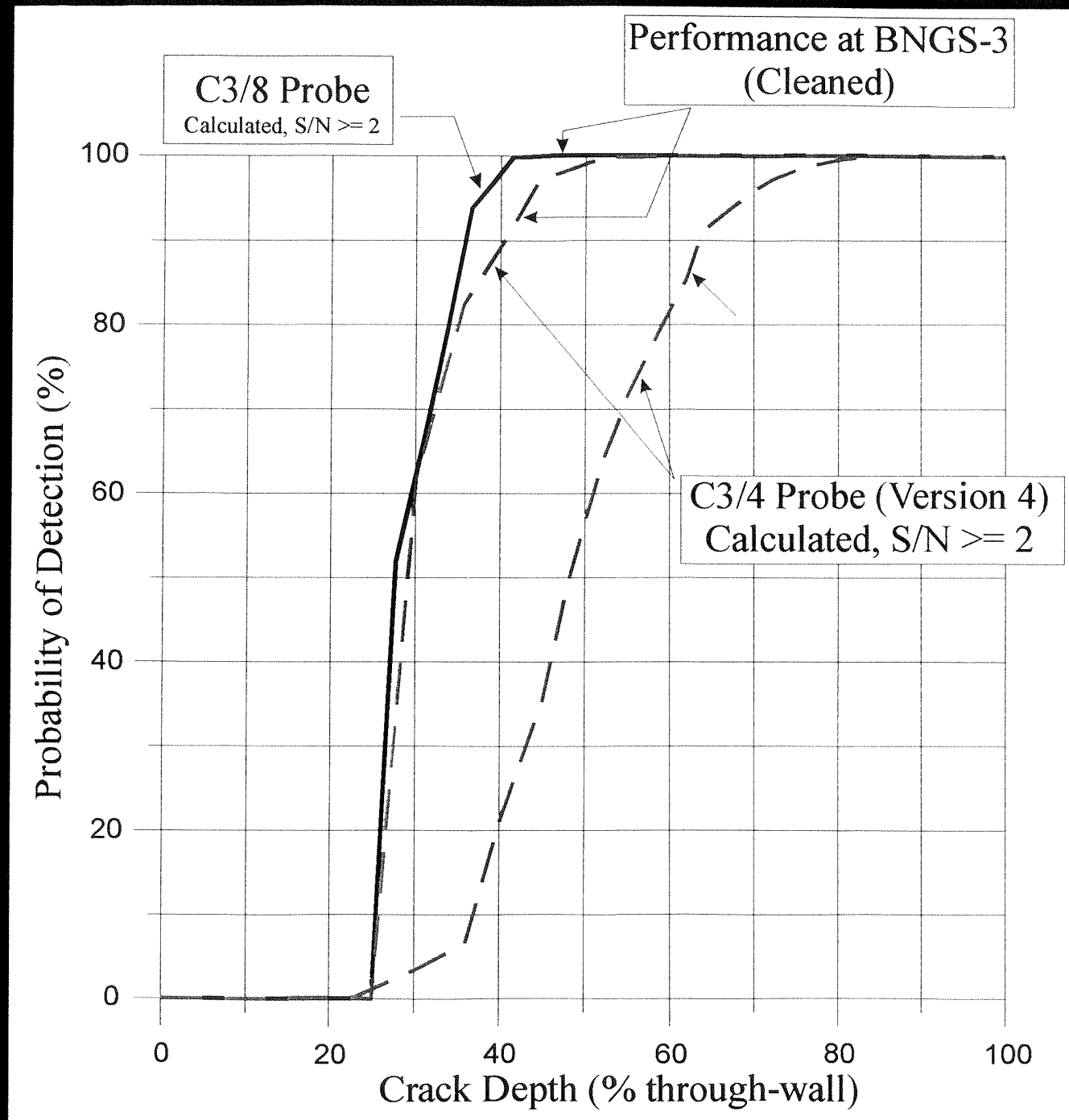
POD curves for C3/4 probe detecting circumferential OD stress corrosion cracks at the HU1 support plate location.



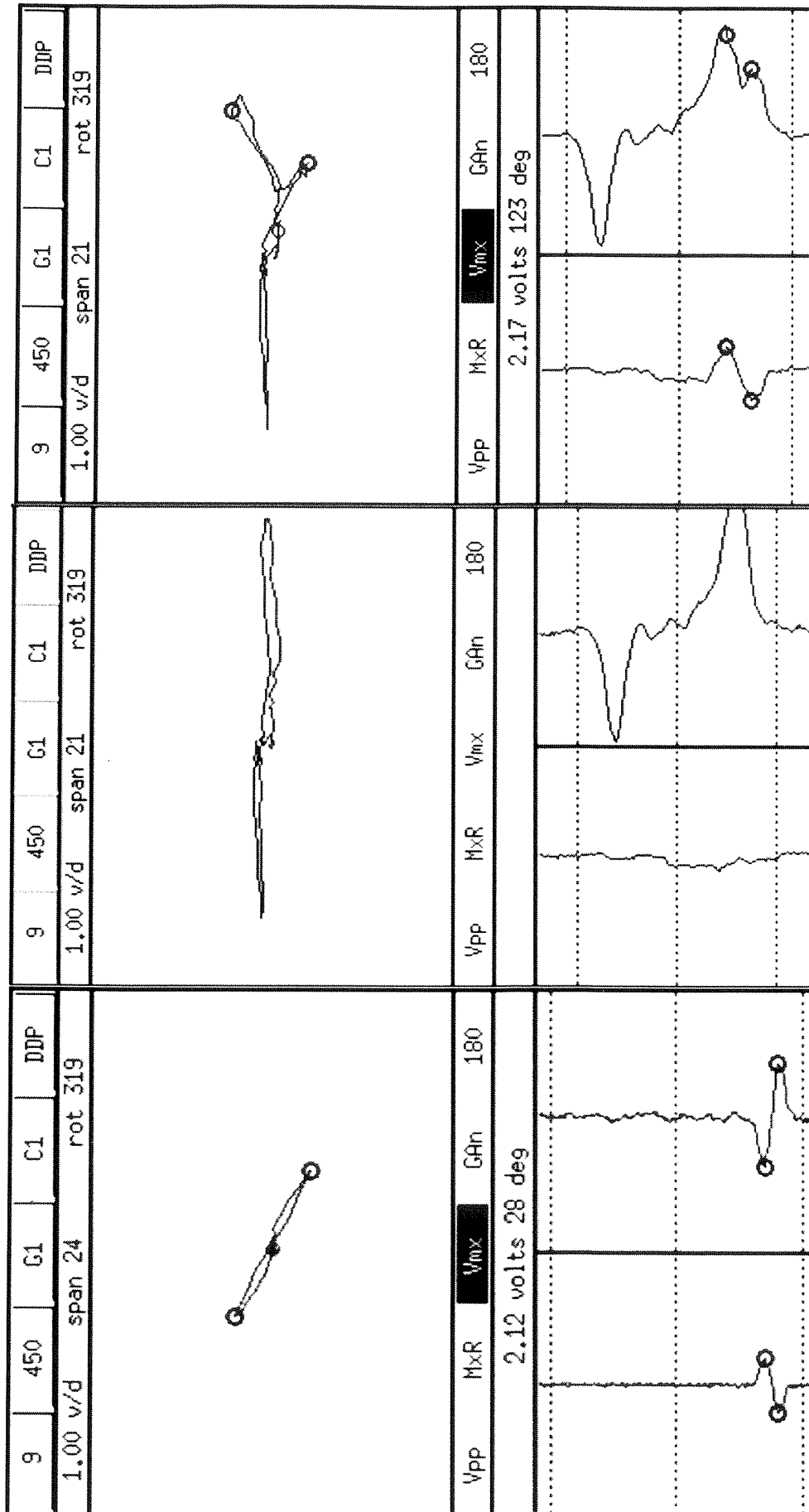
Calculated C3/4 probe probability of detection curve, using circumferential crack signals and field noise.



POD curves for C3/4 probe detecting circumferential OD stress corrosion cracks at the HU1 support plate location.



POD curves calculated for C3/4 and C3/8 probes detecting circumferential OD stress corrosion cracks at the HU1 support plate locations in chemically cleaned SG tubes.



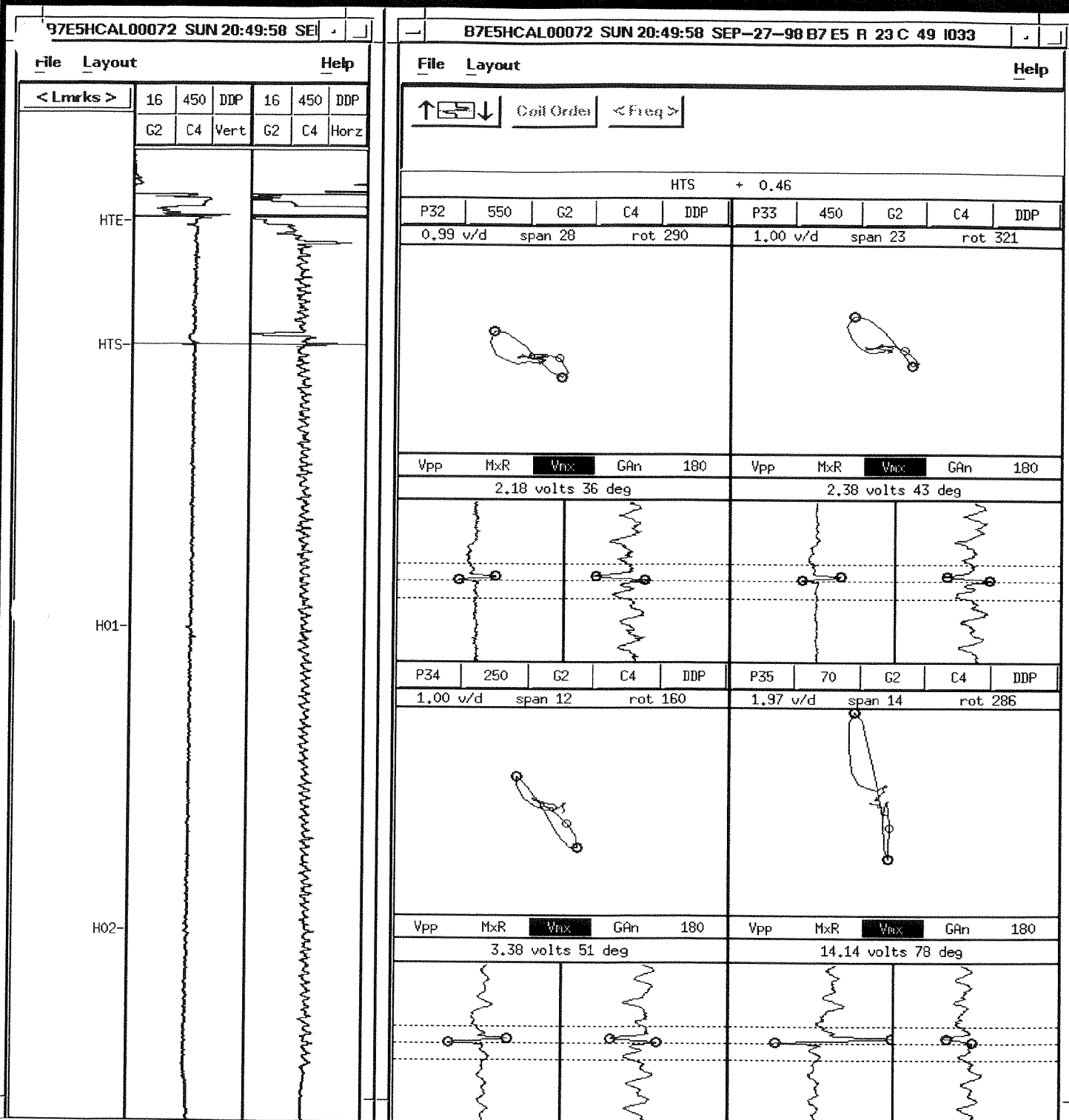
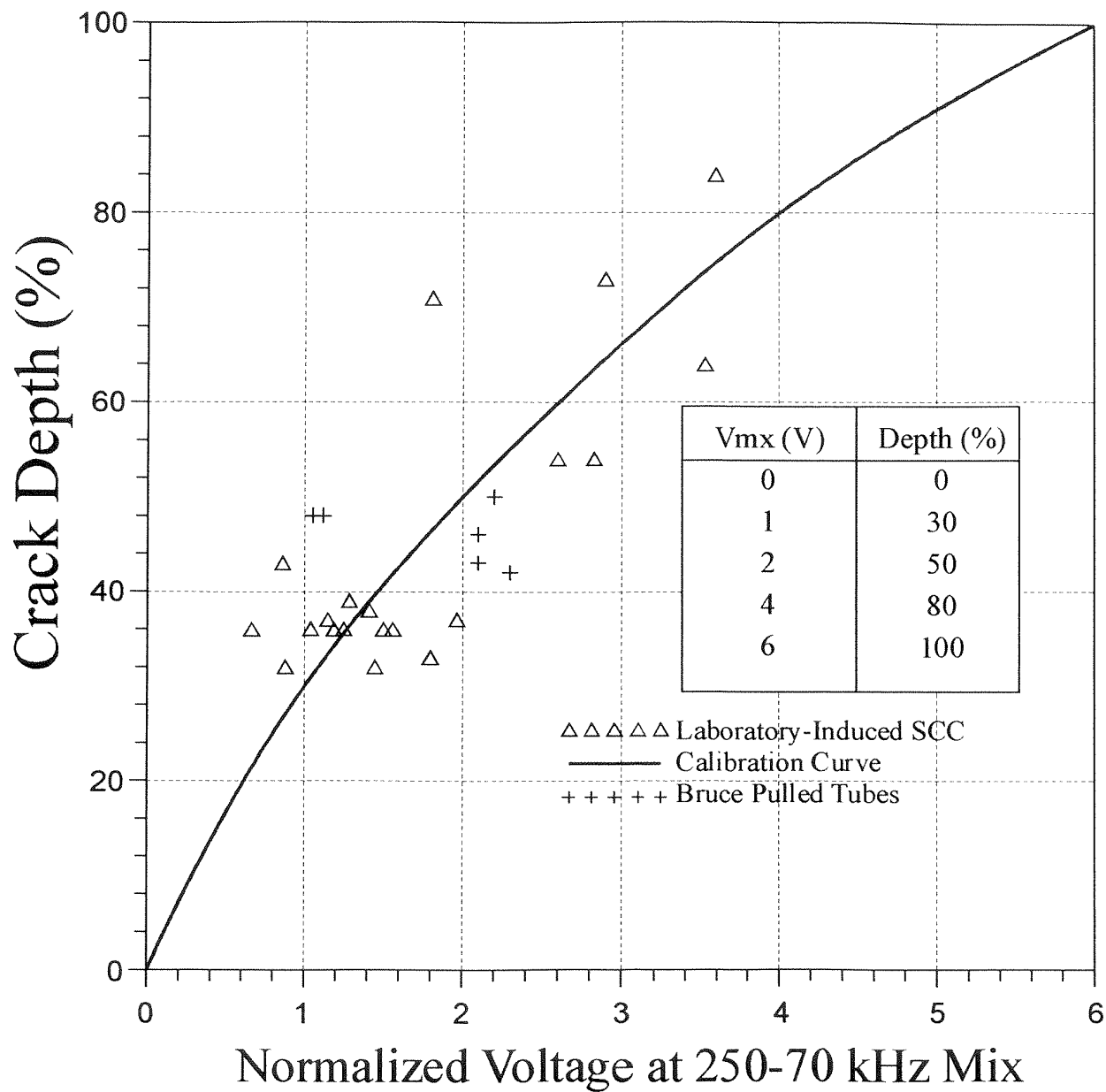
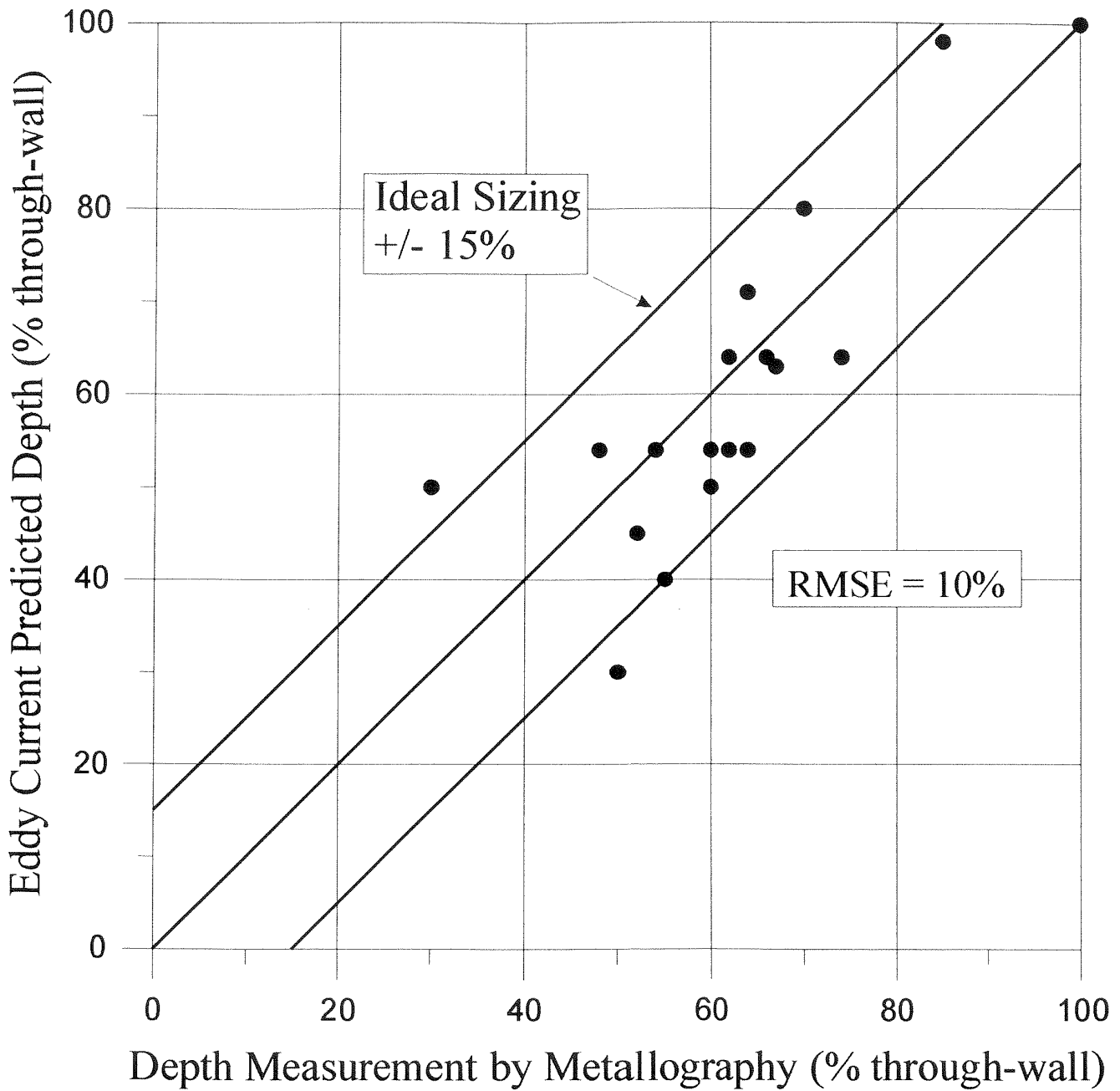


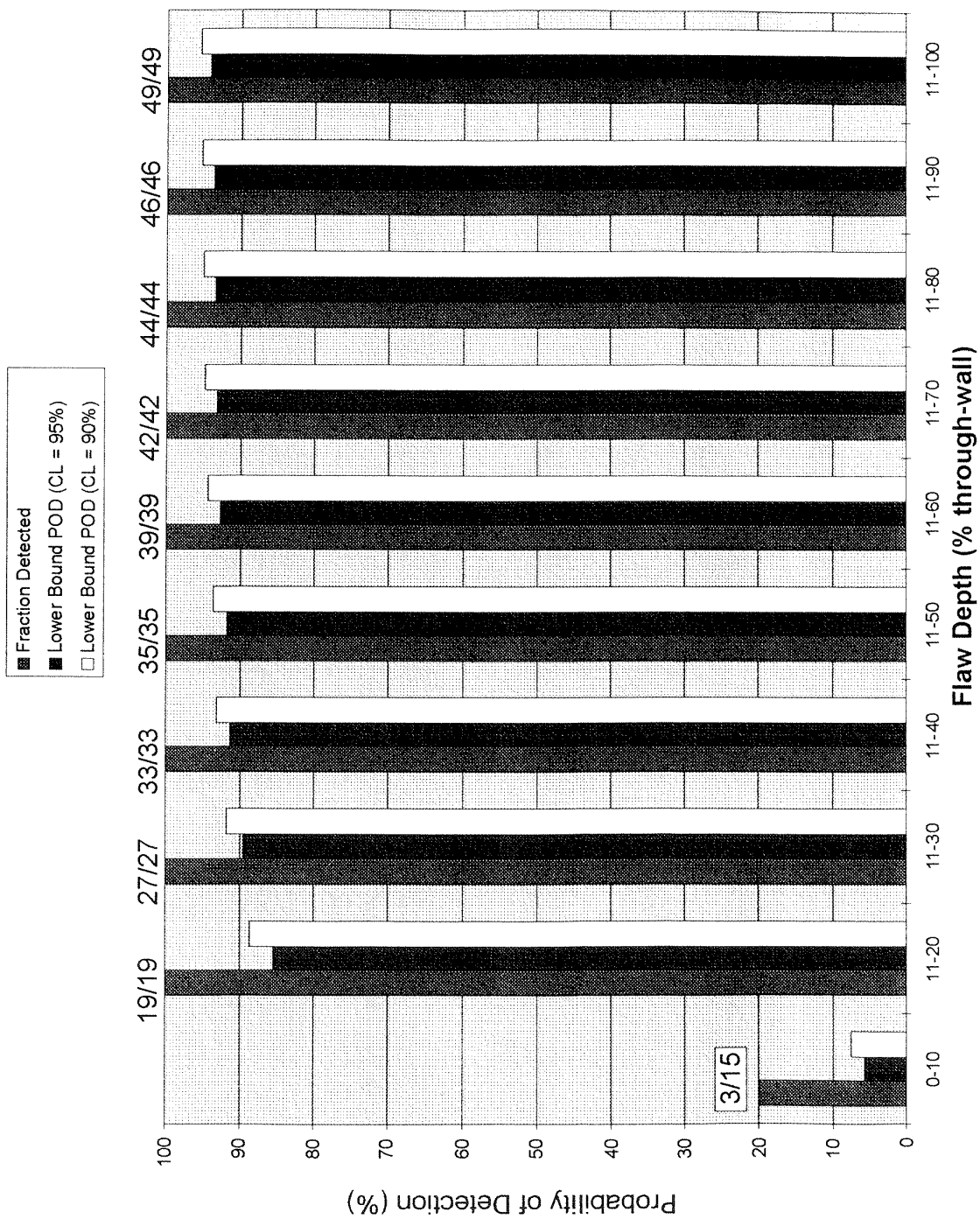
Figure: C3 probe response from an internal ferromagnetic deposit at the tubesheet expansion transition, using multi-channel subtraction.



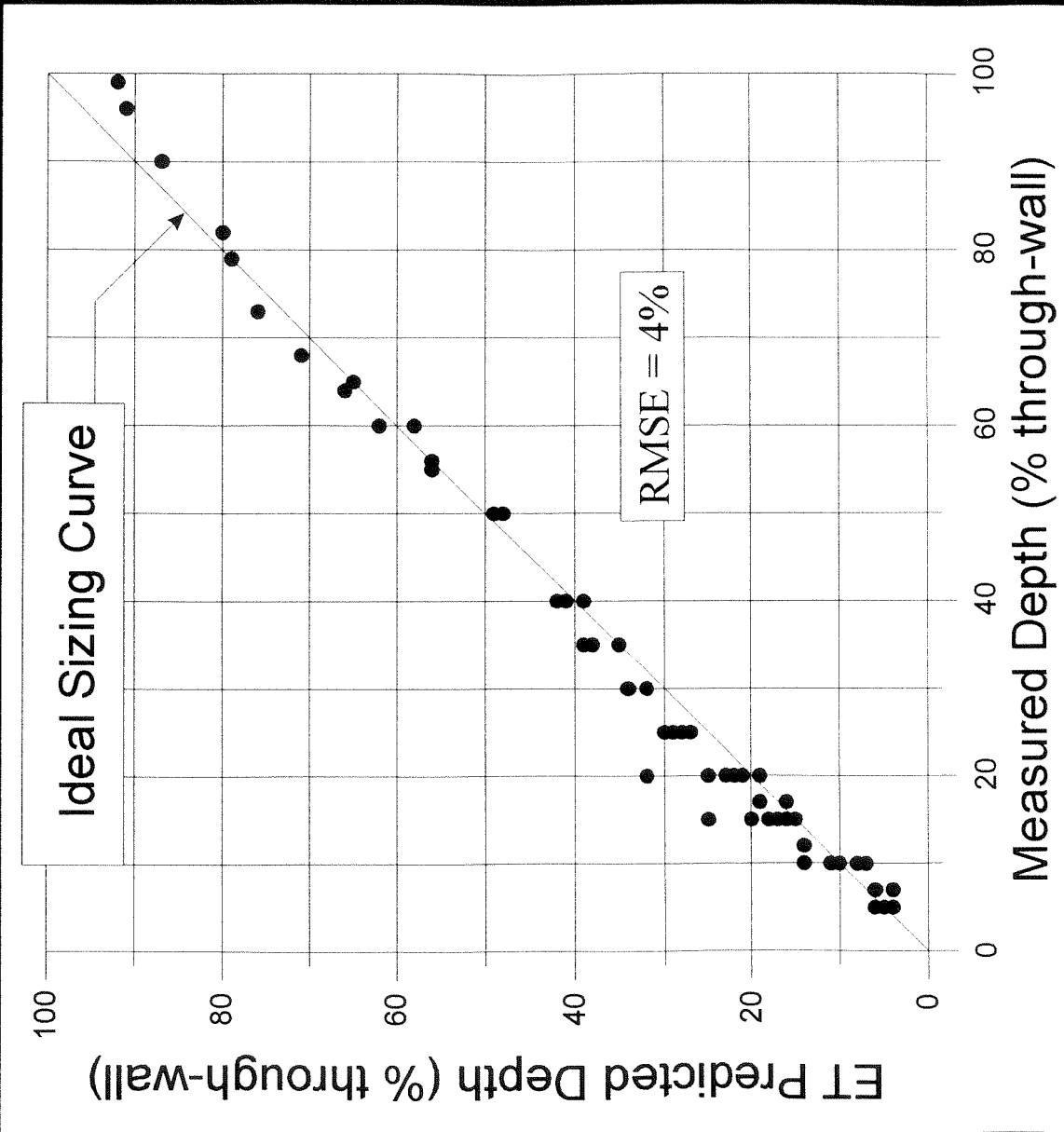
Calibration curve of crack depth vs. normalized voltage at 250-70 kHz mix for C3/4 probe.



Depth Sizing accuracy plot for C3/4 probe based on destructive measurements of ODSCC in pulled tubes.



POD Histogram for HD Bobbin Probe Detecting Fretting Wear Scars in Darlington-type SG Tubes



Sizing Accuracy Plot for HD Bobbin Probe Detecting Fretting Wear Scars in Darlington-type SG Tubes

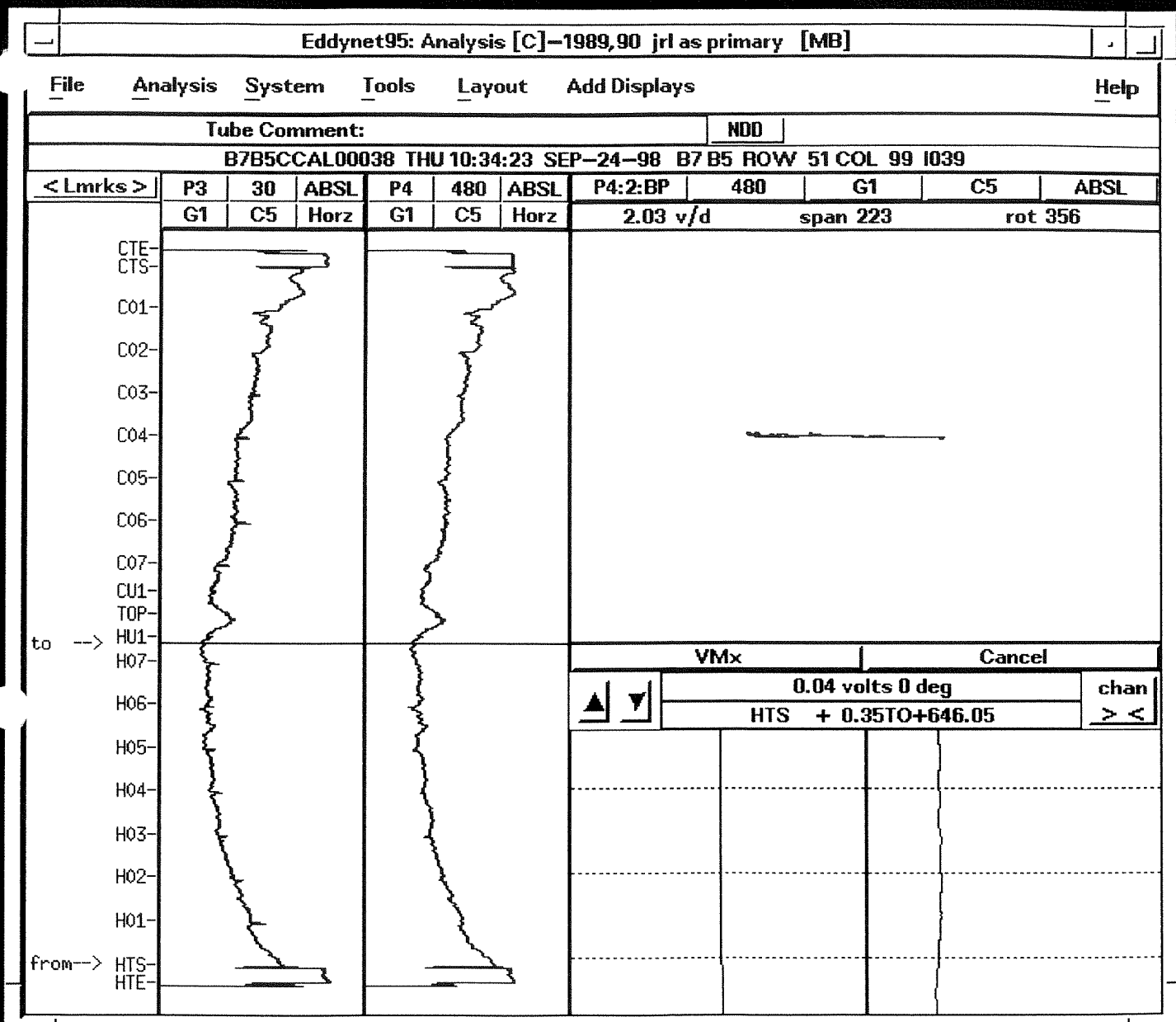


Figure: Absolute bobbin probe response to internal magnetite deposit ($\approx 25 \mu\text{m}$) along the tube length at 30 and 480 kHz.

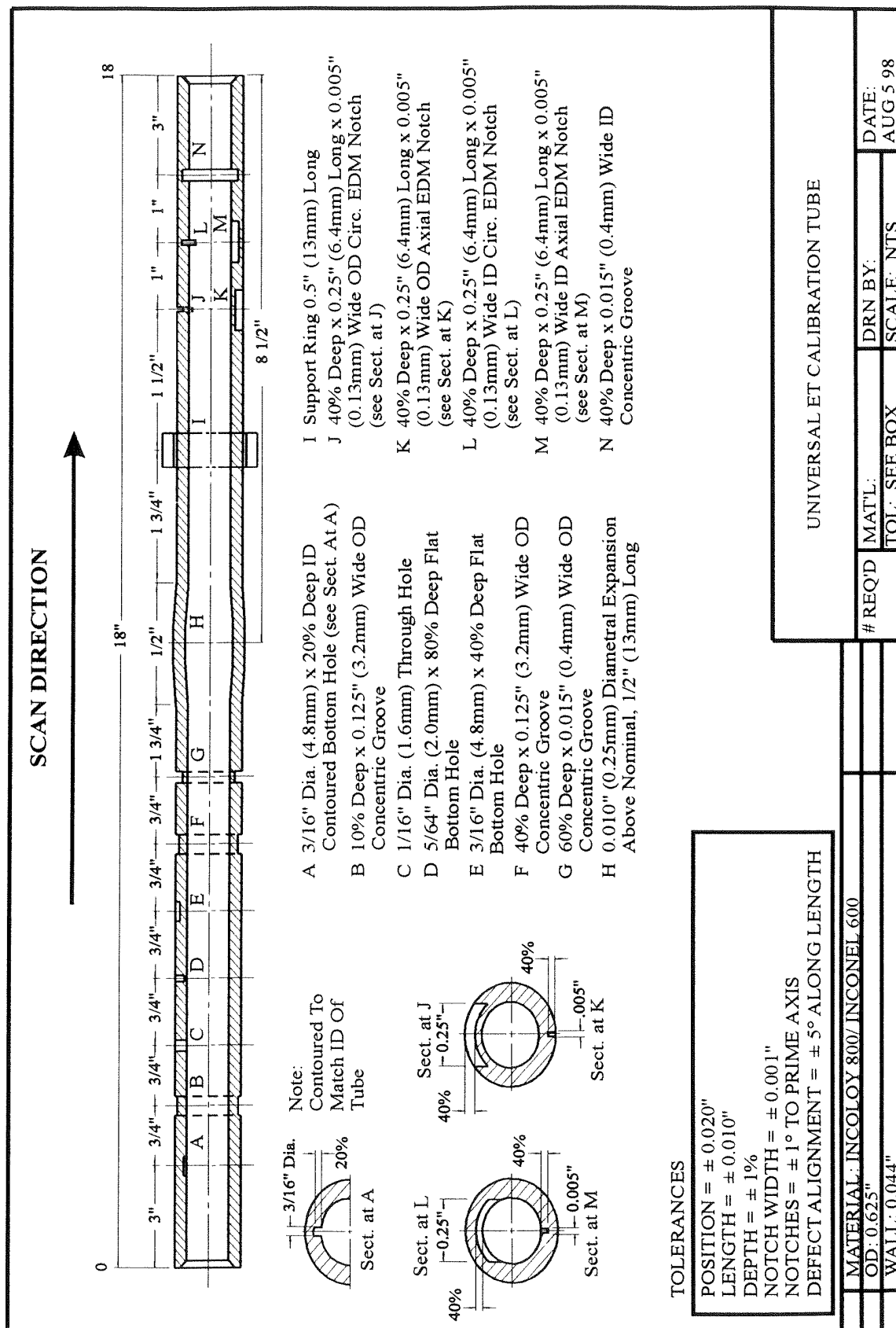


Figure: Universal Calibration Tube