December 11, 1996

MEMORANDUM TO: Keith Wichman, Acting Branch Chief
Materials and Chemical Engineering Branch
Division of Engineering

THRU: Edmund J. Sullivan, Section Chief
Materials and Chemical Engineering Branch
Division of Engineering

FROM: Cheryl Beardslee, Materials Engineer
Materials and Chemical Engineering Branch
Division of Engineering

SUBJECT: SUMMARY OF NOVEMBER 6, 1996 MEETING WITH NEI\EPRI REGARDING EDDY CURRENT TECHNIQUE QUALIFICATION

On November 6, 1996, the NRC staff met with representatives of the Nuclear Energy Institute (NEI) and the Electric Power Research Institute (EPRI) in Rockville, Maryland, to discuss issues concerning eddy current technique qualification. Attachment 1 is a list of the meeting attendees. Attachment 2 is a copy of the slides that were used in EPRI's presentation.

EPRI informed the NRC that eddy current technique qualifications performed in 1992, as part of the EPRI Appendix H qualifications, were recently updated. As a result, two previously qualified techniques no longer meet Appendix H qualification requirements. Steam Generator Management Project (SGMP) utilities and vendors were notified by EPRI.

EPRI also discussed their recently developed eddy current technique for sizing inside diameter (ID) initiated circumferential cracks at expansion-transition regions. EPRI stated that this technique was qualified per the EPRI Appendix H qualification process. NRC staff indicated that although this technique was qualified per EPRI Appendix H, this technique could not be used to meet current Technical Specification (TS) requirements for determination of plug/repair limits. The EPRI qualified sizing technique does not demonstrate the ability to detect and size cracks less than 40% throughwall (which is the typical TS plug/repair limit).

The third issue discussed was related to EPRI SGMP Database Protocol. Following discussion, NEI indicated that they would send a new, revised protocol that would address the issues, contained in our September 24, 1996, letter to NEI, and discussed during the meeting.

PROJECT NO. 689

Attachments: As stated
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See Attached List
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DATE	12/3/96		12/4/96		12/5/96	

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cc: Mr. Ralph Beedle
Senior Vice President
and Chief Nuclear Officer
Nuclear Energy Institute
Suite 400
1776 I Street, NW
Washington, DC 20006-3708

Mr. Thomas Tipton, Vice President
Operations
Nuclear Energy Institute
Suite 400
1776 I Street, NW
Washinton, DC 20006-3708

Mr. Alex Marion, Director
Programs
Nuclear Energy Institute
Suite 400
1776 I Street, NW
Washington, DC 20006-3708

Mr. Jim Davis, Director
Operations
Nuclear Energy Institute
Suite 400
1776 I Street, NW
Washington, DC 20006-3708

Mr. David Modeen, Director
Engineering
Nuclear Energy Institute
Suite 400
1776 I Street, NW
Washington, DC 20006-3708

Ms. Lynnette Hendricks, Director
Plant Support
Nuclear Energy Institute
Suite 400
1776 I Street, NW
Washington, DC 20006-3708

Mr. Anthony Pietrangelo, Director
Licensing
Nuclear Energy Institute
Suite 400
1776 I Street, NW
Washington, DC 20006-3708

Mr. Ronald Simard, Director
Advanced Technology
Nuclear Energy Institute
Suite 400
1776 I Street, NW
Washington, DC 20006-3708

Mr. Nicholas J. Liparulo, Manager
Nuclear Safety and Regulatory Activities
Nuclear and Advanced Technology Division
Westinghouse Electric Corporation
P.O. Box 355
Pittsburgh, Pennsylvania 15230

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NEI\EPRI MEETING TO DISCUSS EDDY CURRENT TECHNIQUE QUALIFICATION

LIST OF ATTENDEES

NOVEMBER 6, 1996

NAME	ORGANIZATION
C. Beardslee	NRC/NRR
P. Rush	NRC/NRR
T. Sullivan	NRC/NRR
G. Kammerdeiner	Dusquesne Light/EPRI
C. Welty	EPRI
D. Steininger	EPRI
C. Calaway	NEI
R. Pearson	NSP
S. Bernhoft	Wisconsin Public Service Corp.
G. Henry	EPRI NDE Center
C. Eames	Maine Yankee Atomic Power Co.
J. Tsao	NRC/NRR
J. Muscara	NRC/RES
K. Karwoski	NRC/NRR
E. Murphy	NRC/NRR
D. Mayes	Duke Power
K. Wichman	NRC/NRR
J. Strosnider	NRC/NRR

ATTACHMENT 1

EPRI / SGMP

EDDY CURRENT TECHNIQUE

QUALIFICATION

UPDATE

Presentation to the NRC

November 6, 1996

ATTACHMENT 2

AGENDA

Introduction

ET Technique for Circumferential Crack Sizing

EPRI SGMP ET Technique Qualification Update

- qualification status change

NRC Questions regarding EPRI SGMP Database Protocol

ET TECHNIQUE QUALIFICATION UPDATE

- EPRI performed eddy current technique qualifications in 1992 in conjunction with QDA Program development

  ⇒ best representative samples sets used for qualification

- Technique qualifications are being updated

  ⇒ additional data available from laboratory and pulled tube samples

  ⇒ on going effort to upgrade the quality of the data sets used for Appendix H qualification

ET TECHNIQUE QUALIFICATION UPDATE

- Update effort has identified two previously qualified techniques that do not meet Appendix H qualification requirements for the detection of location specific Outside Diameter IGA/SCC

  ⇒ 0.080" Mid-Range Rotating Pancake Coil -top of tubesheet expansion transitions

  ⇒ Bobbin coil prime/quarter mix within open tubesheet crevice

- Although performance to Appendix H requirements not demonstrated with new data, nothing suggests that either technique could not detect structurally significant degradation

  ⇒ flaws "missed" during qualification attempt would not have challenged structural integrity

ET TECHNIQUE QUALIFICATION UPDATE

- Results of Technique Qualification Update effort were reviewed within EPRI SGMP Advisory Structure

  ⇒ ISI/NDE Issues Resolution Group

  ⇒ Issues Integration Group

  ⇒ Executive Group

- EPRI SGMP Members formally notified of the change in qualification status for these two techniques

  ⇒ discussed at Technical Advisory Group Meeting (October 2-4, 1996)

  ⇒ letter issued on October 11, 1996 providing details of the update results and recomendations

ET TECHNIQUE QUALIFICATION UPDATE

- **EPRI SGMP Recommendations**

  ⇒ **avoid reliance on these techniques for detection of OD IGA/SCC at the specific locations identified**

  ⇒ **alternative techniques are available**

  ⇒ **each utility should review the supplied information for applicability to their unit(s)**

Appendix H
Circumferential Crack Sizing for PWSCC @ Expansion Transitions

Gary Henry

EPRI NDE Center

November 6, 1996

Technique Qualification Process

- Select Technique
  - Frequencies
  - Extraneous Variables
  - Probe
  - Acquisition System
  - Analysis System
  - Analysis Parameters
  - Select Sample Set

Technique Qualification Process

- PWSCC Circ. Cracking @ Expansion Transitions
- 300 or 400 kHz
- Hard Rolls, Explansions, Wextex
- Mid Range Plus Point
- Miz 18, Miz 30, or TC6700
- EDDYNET or ANSER
  - Capability of Axial Lissajous and Phase Measurement
- Pulled Tubes, Lab Cracks
  - Total 16 Samples
    - 5 Pulled Tubes
    - 11 Lab Cracks

Acceptance Criteria

- Technique performance compared to Appendix H Supplement 2 acceptance
  - 80% POD @ 90% C/L
  - Sizing error <25% RMS
- All Appendix H technique qualifications rely on Max. Depth from Metallurgical (Single dimension)
- Appendix H currently does not address acceptable length error

Examination Technique Specification Sheet

ETSS #96701 mr_+pt_pwscc_s_amp.doc	Page 1of 7

TUBING

Material: Inconel 600	OD: 0.750", .875"	Wall: 0.043",.048", .050"

EXAMINATION SCOPE

Test Application: This technique is qualified for detection and sizing by length or depth percent thru-wall of circumferential PWSCC at expansion transitions. This technique meets the requirements for detection and sizing in accordance with Appendix H at 400 or 300 kHz. Additional ACTS which would be applicable are #'s: 96508,96509,96510. **Caution:**Specific training on sizing by length and depth should precede implementation of this technique. This technique received industry peer review on 8/13/96.

ACQUISITION TECHNIQUE

Bobbin Probe _____ Rotating Probe ___X_____ Other _____

DATA ACQUISITION

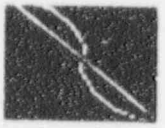
Instrument	**Probe**
Manufacturer: N/A	Manufacturer: Zetec
Model: N/A	Diameter/Coil Dimensions: MR Plus-Point
Acquisition System Software	Part Number: Plus pt .610 MRPC/FH-52 PH
Manufacturer: N/A	Probe Cable Length:83'- MRPC-52 MU
Description or Title: Eddynet95™ or Equivalent.	**Analog Probe Extension**
	Manufacturer: Zetec (Low Loss Cable)
Version/Revision: 2 or equivalent	Length: 50'

Frequencies/Coil Excitation Modes

Absolute Mode		Absolute Mode	
Channel/Coil/Frequencies		**Channel/Coil/Frequencies**	
	6/5/400 kHz		
	7/5/300 kHz		

Data Recording Equipment

Manufacturer: Hewlett Packard or equivalent	Model: 650 Mb Re-writable or equivalent



Examination Technique Specification Sheet	
ETSS #96701 mr_+pt_pwscc_s_amp.doc	Page 2 of 7

Digitizing Rate, Scan Direction & Scan Pattern	
Bobbin Probe	**Rotating Probe**
Digitizing Rate Min (DR):*	Digitizing Rate Min (DR)* 30 samples/inch circumferentially and axially
Sample Rate Min (SR)	Sample Rate Min (SR)
Probe Speed (PS)	Withdrawal Speed Max (WS)
Scan Direction	Rotation Speed Max (RPM)
* Note: Digitizing rate applies in the axial direction. SR min = DR min x PS max	* Note: Digitizing rate applies in both the axial and circumferential directions; for the circumferential direction, SR min = DR min x (1/RPM) x (1/tube diameter) x 19.09

DATA ANALYSIS

Instrument	Analysis System Software
Manufacturer: Hewlett Packard	Manufacturer: Zetec
Model: 710 or equivalent	Title/Rev.: Eddynet95/Ver 2 or equivalent

Analysis Channels			
Single Frequency	**400 kHz**	**300 kHz**	
Span Setting	40% ID circ 1 div	40% ID circ 1 div	
Phase Rotation	40% ID circ at 15 degrees (circ flaws going up)	40% ID circ at 15 degrees (circ flaws going up)	
Calibration Std.	100% , 60%, &40% circ ID, 100% axial EDMs	100% , 60%, &40% circ ID , 100% axial EDMs	
Calibration Curve	Phase curve, axial lissajous circ. 100,60, &40 ID notches	Phase curve, axial lissajous circ. 100,60, &40 ID notches	
Volts	20 volts on 100% circ	20 volts on 100% circ	
Single Frequency			
Span Setting			
Phase Rotation			
Calibration Std.			
Calibration Curve			
Volts			

Examination Technique Specification Sheet			
ETSS #96701 mr_+pt_pwscc_s_amp.doc			Page 3 of 7
Analysis Channels (Cont'd)			
Process Channels	**P1 - 400 kHz**	**P? - 300 kHz**	
Span Setting	40% ID circ 1 div	40% ID circ 1 div	
Phase Rotation	40% ID circ at 15 degrees (circ flaws going up)	40% ID circ at 15 degrees (circ flaws going up)	
Calibration Std			
Calibration Curve	Amplitude based on max depth phase	Amplitude based on max depth phase	
Volts	20 volts on 100% circ,axial lissajous	20 volts on 100% circ, axial lissajous	
Mixing Frequencies			
Filtering			

Analysis Guidelines:
Voltage normalization is performed in the axial lissajous window and is set on the 100% circumferential notch at 20 volts. Adjust the span such that the 40% ID circ notch is 1 div for 400 kHz. Set phase so that the 40% ID circ notch is 10 to 15 degrees on the raw frequencies and 190 to 195 on the process channels for axial indications. Monitor the 400 raw and process channels on the strip chart and scroll the region of interest while viewing the lissajous. Terrain plot the 400 or 300 kHz raw and process channels in the area of interest.

With the raw channels set so circumferential indications form in the positive direction, axial indications will form in the negative (180 degrees out) direction on the same channel.

An additional process channel will be required for the amplitude curve. This channel will be a duplicate of the 300 or 400 kHz raw channel, the circumferential notch response will be in the positive direction. This channel will be used to establish the amplitude peak_peak measured response linear line curve based on the phase measurement. Each intersection will require a new linear peak_peak amplitude curve based on the voltage and the phase % at maximum amplitude. If the voltage at maximum amplitude from the indication exceeds the voltage of the notch set at 20 volts in the axial lissajous window, use a curve where 20 volts equals 100%. This provides a conservative approach should this be required.

A phase curve is established on the raw channel using 100, 60, 40, and 0% values.

Examination Technique Specification Sheet	
ETSS #96701 mr_+pt_pwscc_s_amp.doc	Page 4 of 7

Analysis Guidelines:

Phase and amplitude measurements are performed on the lissajous response from the axial lissajous window. Dent responses may also form in the same plane as the flaw response. Careful analysis should be performed watching specifically for any change in the lissajous signal. Record a zero percent call prior to the first call of the indication and after the last call unless the indication is 360 degrees. Record only those indications which provide a flaw-like lissajous response at a maximum of 10 degree increments. Applying an axial to-from may be necessary to reduce the affect of geometry on the indication phase measurement. Filters are acceptable for detection but are not applied for sizing. Axial averaging may be used on low signal-to-noise ratio indications at expansion transitions.

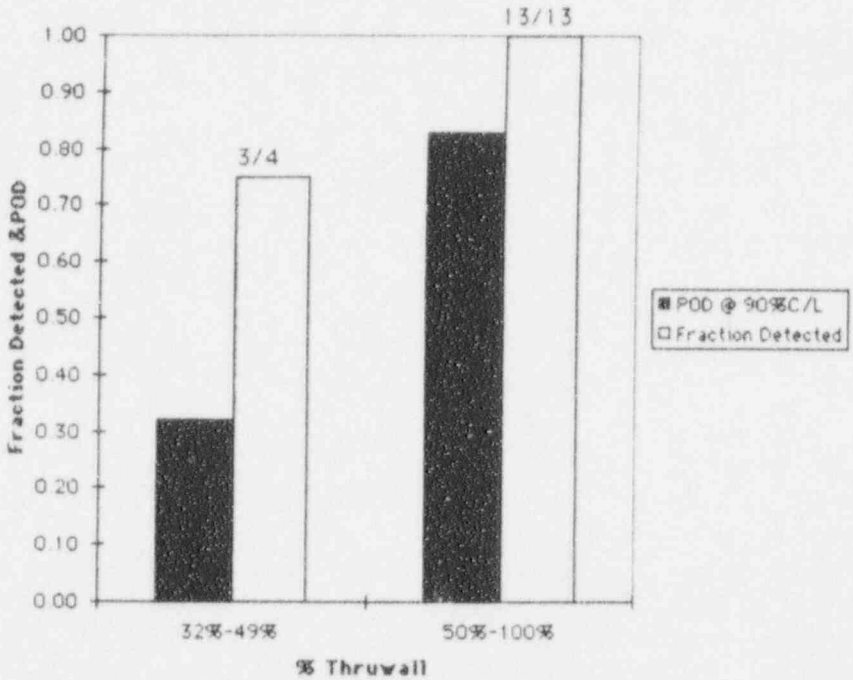
At maximum amplitude measure the % TW based on the phase curve, then in a process channel establish a linear curve using the amplitude and %TW values extrapolated to zero. **Caution**: Don't use the 1pt magnitude curve in the EDDYNET95™ software to create the curve.

400 or 300 kHz Technique Performance	
Detection Probability at (90% CL)	**RMSE Sizing Error**
0.83, POD @ 90% CL	_ 9.84_, % TW Max Depth __12.42_, PDA (Percent Degraded Area) Error __25.11_, Length Error Degs.

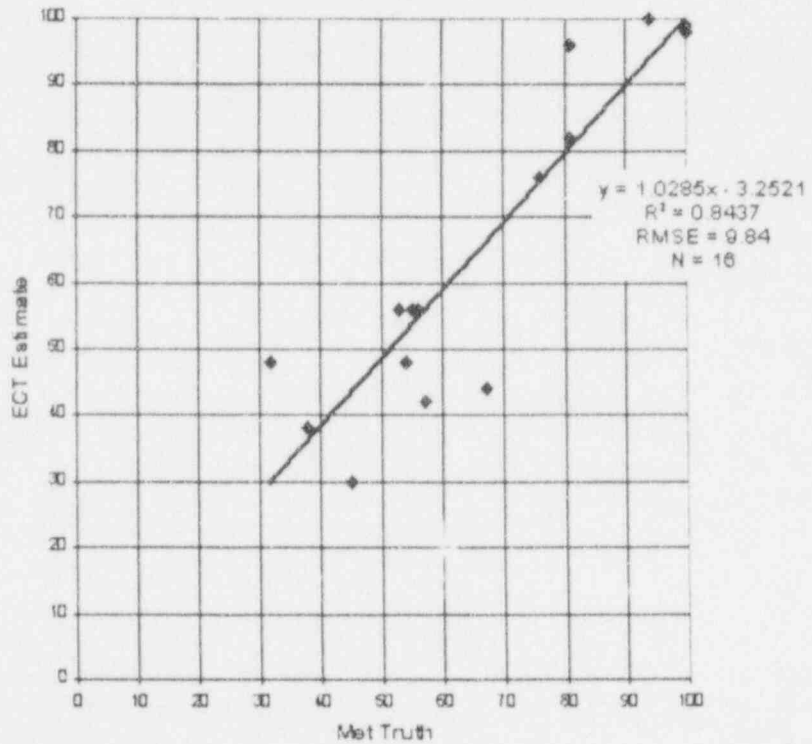
Examination Technique Specification Sheet

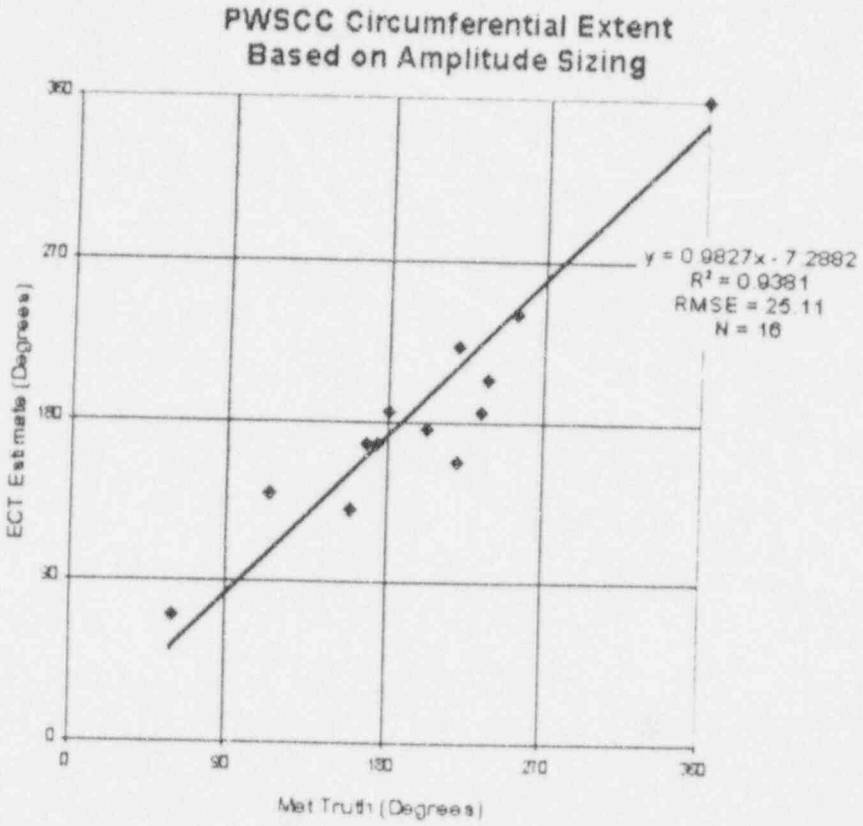
ETSS #96701 mr_+pt_pwscc_s_amp.doc	Page 5 of 7

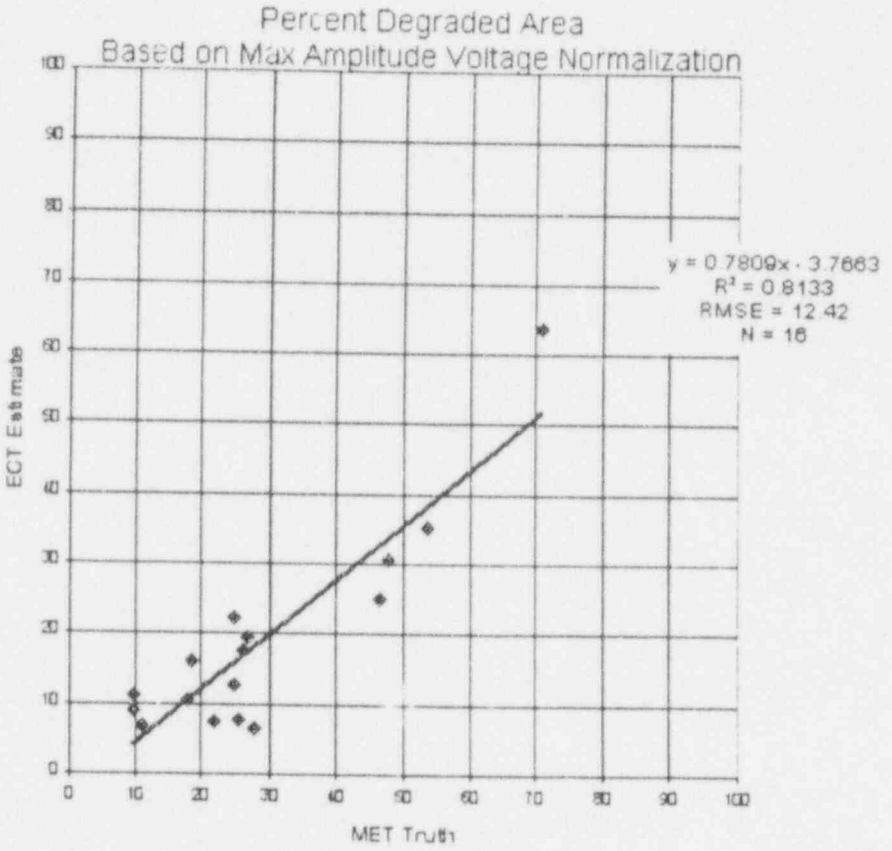
PWSCC CIRCUMFERENTIAL CRACKING

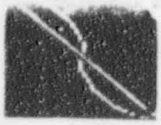


PWSCC Sizing Max Depth
Based on Maximum Amplitude Signal




PWSCC Circumferential Extent
Based on Amplitude Sizing
y = 0.9827x - 7.2882
R² = 0.9381
RMSE = 25.11
N = 16
ECT Estimate (Degrees)
Met Truth (Degrees)
0
90
180
270
360


Percent Degraded Area
Based on Max Amplitude Voltage Normalization
y = 0.7809x - 3.7663
R² = 0.8133
RMSE = 12.42
N = 16
ECT Estimate
MET Truth
0
10
20
30
40
50
60
70
80
90
100



Based on Max Amplitude Voltage Normalization — MR Plus-Point

Sample #/Loc	Length Met	Length Est.	Max Depth Met	Max Depth Est.	360 Depth Met	360 Depth Est.	RMSE %TW	COEF
2396-A	360	360	81	82	71.01	63.88	9.83	0.81
BGE 51-113	60	71	94	100	10.98	6.78	13.37	0.95
15 - 23 TVA	220	222	81	96	26.30	17.55	19.43	0.84
4496-A	238	204	100	97	47.76	30.63	30.43	0.88
4496-B	220	158	54	48	21.76	7.41	26.15	0.82
4496-C	203	176	67	44	27.68	6.45	38.14	0.68
4496-F	254	241	100	98	46.27	25.06	29.29	0.91
5096-A	234	185	100	99	53.58	35.18	31.09	0.86
5096-B	180	185	76	76	24.98	22.27	8.97	0.93
5096-C	168	167	55	56	18.71	16.16	13.10	0.76
5096-E	160	130	32	48	9.94	9.05	12.97	0.56
5096-F	175	167	56	56	18.03	10.53	15.76	0.86
MY-87-78	360	360	38	38	24.75	12.60	12.69	0.78
MY-90-57	360	360	57	42	26.75	19.44	10.29	0.88
MY-79-90	360	360	45	30	25.33	7.73	18.67	0.45
4596-F	113	139	53	56	9.81	11.09	11.26	0.79
RMSE	25.11		9.84		12.42	Average	18.84	0.77

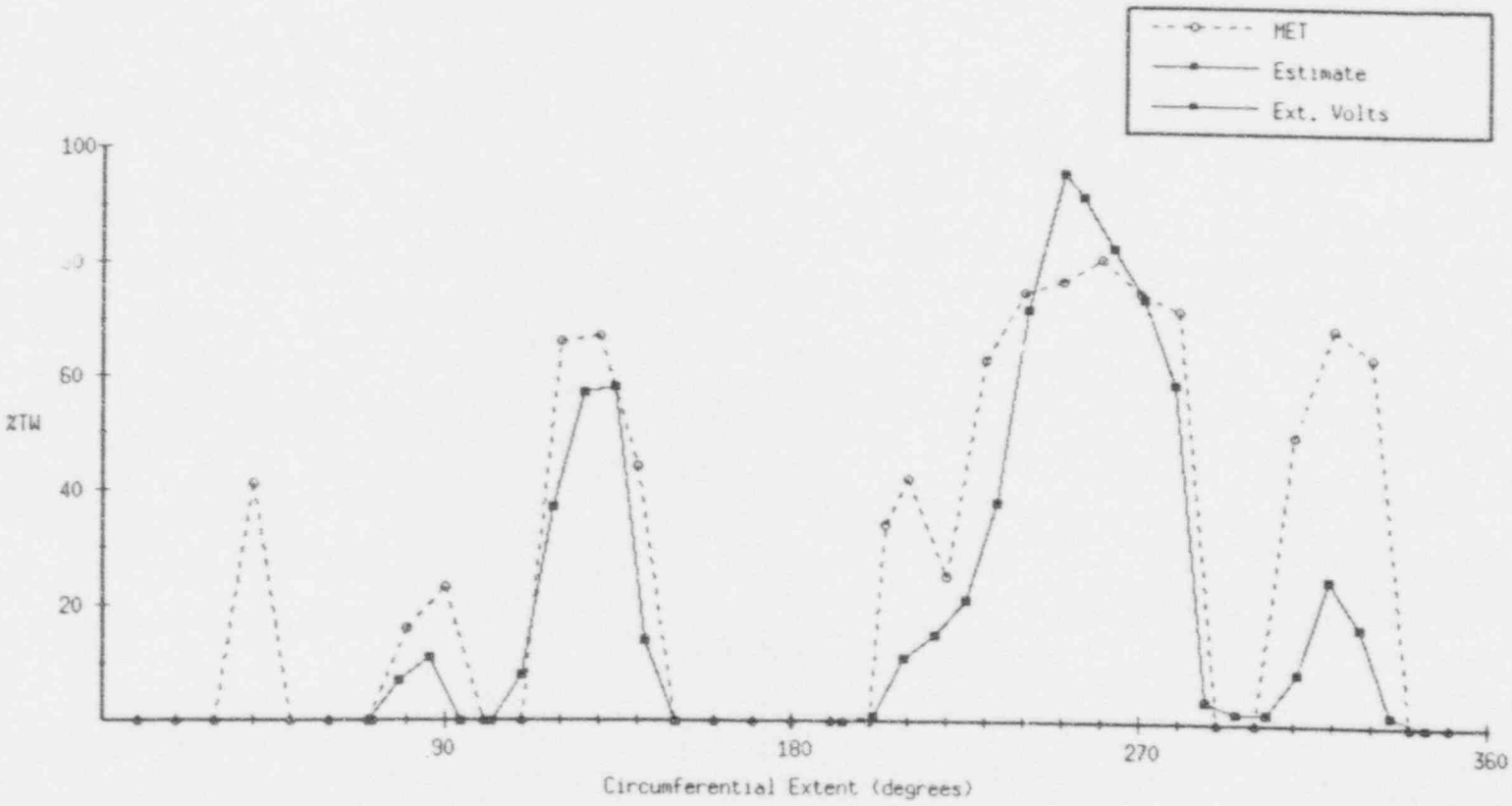
Percent	32%-49%	50%-100%
POD @ 90% C/L	0.32	0.83
fraction detected	0.75	1
	3 / 4	13 /13

Flaw Profile for TVA R15-C23 Pulled Tube Based on Max Amplitude Normalized Voltage

300 kHz MR Plus-Point

PWSCC

MET	Flaw Length Degraded Area = 43.04%	Length = 220 deg.	RMSE = 19.43
	360 Degree Degraded Area = 26.30%	Max Depth = 81%	COEF = 0.84
EST.	Flaw Length Degraded Area = 28.35%	Length = 222 deg.	Dia. = 0.8750
	360 Degree Degraded Area = 17.55%	Max Depth = 96%	Wall = 0.0500



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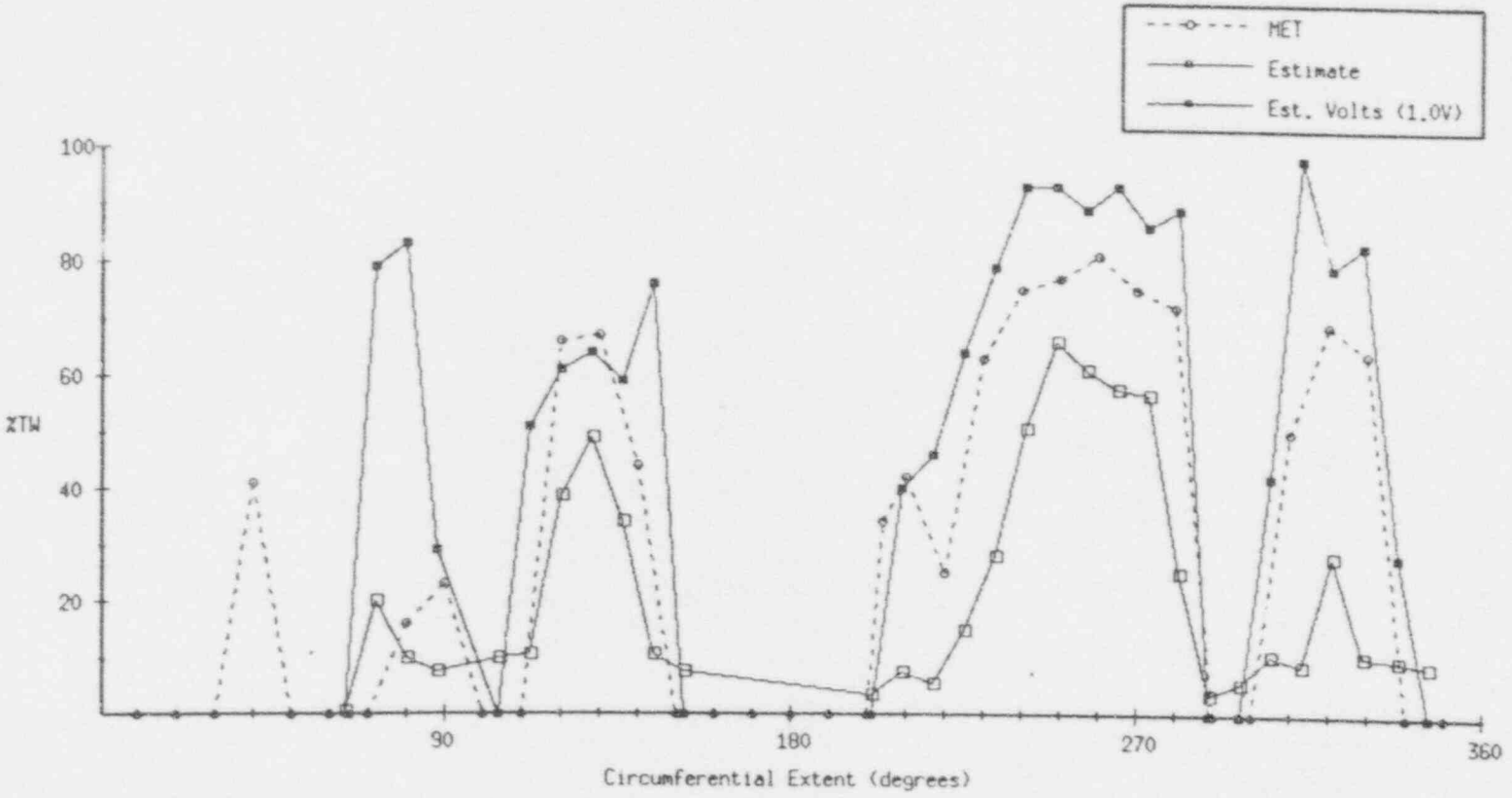
Analysing only flaw component which is Distinguishable from noise.

TVA R15-C23 300 kHz +pt

Phase Analysis

PWSCC

MET	Flaw Length Degraded Area = 43.04%	Length = 220 deg.	RMSE = 20.88
	360 Degree Degraded Area = 26.30%	Max Depth = 81%	COEF = 0.85
EST.	Flaw Length Degraded Area = 57.27%	Length = 225 deg.	Dia. = 0.8750
	360 Degree Degraded Area = 35.90%	Max Depth = 98%	Wall = 0.0500



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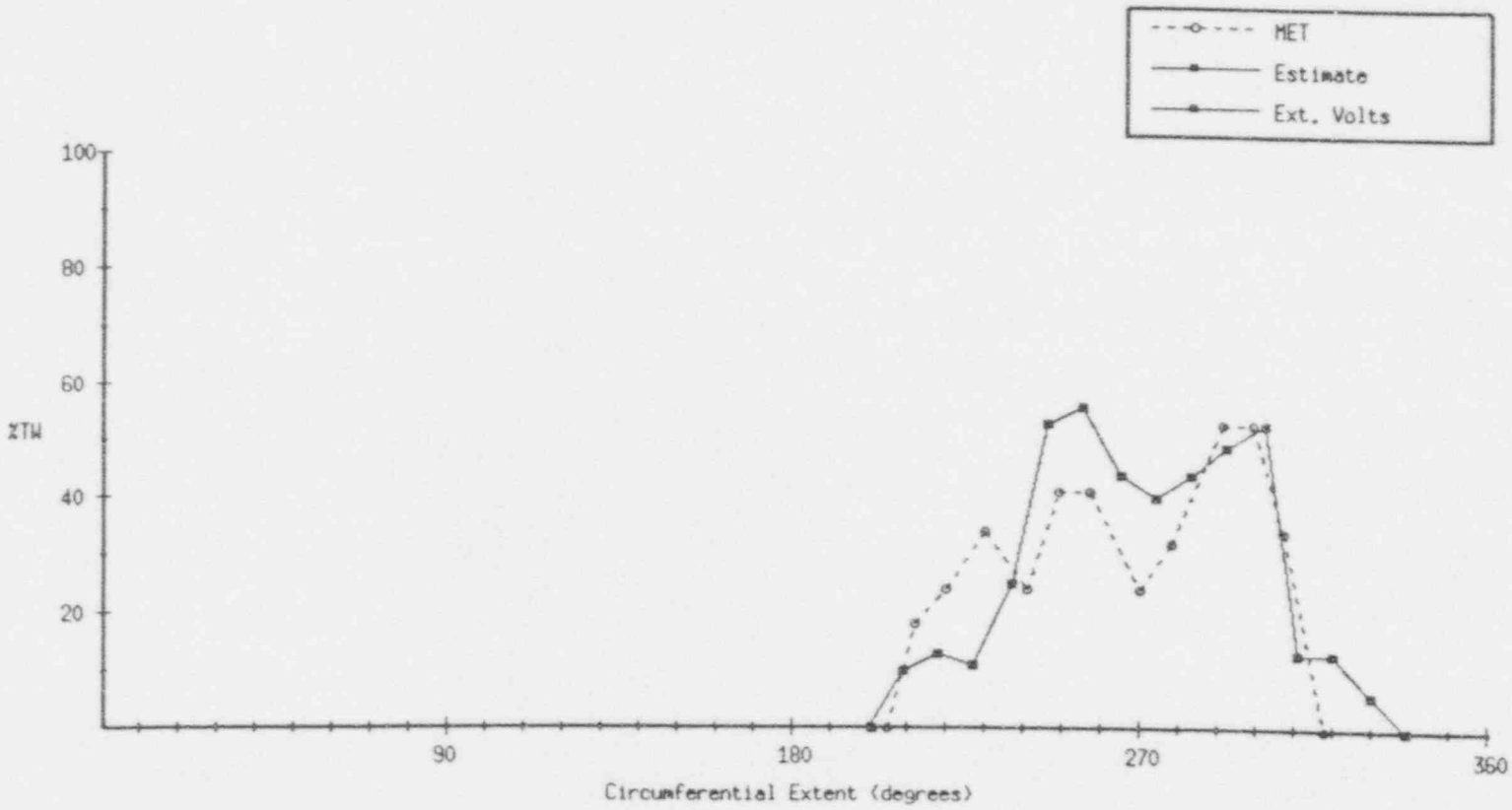
Flaw Profile for 4596 Exp F Based on Amplitude Normalized Voltage

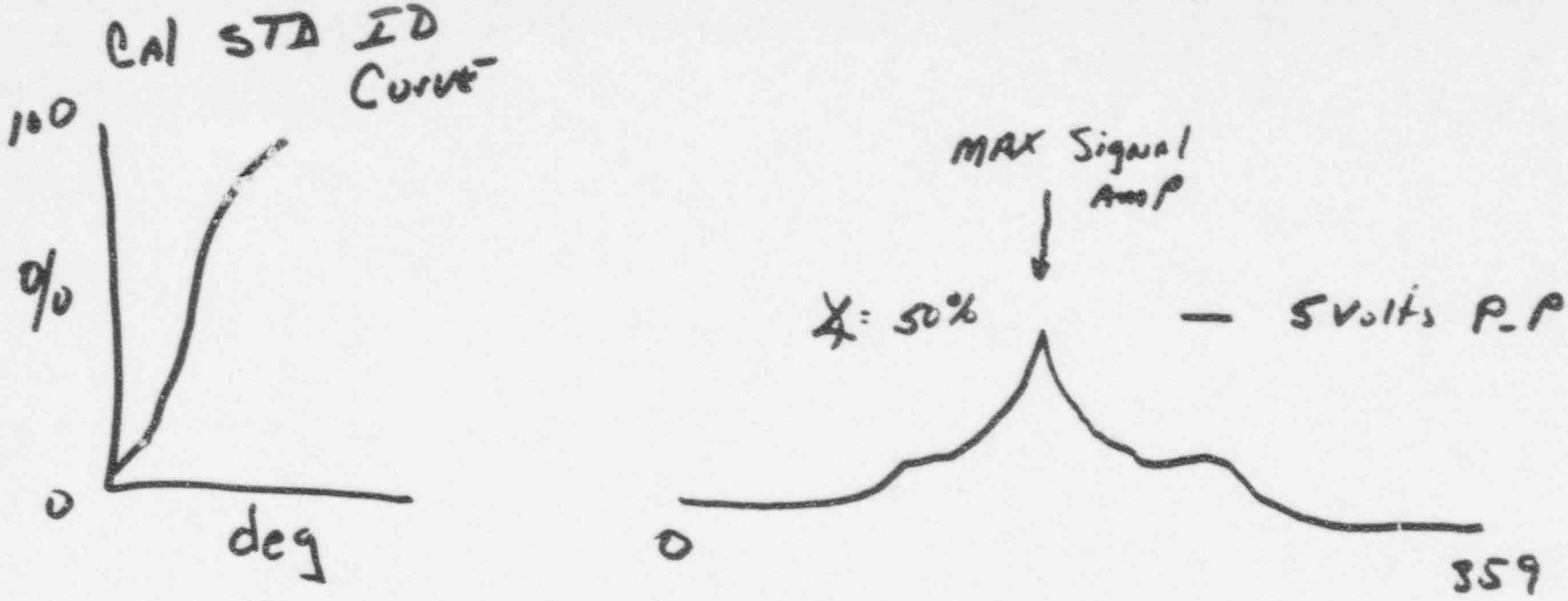
300 kHz MR Plus-Point

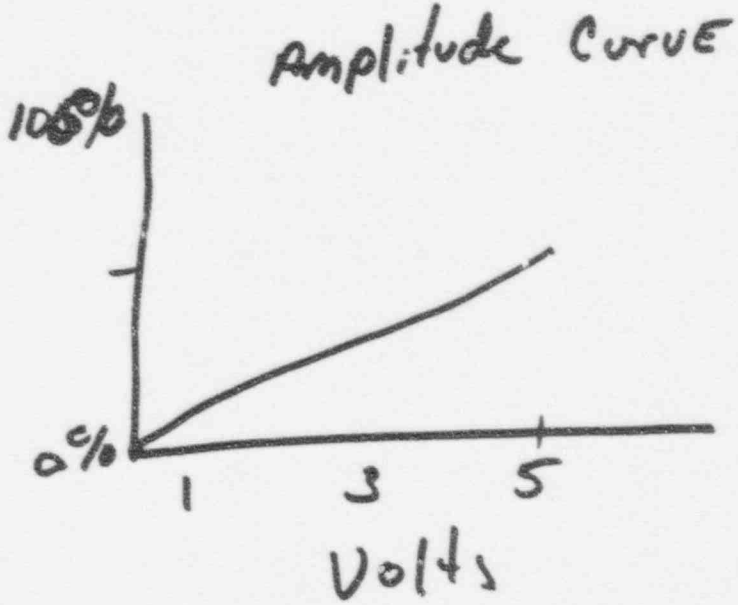
PWSCC

MET	Flaw Length Degraded Area = 31.25%	Length = 113 deg.	RMSE = 11.26
	360 Degree Degraded Area = 9.81%	Max Depth = 53%	COEF = 0.79
EST.	Flaw Length Degraded Area = 28.65%	Length = 139 deg.	Dia. = 0.7500
	360 Degree Degraded Area = 11.09%	Max Depth = 56%	Wall = 0.0430



11:37 07/03/96 (ver 11)


Cal STD ID Curve
100
%
0
deg
MAX Signal Amp
X = 50%
5 Volts P-P
0
359


Amplitude Curve
100%
0%
1
3
5
Volts

Conclusions

- Two Techniques Meet the Requirements of Appendix H for ID PWSCC at Expansion Transitions
  - Phase
  - Phase and Amplitude
- Both Techniques Compliment Each Other
- Additional Tools for the Toolbox
- Only Provides a Measure of the Techniques Capability