Technical Letter Report

Title: Characterization of Potential Flaws Based on Eddy Current Data Taken from Steam Generator Tubes at Catawba Unit 2

Job Code: Task Order 1, JCN J-3214

NRC TAC Number: MC7374

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Background

In 2004, at Catawba Unit 2, Duke Energy (the licensee) conducted steam generator tube inspections. At the time of inspections, Catawba Unit 2 had operated for approximately 14.7 EFPY and the licensee had never previously identified crack-like indications in the steam generator (SG) tubes or welds. Following the 2004 inspections, 16 tubes in one SG were removed from service due to crack-like indications in tubes and tube welds.

As a result of the 2004 inspections, the licensee found three discrete circumferential indications in an overexpanded region of one tube in SG 2B. Overexpansions in the tubesheet (TS) region, sometimes called bulges or TS anomalies, are a result of expanding the tube into a region of TS which is not perfectly round (associated with imperfect drilling). The indications were located approximately 7 inches below the top of hot-leg TS. The indications began from the inside diameter (ID) of the tubes and were approximately 30 degrees in circumferential extent. The overexpanded region extended for approximately 6 inches axially and the diameter was estimated to be ~0.003-in. greater than the diameter observed in the remainder of the expanded region.

In addition to the three indications found in an overexpanded region of one tube, 9 tubes in SG 2B were found to have indications in the tack roll region. These indications were circumferentially oriented and consisted of either single or multiple cracks. No indications were found in the tack roll region in SGs 2A, 2C, or 2D. In the tube-to-tubesheet region, 188 tubes in SG 2B, 1 tube in SG 2A, and 7 tubes in SG 2D contained indications in the tube-to-tubesheet weld. No indications were found in the tube-to-tubesheet weld region in SG 2C. Six tubes in SG 2B were identified with tube-end indications that extended into the tube material. These indications were axially and circumferentially oriented and consisted of either single or multiple cracks.

It is important to better understand these indications for the following reasons:

- Only a few cracks (or crack-like indications) have been detected in thermally treated Alloy 600 SG tubes
- Cracking of SG tubes at other locations has potential to challenge tube integrity

Eddy Current Data Analysis Results

Analysis results are presented for eddy current data from 16 tubes in SG 2B with potential flaws due to indications of cracking in overexpansions/bulges, tack expansions, and tube-to-tubesheet welds collected during the 2004 inspection at Catawba Unit 2. The original data was provided on an optical disk in ANSER (Westinghouse) format. To analyze the data with the available Eddynet (Zetec) software used at ANL, all data files were converted to appropriate format by using the conversion spooler software under Eddynet environment. The eddy current data were analyzed in accordance with standard practices and the information provided by the licensee, which included site-specific data acquisition and analysis guidelines from the licensee and related EPRI examination technique specification sheets (ETSS). Because the conversion spooler does not convert the setup files created by the ANSER software, new setup files had to be independently created under the Eddynet environment in order to analyze the data. The setup files store the process channel information and the calibration data created by a particular analyst thus allowing different users to reproduce the analysis results in a more consistent manner. The independent construction of setup files is expected to result in some quantitative differences between the signal amplitude and phase values reported by the licensee and those presented in this report.

Eddy current rotating probe data from all 16 tubes were reviewed, including the data from cracks found in the overexpansions/bulges (1 tube), the cracks found in the tack expansions (9 tubes), and the cracks found in the tube-to-TS weld that extended into the parent tube (6 tubes). The data had been collected using the midrange +Point and pancake coils of a 3-coil motorized rotating probe coil (MRPC) at 300kHz, 200kHz, 100kHz, and 15kHz frequencies. As noted, independent setup files had to be created for each calibration group. In all cases calls were recorded based on the +Point primary channel at 300kHz. To determine the approximate location of signals, landmarks were established on the stripchart plots using the low-frequency response and a spatial scaling based on positions of known indications on the calibration standard tube. To determine estimates of flaw depth, calibration curves were generated based on the nominal dimensions of machined flaws in an EDM notch-calibration-standard tube. The measurement of flaw extent was determined based on the sampling rate for axially oriented signals and the measured degrees for circumferentially oriented signals. For each test section, the data are displayed as stripchart and terrain plots of the primary +Point (separate axial and circumferential channels) and pancake coil. The measurement of flaw size in most cases was made from the main Eddynet window. To allow comparison of the results here with those performed during field inspection, additional process channels were created for sizing of circumferential indications using the axial Lissajous window.

Table 1 contains a listing of all 16 tubes, the measured data, and ANL's characterization results based on +Point response. The location of the indications was measured with respect to either the tube-end or top of the tubesheet on the hot-leg side of the SG, which are denoted as TEH and TSH, respectively. Figure 1 shows the nominal location of support structures and other specifications for Westinghouse recirculating D5 type SGs. Locations at which there are differences between the calls made at ANL and those reported by the licensee are marked in the table.

Table 2 contains the results of data analysis that was provided by the licensee and the additional information on the location of indications that was provided as part of the NRC furnished materials. More detailed descriptions of the eddy current data analysis results carried out at ANL including additional calls from certain test sections with multiple indications are provided in Figs. 2-17. In most cases, there is reasonably close agreement between the results of analysis presented in this report and that provided by the licensee. The main discrepancies are:

1. Differences in the measured signal amplitude and phase that can lead to different estimates of flaw size and extent. The differences are due to either the variability of calibration setup or improper selection of maximum signal by the analyst (see the results for R04C61, R13C64, and R02C57). While variability of the analysis results due to small differences in calibrations are expected and are generally within the acceptable limits of measurement uncertainty, improper selection of signals can lead to large measurement variability.
2. Differences in the number and orientation of indications. It appears the licensee reported no more than one indication for each tube section. The analysis by ANL detected multiple indications or orientations in some of these sections. However, the licensee's reporting requirements are based on site-specific analysis guidelines, and may require recording just one indication (e.g., based on maximum amplitude or depth) over a given axial extent along the flawed section of a tube.

General Remarks

The +Point probe response from the majority of indications in this data set is consistent with those exhibited by PWSCC type degradation. A subset of tubes contains indications with relatively complex signals and with large amplitudes including multiple axial/circumferential and mixed-mode cracking. The damage mechanism can in part be associated with the residual stresses in the deformed regions of the tube (i.e., tack expansion and over-expanded regions) that are more susceptible to SCC.

Based on the observed signal-to-noise ratios in data from the +Point probe, a qualitative judgment can be made that the level of eddy current noise present in the majority of TS sections from Catawba Unit 2 steam generator with thermally treated Alloy 600 tubes did not hinder detectability of limiting flaws. The data from a small subset of tubes, however, exhibited a measurably higher level of noise than the rest. An example of the results from a tube with higher level of noise in the upper portion of the TS section is shown in Fig. 18. The signals in this particular case are in part indicative of tube geometry variations.

The analysis efforts reported here were focused on detection and characterization of flaws in three specific regions of the tube sheet section, namely, tube end, tack-expansion, and over-expanded regions. Low amplitude signals, not listed in Table 1, were detected in the over-expanded region of at least one tube (see Fig. 19) that are indicative of incipient cracking. Although the eddy current data from tube sections outside these regions have not been thoroughly examined, the initial screening of the data suggests that any additional indications will have a significantly smaller eddy current response in comparison to those listed in Table 1. Because of low signal-to-noise ratio, small amplitude signals like the one shown in Fig. 19 are difficult to characterize and size (and may not be a result of a crack), and they may not be reported by the licensee if a more significant indication was already called in that tube section.

For ID-originated indications, it is expected that acquiring of supplementary eddy current data at higher frequencies can help to more accurately estimate the depth of shallow flaws. In conjunction with the available positional information, supplementary data at higher frequencies can also help to better determine if indications in the tube-to-tubesheet weld region extend into the parent tube.

Table 1. Results of analyses carried out at ANL on characterization of 16 tubes from Catawba Unit 2 based on the 2004 eddy current inspection data.

Cal	Row	Col.	Ampl.(v)	Ph.(deg)	Ch.	IND	%TW	Extent (in./deg)	Location
042	01	47	6.0	29	2	SAI	88	0.18”	TEH+0.17[a]
082	03	52	2.94	31	P4	SCI	99	116°	TEH+0.78[b]
094	04	61	1.24 0.89[1]	25 24[1]	P4 P4[1]	SCI SCI[1]	81 76[1]	38° 38°	TSH-7.9[c] TSH-7.9[c] [1]
094	07	71	1.12	19	P1	SCI	54	38°	TEH+0.65[b]
120	01	22	6.52	25	2	MMI[2]	73	0.4”	TEH+0.15[a]
128	08	27	6.05	35	2	SAI	99	0.26”	TEH+0.21[a]
136	36	53	0.73	27	P1	SCI	86	31°	TEH+0.62[b]
158	03	58	0.89	25	P4	MCI	81	32°	TEH+0.77[b]
158	13	64	4.29[2] 3.0[1]	22 23[1]	2 2[1]	SAI SAI[1]	63 63	0.15” 0.15”	TEH+0.16[a] TEH+0.16[a] [1]
160	02	57	1.85[2]	32[2]	P1	SCI	99	40°	TEH+0.71[b]
160	02	63	9.26	35	2	SAI	99	0.25”	TEH+0.17[a]
170	02	52	1.92	24	P1	SCI	74	44°	TEH+0.74[b]
170	03	45	0.71	20	P1	SCI	58	28°	TEH+0.68[b]
170	15	45	6.95 2.77[1]	24 28[1]	2 P1[1]	SAI SAI[1]	70 91	0.15” 67°	TEH+0.13[a][2] TEH+0.69[b] [1]
174	01	55	8.75	34	2	MMI[2]	99	0.15”	TEH+0.18[a]
174	04	52	3.98	36	P1	SCI[2]	97	129°	TEH+0.75[b]

(a) Indication near tube end
(b) Indication in tack expansion region
(c) Indication in over-expanded region

(1) Indication not listed in Table 2
(2) Call made at that location is different from that listed in Table 2

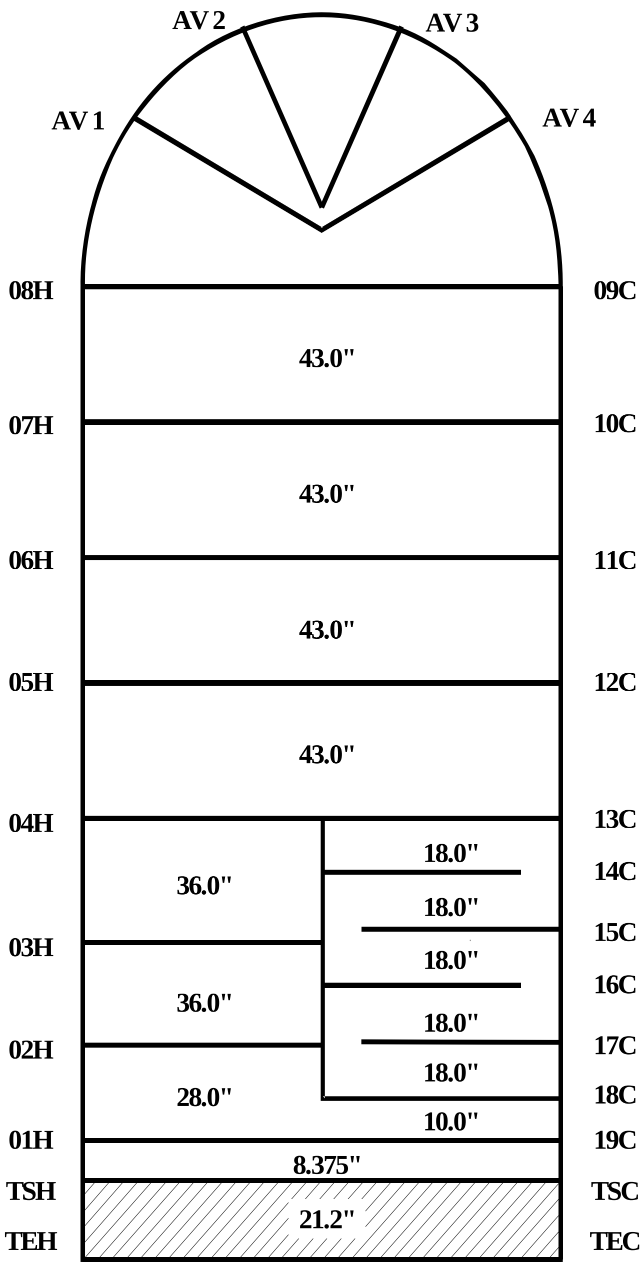
Channel numbers:
Ch.1 – 300kHz Pancake   ch.2 – 300kHz +Point™ (Ax)   ch. P1 & P4 – 300kHz +Point (Cr)

Landmark:
TEH – tube-end hot-leg   TSH – tubesheet hot-leg (TTS)

Indication:
SAI – single axial indication   SCI – single circumferential indication
MAI – multiple axial indication   MCI – multiple circumferential indication
MMI – mixed mode indication

Table 2. Analysis results on 16 tubes from Catawba Unit 2 based on the 2004 eddy current inspection data provided by the licensee. The location of indications (last column) came from the supporting documents provided by the U.S. NRC.

ROW	COL	VOLTS	DEG	CHN	IND	%TW	LOCATION	EXT EXT	UTIL 1	UTIL 2	CAL #	LEG	PROBE	Location
1	22	6.51	27	2	SAI		TEH 0.11	TEH TSH	IT		120	HOT	3C+PT	tube end
1	47	5.94	29	2	SAI		TEH +0.17	TEH TSH			42	HOT	610PP	tube end
1	55	8.72	34	2	MAI		TEH 0.12	TEH TEH		OR	162	HOT	3C+PT	tube end
2	52	1.93	24	P1	SCI		TEH 0.80	TEH TEH			170	HOT	3C+PT	TS tack expansion
2	57	0.31	47	P 1	SCI		TEH +0.70	TEH TEH			160	HOT	610PP	TS tack expansion
2	63	9.81	31	2	SAI		TEH +0.06	TEH TEH			160	HOT	610PP	tube end
3	45	0.7	20	P1	SCI		TEH 0.62	TEH TEH			170	HOT	3C+PT	TS tack expansion
3	52	2.8	32	P 4	SCI		TEH +0.70	TEH TSH			82	HOT	610PP	TS tack expansion
3	58	0.96	26	P 4	MCI		TEH +0.70	TEH TEH			158	HOT	610PP	TS tack expansion
4	52	4.05	36	P1	MCI		TEH 0.70	TEH TEH			174	HOT	3C+PT	TS tack expansion
4	61	0.43	17	P 4	SCI		TSH -7.08	TSH TSH			18	HOT	610PP	TS over-expansion
7	71	1.05	21	P1	SCI		TEH 0.44	TEH TSH			94	HOT	3C+PT	TS tack expansion
8	27	6.15	35	2	SAI		TEH +0.21	TEH TSH			128	HOT	610PP	tube end
13	64	2.56	23	2	SAI		TEH 0.16	TEH TEH	IT		158	HOT	3C+PT	tube end
15	45	6.58	25	2	SAI		TEH 0.14	TEH TEH			170	HOT	3C+PT	TS tack expansion
36	53	0.75	28	P1	SCI		TEH 0.63	TEH TEH			136	HOT	3C+PT	TS tack expansion



D5 STEAM GENERATOR SPECIFICATIONS

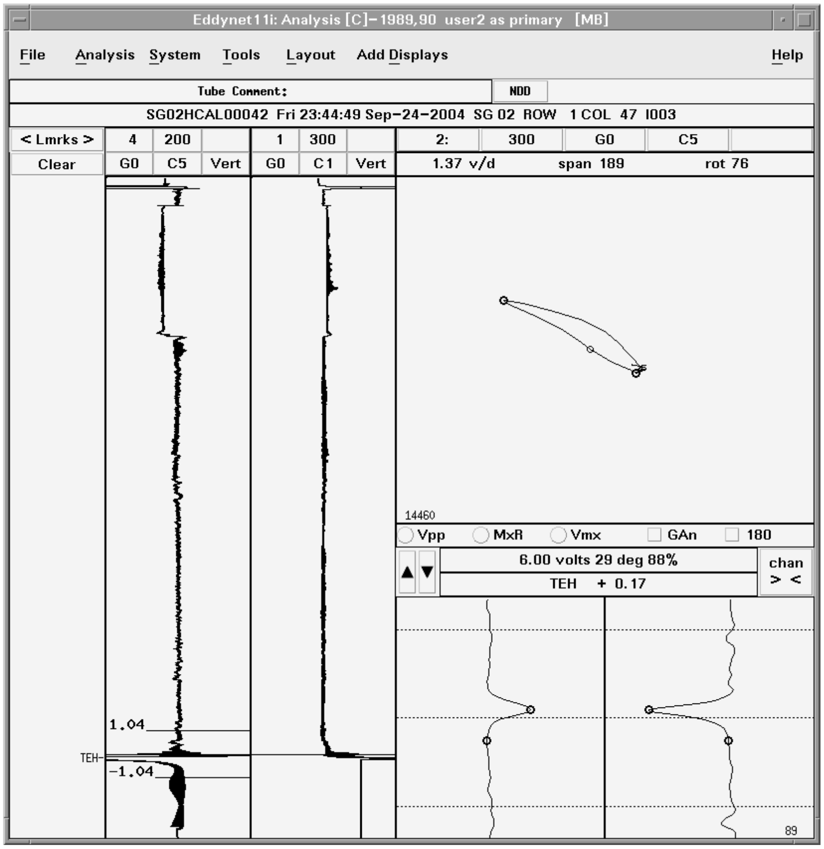
TUBE INFORMATION:
NO. OF TUBES = 4578
MATERIAL = Inconel 600
NOMINAL DIA. = 0.750"
NOMINAL WALL = 0.043"
ROW 1 RADIUS = 2.250"
STRAIGHT LENGTH = 305.0"
TUBE PITCH = 1.0625"

TUBE SUPPORT INFORMATION:
TYPES = Drilled / Quatrafoil
MATERIAL=405 Stainless Steel
THICKNESS = 0.75"/ 1.12"

AVB INFORMATION:
MATERIAL = Chrome Plated Inconel
THICKNESS = 0.296"

NOTE: Dimensions are to the centerline of the tube support structures.

Figure 1. Westinghouse recirculating D5 steam generator [Eddy Current Analysis Guidelines for Duke Power Company's D5 Steam Generator, Revision 3].



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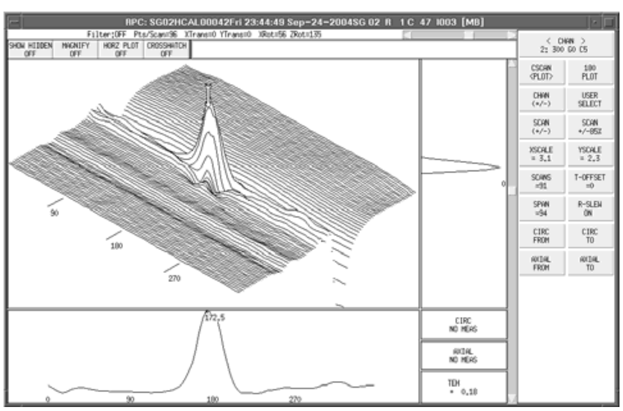

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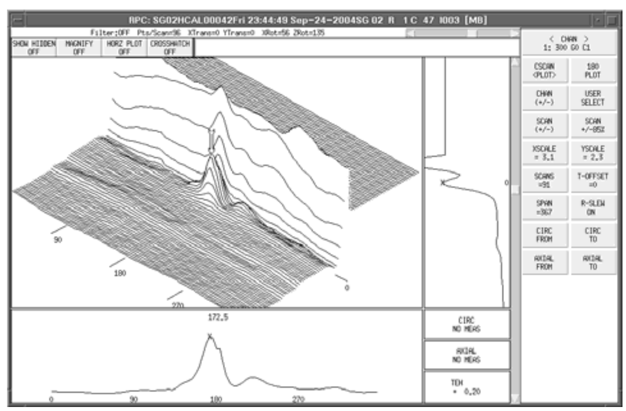
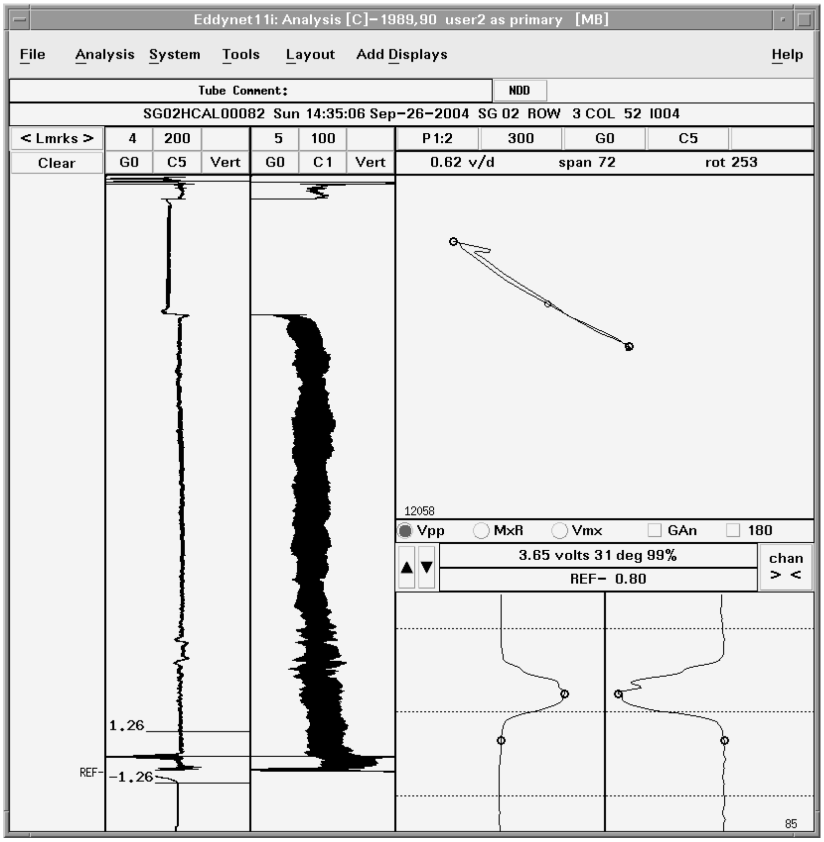


(c)

Figure 2. Data analysis results for tube R01C47. Graphics show (a) the main Eddynet window for +Point ch. 2 and terrain plots of degraded zone using (b) ch. 2 and (c) pancake coil ch. 1. Based on +Point response, the signal is characterized as an ID-originated 0.18-in.-long SAI located ~0.17-in. above hot-leg tube-end with maximum amplitude of 6v and phase angle of 29^{o} corresponding to ~88%TW depth.



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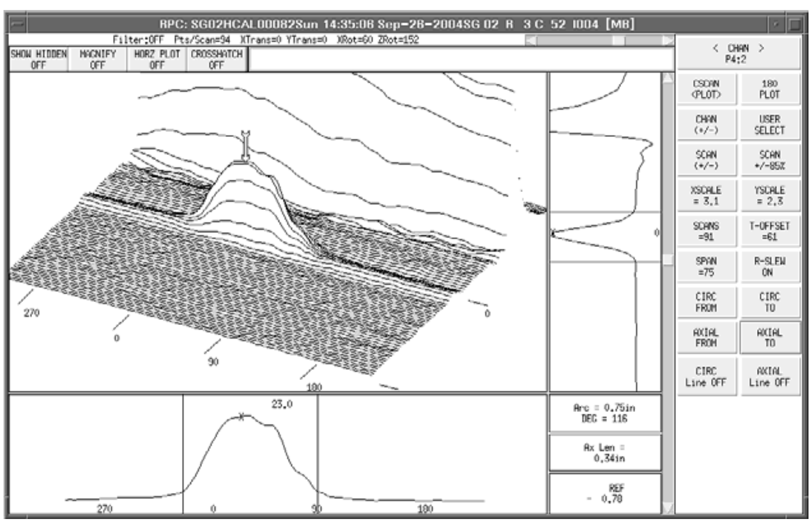
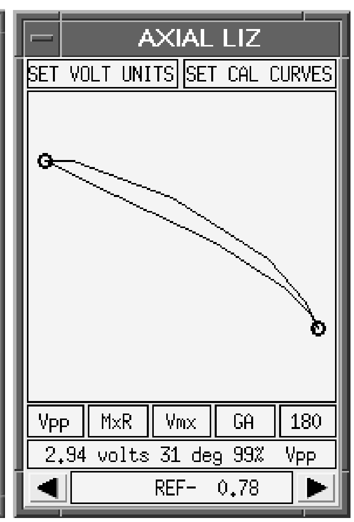
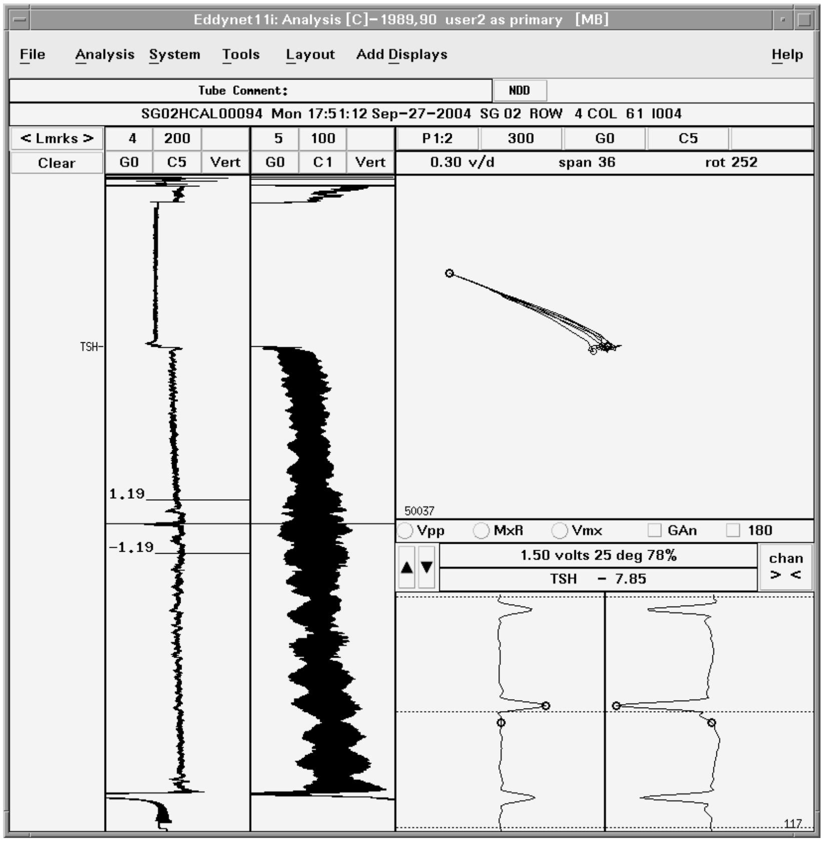




(b) (c)

Figure 3. Data analysis results for tube R03C52. Graphics show (a) main Eddynet window for +Point ch. P1 and (b) terrain plot of degraded zone using ch. P4, and (c) axial lissajous of maximum signal. Based on +Point response, the signal is characterized as an ID-originated 116^{o} extent SCI located ~0.78-in. above hot-leg tube-end in TS tack expansion region with maximum amplitude of 2.94v and phase angle of 31^{o} corresponding to ~99%TW depth.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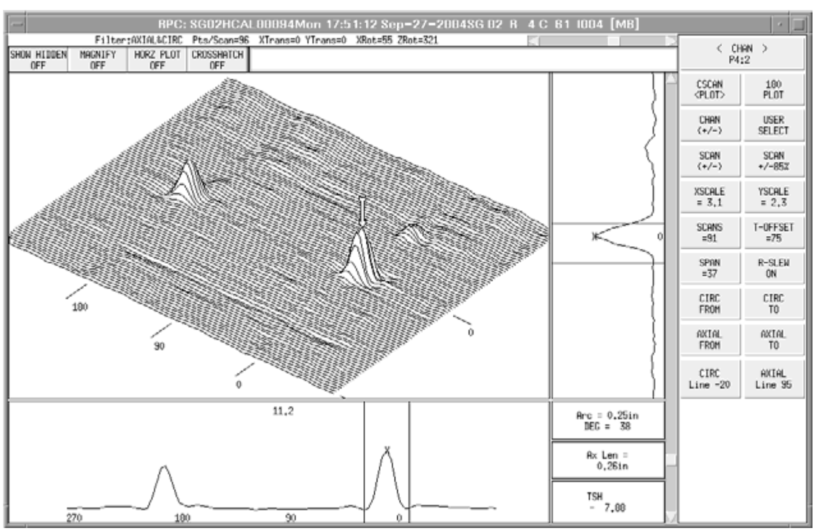
(a)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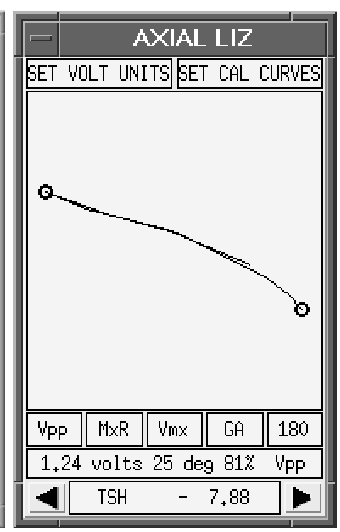
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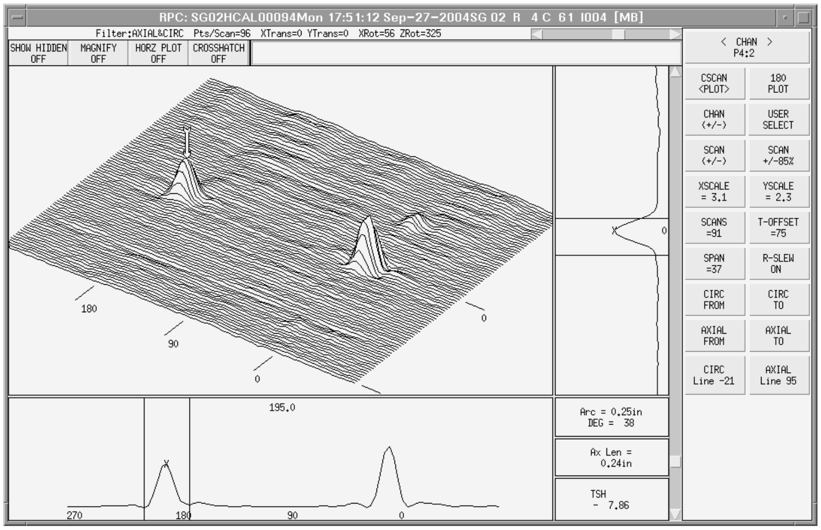

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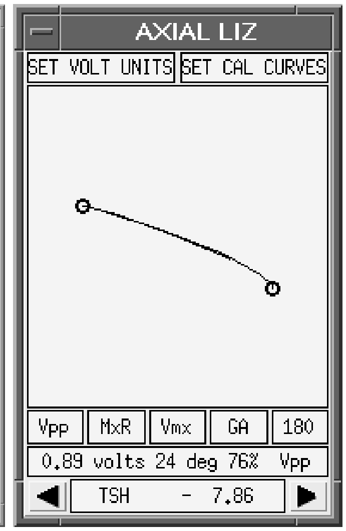

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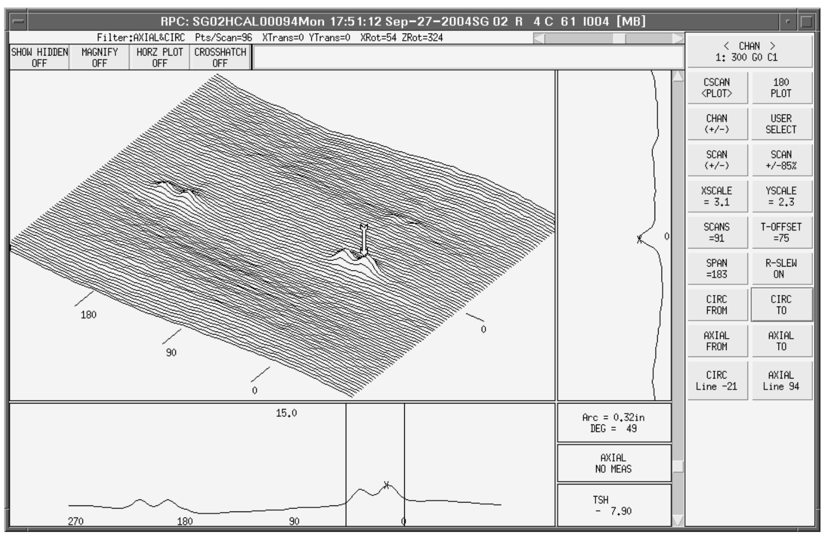
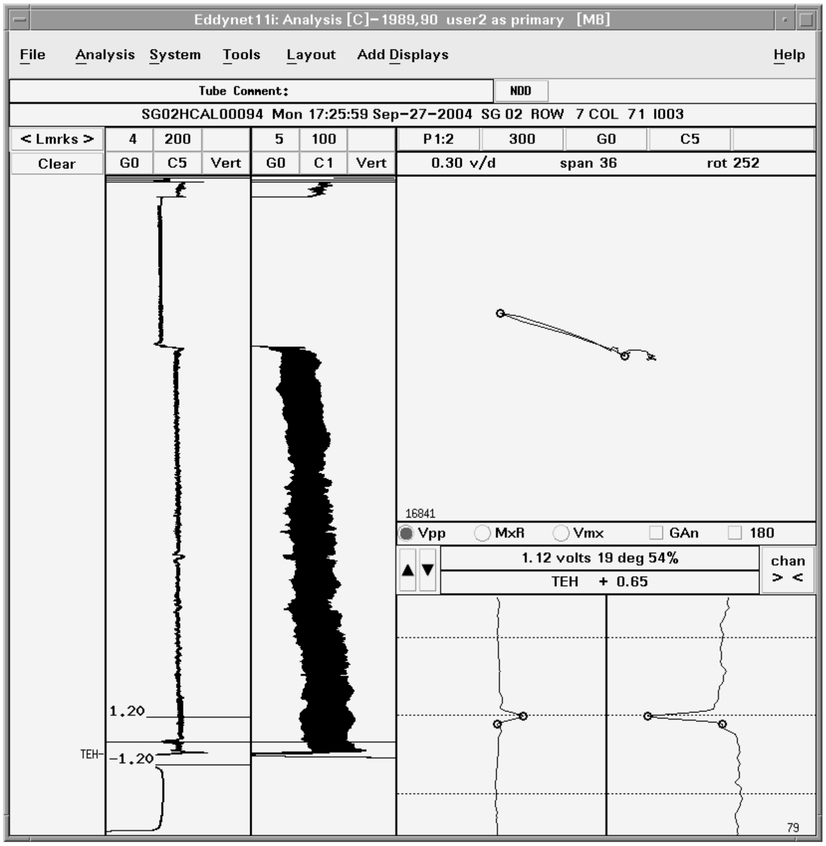


(f)

Figure 4. Data analysis results for tube R04C61. Graphics show (a) the main Eddynet window for +Point ch. P1 and (b) terrain plot of degraded zone using ch. P4 with arrow pointing at the first (largest) indication, (c) axial lissajous of maximum signal for the first indication, (d) terrain plot of degraded zone using ch. P4 with arrow pointing at the second indication, (e) axial lissajous of maximum signal for the second indication, and (f) terrain plot of degraded zone using pancake coil ch. 1. Based on +Point response, the three discrete signals are characterized as ID-originated SCI with the larger signals having ~38^{o} circumferential extent and located ~7.9-in. below hot-leg TTS in TS overexpansion region. The first indication has maximum amplitude of 1.24v and phase angle of 25^{o} corresponding to ~81%TW depth and the second indication has maximum amplitude of 0.89v and phase angle of 24^{o} corresponding to ~76%TW depth.



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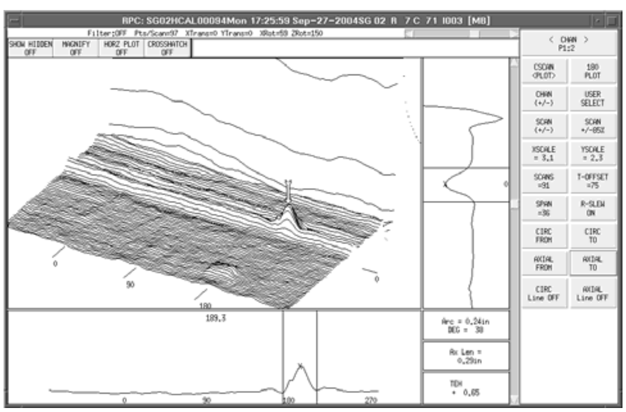
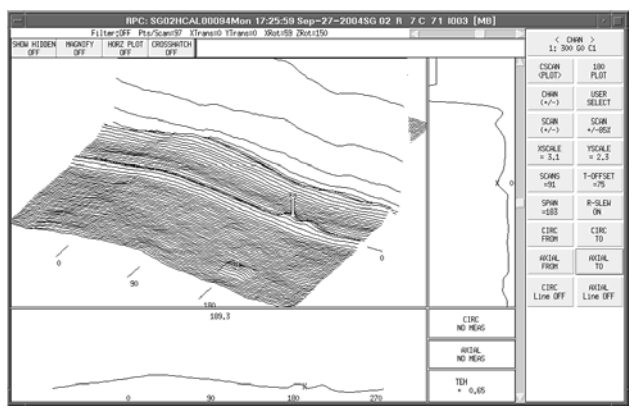
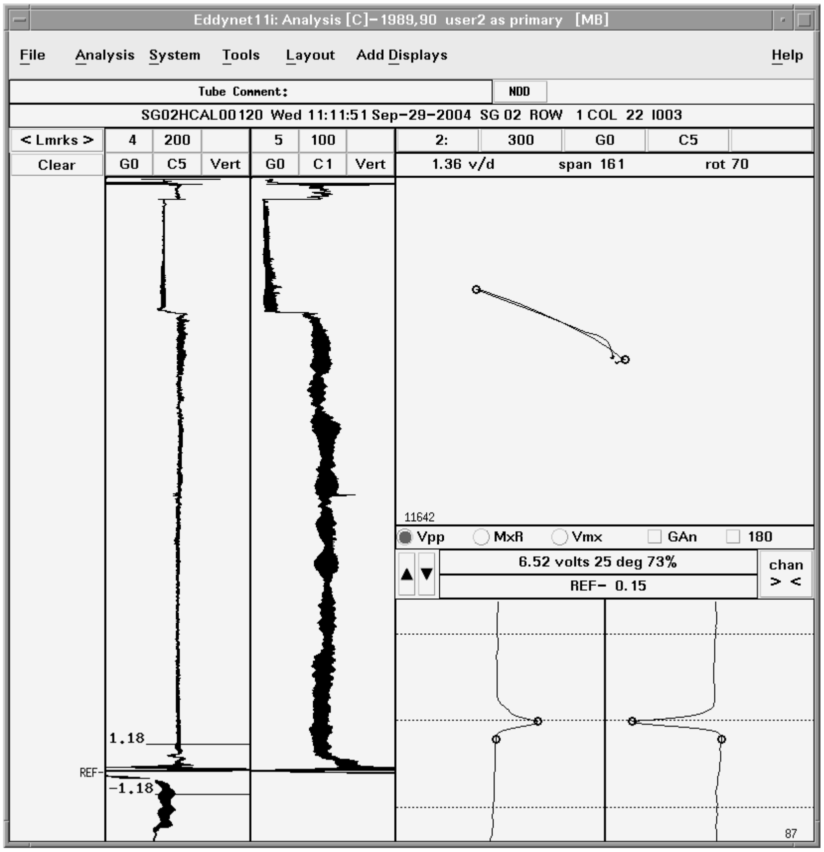




(b) (c)

Figure 5. Data analysis results for tube R07C71. Graphics show (a) the main Eddynet window for +Point ch. P1 and terrain plots of degraded zone using (b) ch. P1 and (c) pancake coil ch. 1. Based on +Point response, the signal is characterized as an ID-originated SCI with 38^{o} extent and located ~0.65-in. above hot-leg tube-end in tack expansion region. The maximum amplitude is 1.12v with phase angle of 19^{o} corresponding to ~54%TW depth.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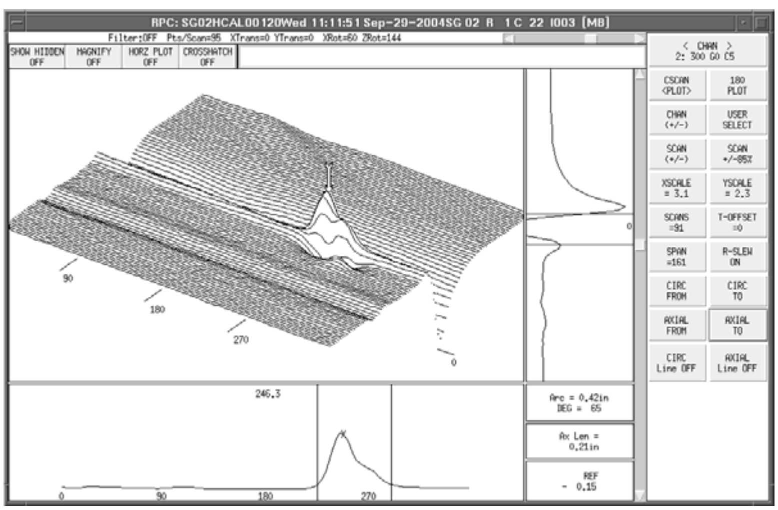
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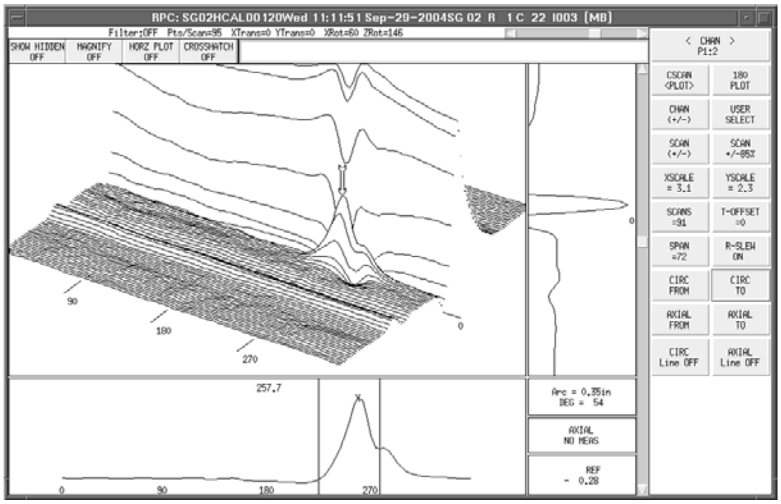

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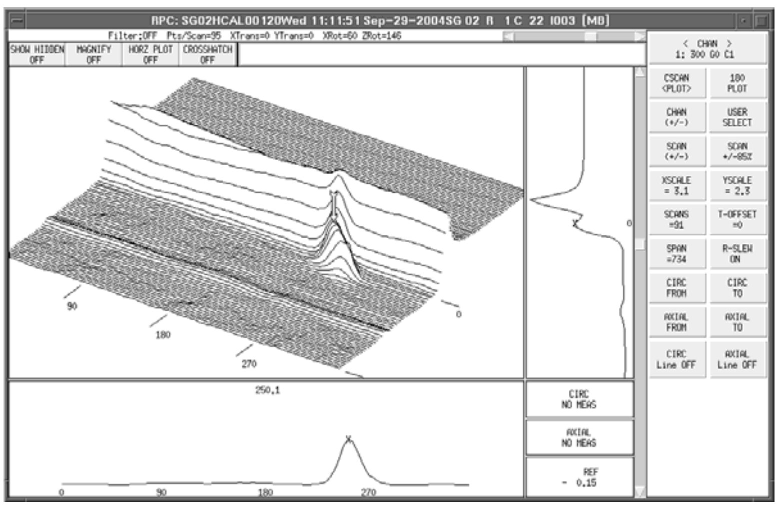
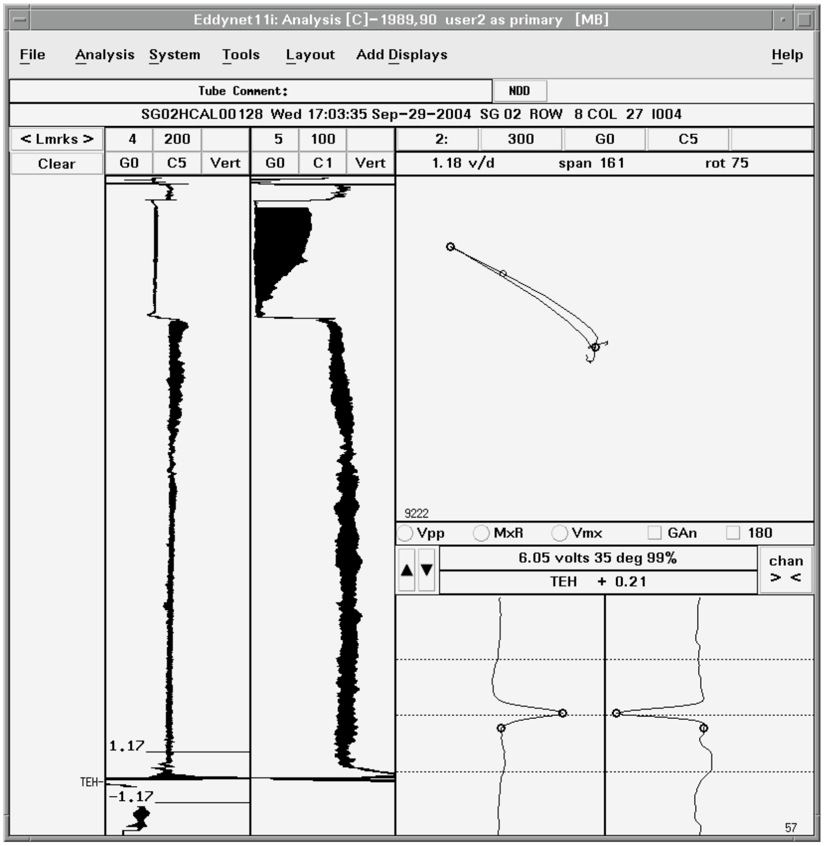


(d)

Figure 6. Data analysis results for tube R01C22. Graphics show (a) the main Eddynet window for +Point ch. 2 and terrain plots of degraded zone using (b) ch. 2, (c) ch. P1 and (d) pancake coil ch. 1. Based on +Point response, the signal is characterized as an ID- and OD-originated MMI (skewed orientation) with total length of 0.4 in. located ~0.15-in. above hot-leg tube-end. The maximum amplitude of the ID component is 6.52v with phase angle of 25^{o} corresponding to >73%TW depth. The maximum amplitude of the OD component is 2.42v with phase angle of 51^{o} corresponding to ~87%TW depth.



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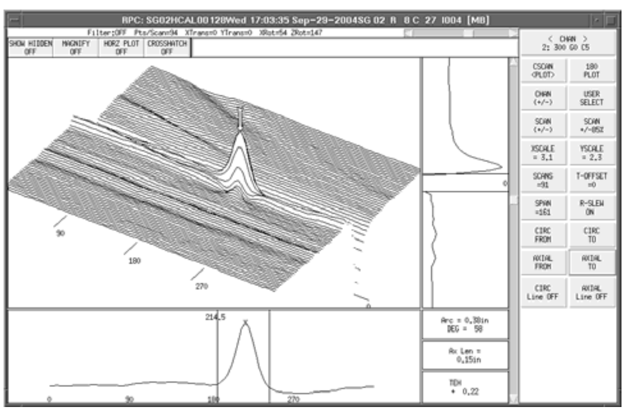

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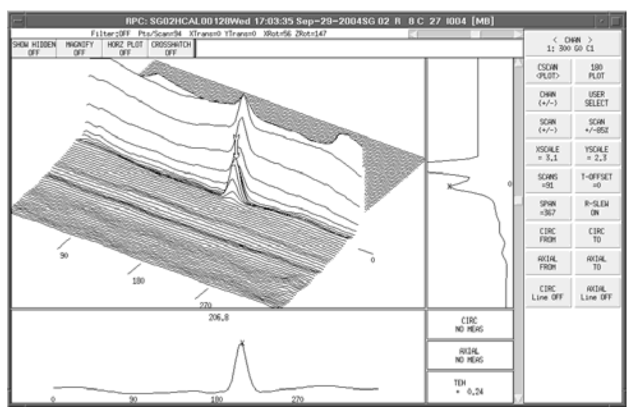
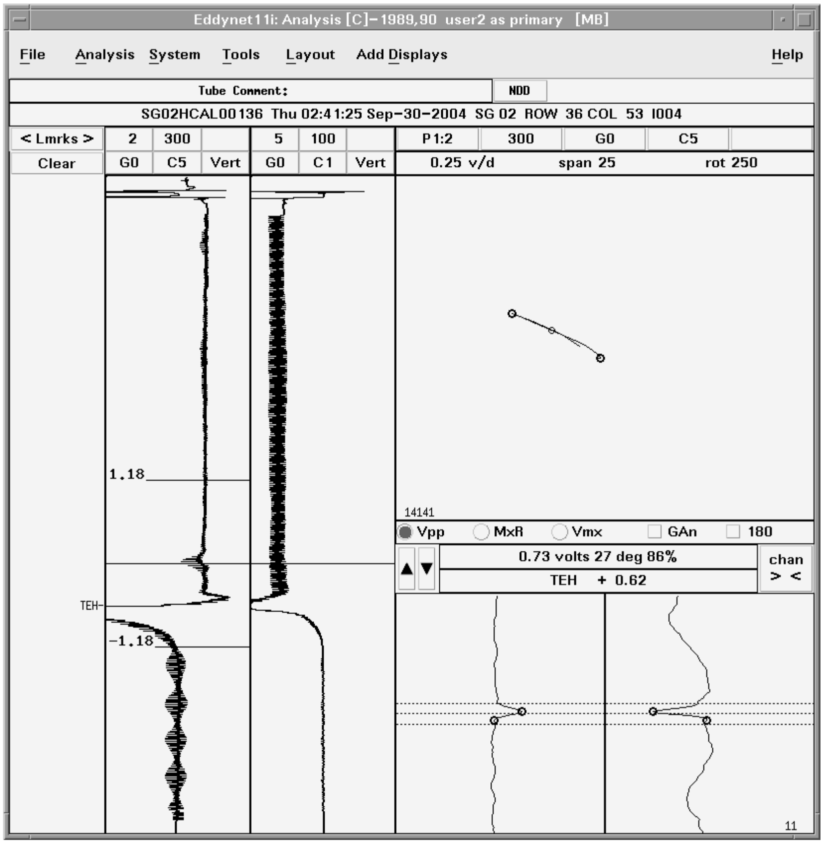
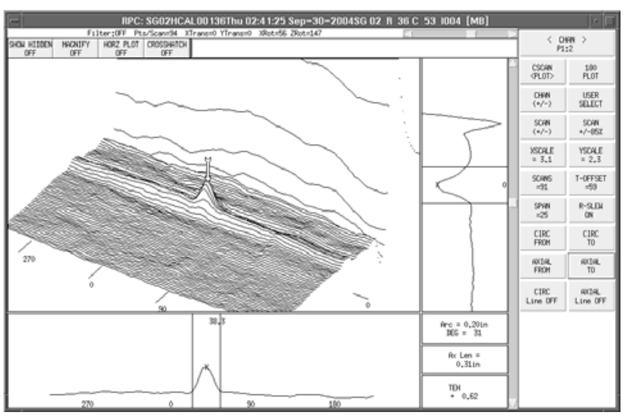


(c)

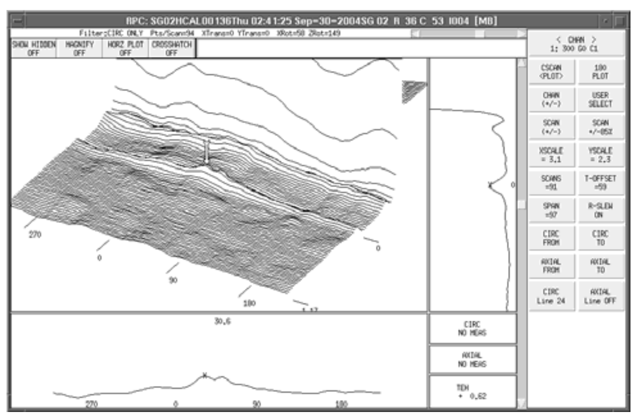
Figure 7. Data analysis results for tube R08C27. Graphics show (a) the main Eddynet window for +Point ch. 2 and terrain plots of degraded zone using (b) ch. 2 and (c) pancake coil ch. 1. Based on +Point response, the signal is characterized as an ID-originated 0.26-in.-long SAI located ~0.21-in. above hot-leg tube-end with maximum amplitude of 6.05v and phase angle of 35^{o} corresponding to ~100%TW depth.



(a)

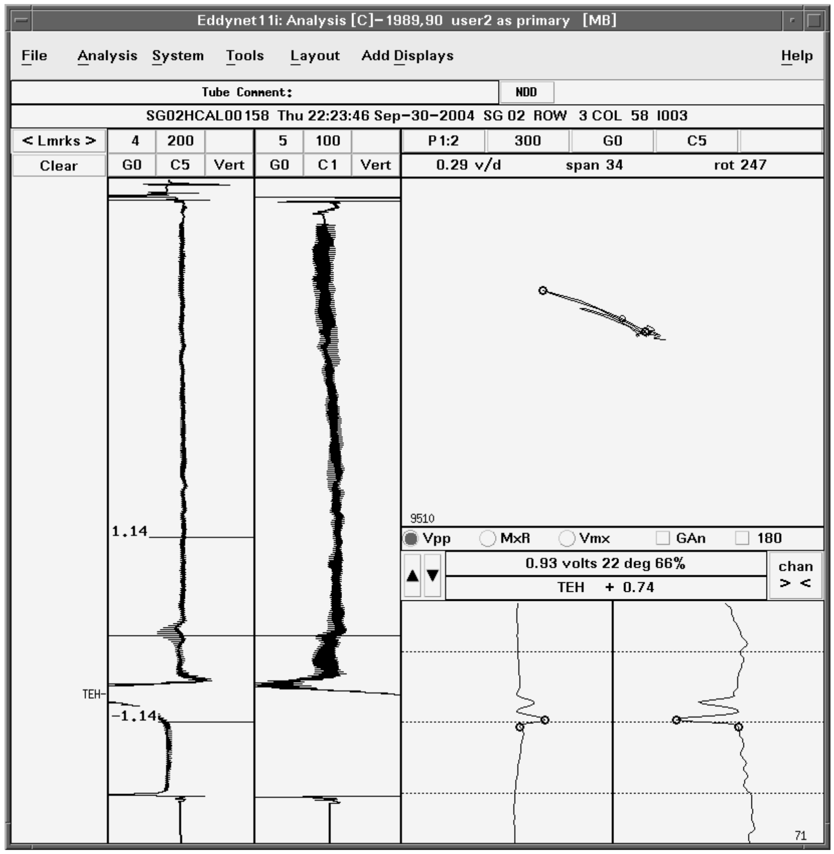


(b)

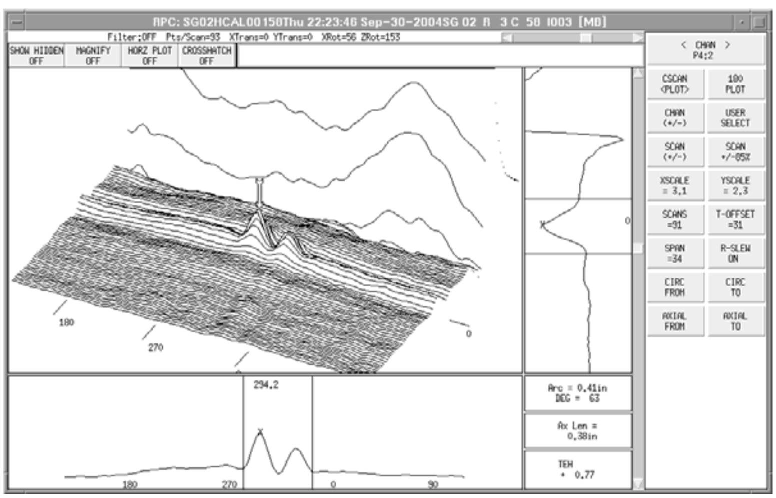


(c)

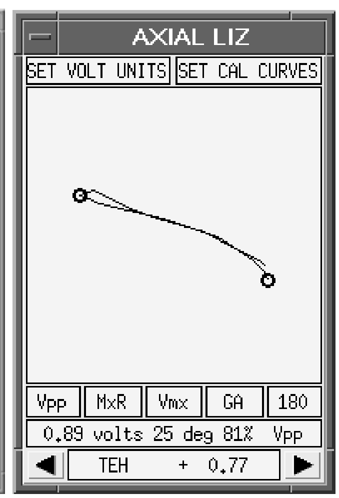
Figure 8. Data analysis results for tube R36C53. Graphics show (a) the main Eddynet window for +Point ch. P1 and terrain plots of degraded zone using (b) ch. P1 and (c) pancake coil ch. 1. Based on +Point response, the signal is characterized as an ID-originated 31^{o} extent SCI located ~0.62-in. above hot-leg tube-end in the tack expansion region with maximum amplitude of 0.73v and phase angle of 27^{o} corresponding to ~86%TW depth.



(a)

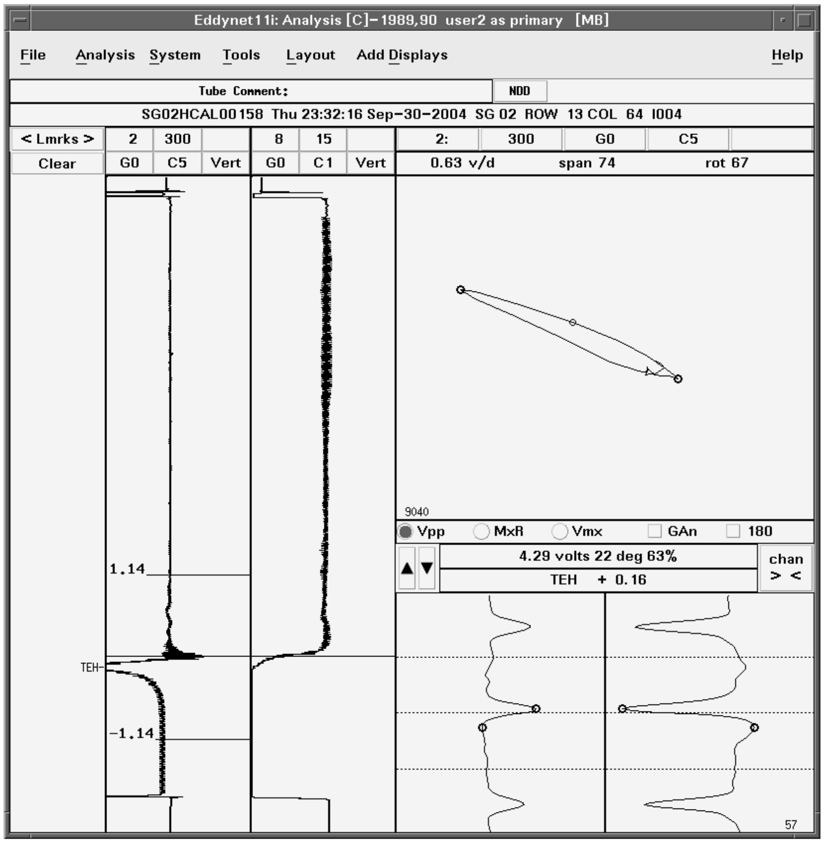


(b)

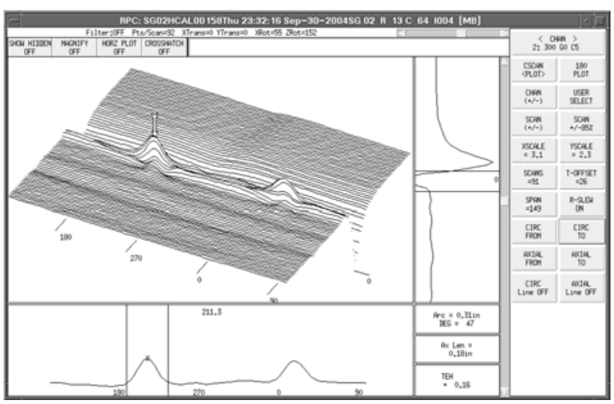


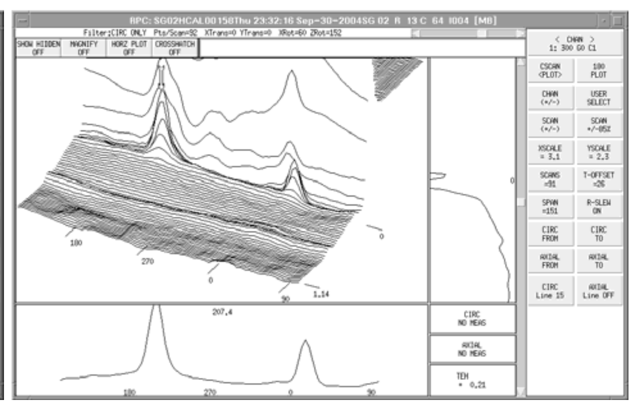
(c)

Figure 9. Data analysis results for tube R03C58. Graphics show (a) main Eddynet window for +Point ch. P1 and (b) terrain plot of degraded zone using ch. P4, and (c) axial lissajous of maximum signal. Based on +Point response, the signal is characterized as ID-originated MCI located ~0.77-in. above hot-leg tube-end in TS tack expansion region. The maximum amplitude of larger indication is 0.89v with phase angle of 25^{o} corresponding to ~81%TW depth. The maximum amplitude of smaller indication is 0.62v with phase angle of 22^{o} corresponding to ~68%TW depth. The circumferential extent of each indication is ~32^{o}.



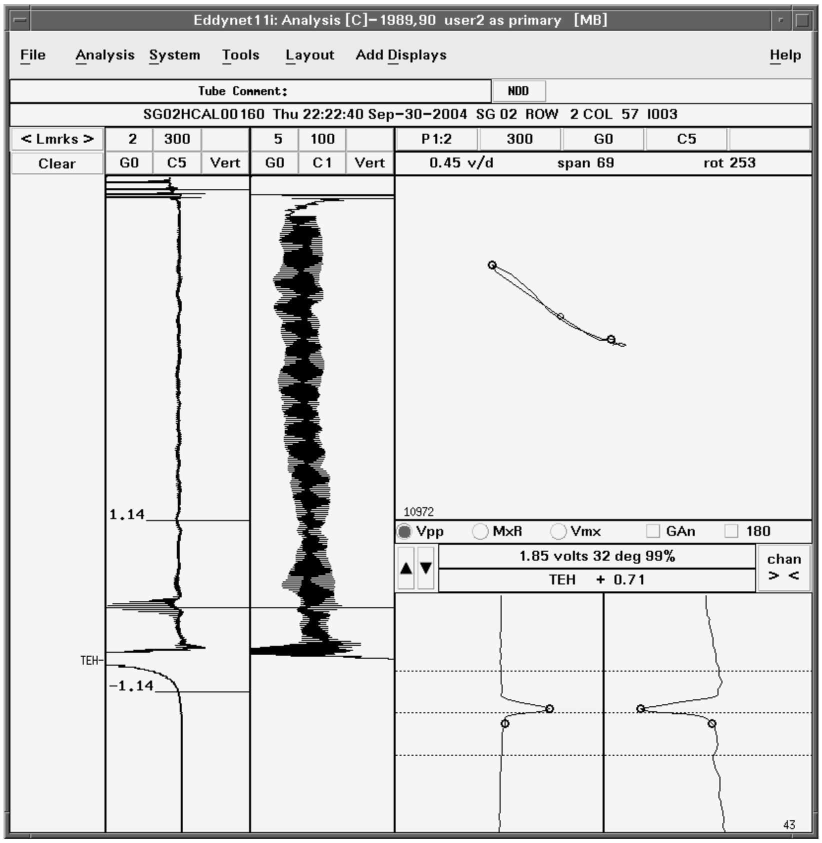
(a)



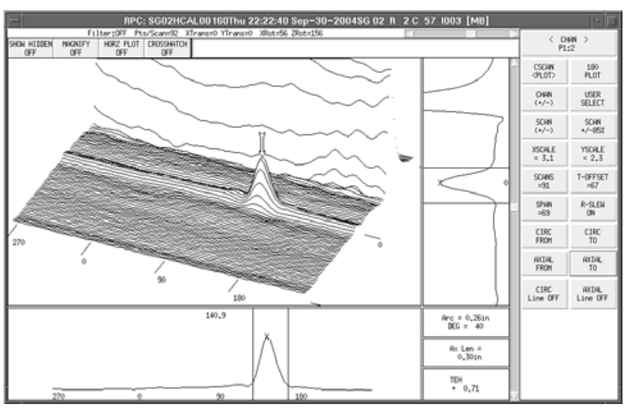


(b) (c)

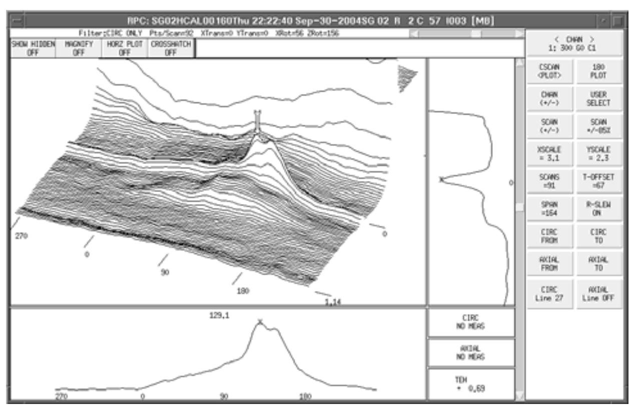
Figure 10. Data analysis results for tube R13C64. Graphics show (a) the main Eddynet window for +Point ch. 2 and terrain plots of degraded zone using (b) ch. 2 and (c) pancake coil ch. 1. Based on +Point response, the signals are characterized as multiple ID-originated SAI located ~0.16-in. above hot-leg tube-end with ~0.15-in. and ~0.13-in. axial extent. The maximum amplitude of the larger indication is 4.29v with phase angle of 22^o corresponding to ~63%TW depth. The deeper portion of the same indication is 3.61v with phase angle of 27^o corresponding to ~81%TW depth. The maximum amplitude of the smaller indication is 3.0v with phase angle of 23^o corresponding to ~66%TW depth.



(a)

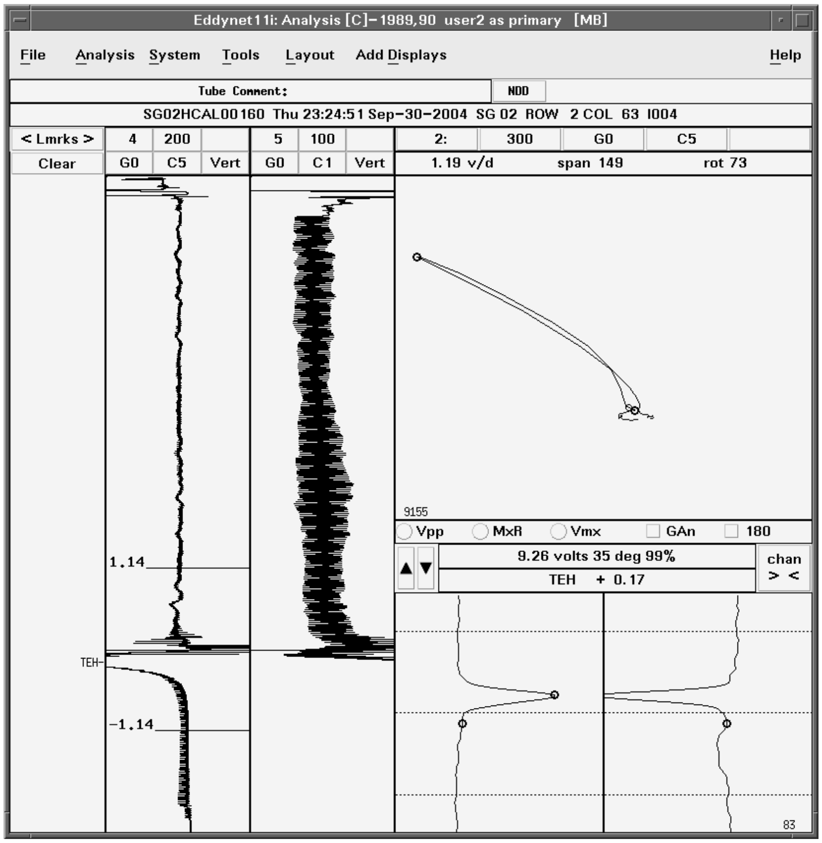


(b)

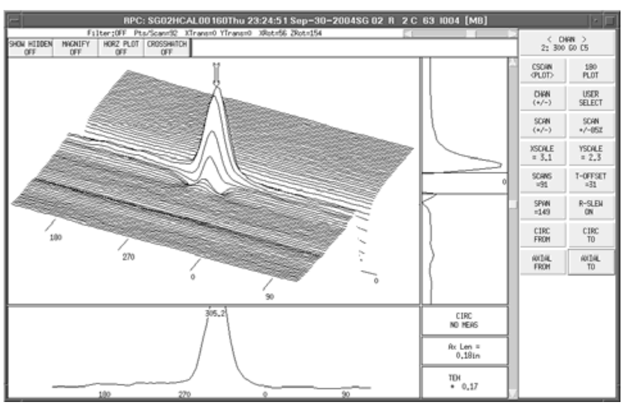


(c)

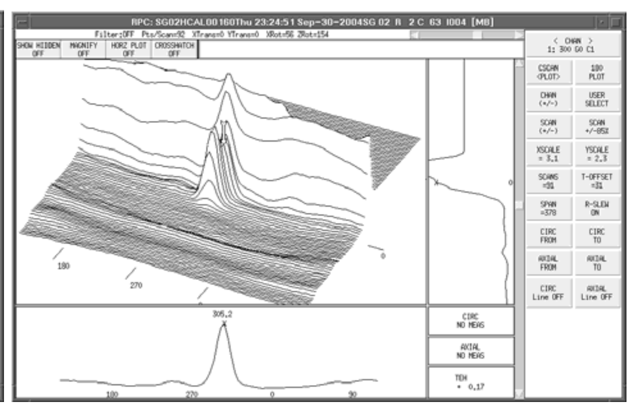
Figure 11. Data analysis results for tube R02C57. Graphics show (a) the main Eddynet window for +Point ch. P1 and terrain plots of degraded zone using (b) ch. P1 and (c) pancake coil ch. 1. Based on +Point response, the signal is characterized as an ID-originated 40° extent SCI located ~0.71-in. above hot-leg tube-end in tack expansion region with maximum amplitude of 1.85v and phase angle of 32° corresponding to ~99%TW depth.



(a)

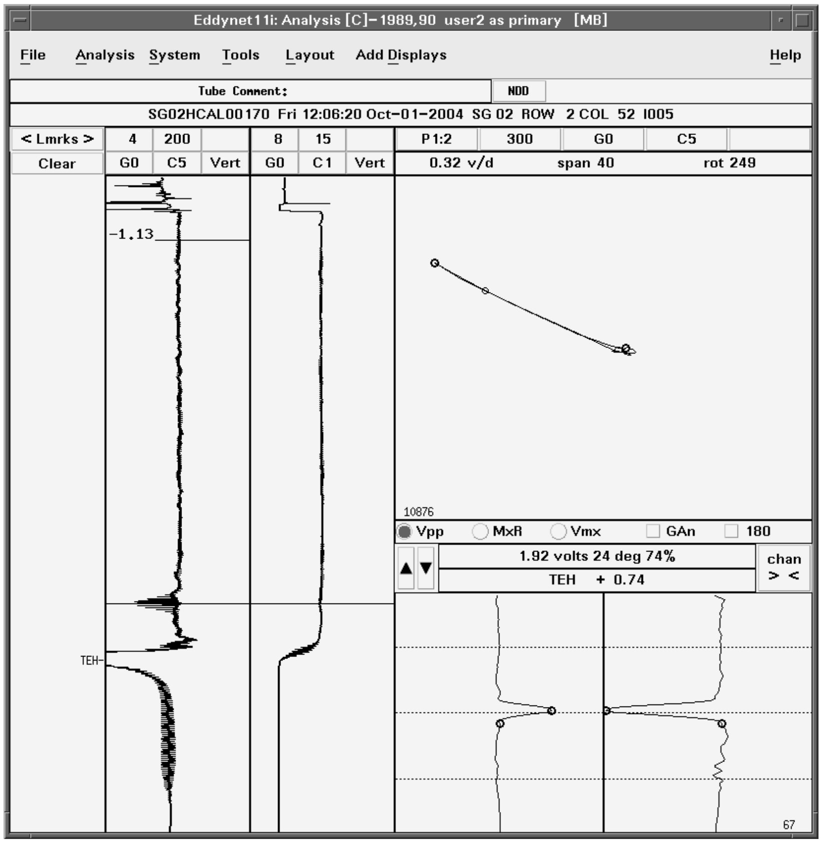


(b)

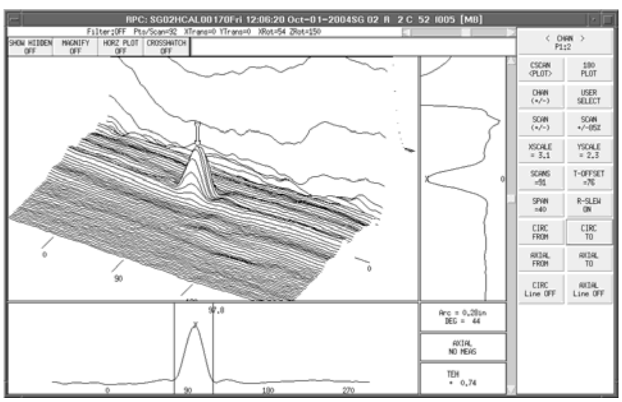


(c)

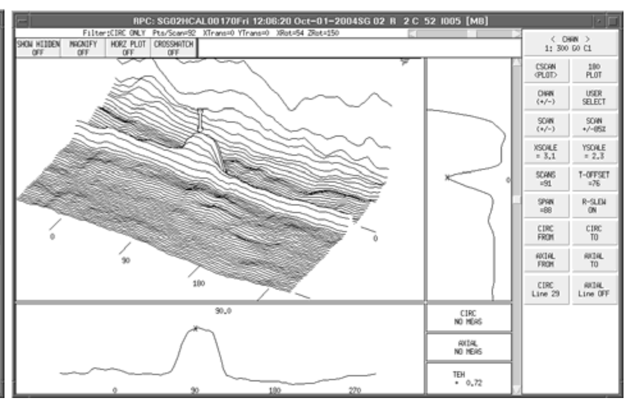
Figure 12. Data analysis results for tube R02C63. Graphics show (a) the main Eddynet window for +Point ch. 2 and terrain plots of degraded zone using (b) ch. 2 and (c) pancake coil ch. 1. Based on +Point response, the signal is characterized as an ID-originated ~0.25-in.-long SAI located ~0.17-in. above hot-leg tube-end with maximum amplitude of 9.26v and phase angle of 35^o corresponding to ~100%TW depth.



(a)

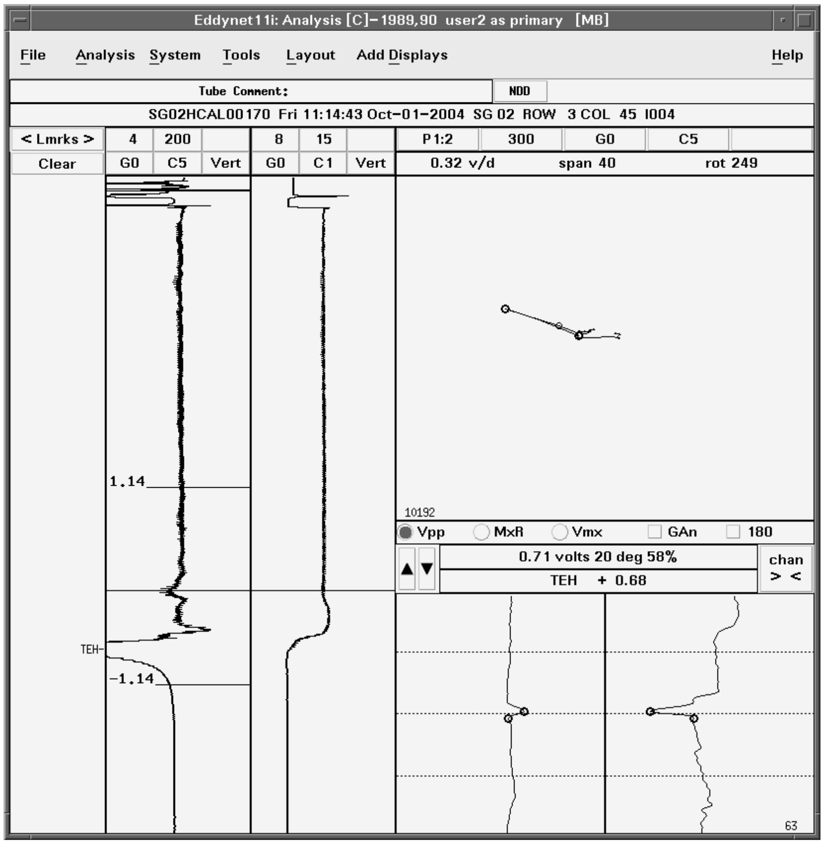


(b)

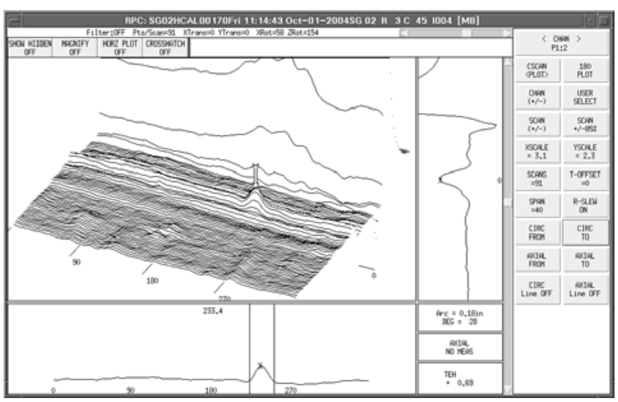


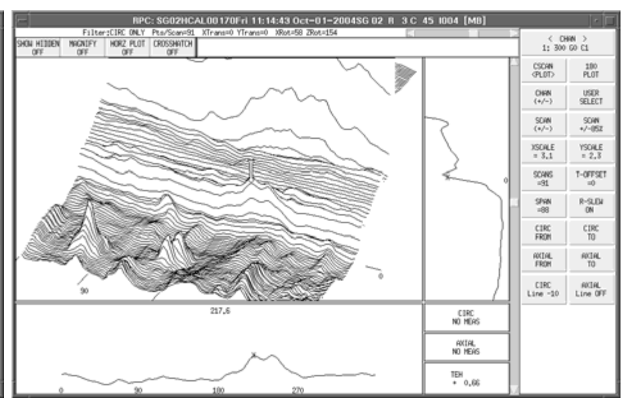
(c)

Figure 13. Data analysis results for tube R02C52. Graphics show (a) the main Eddynet window for +Point ch. P1 and terrain plots of degraded zone using (b) ch. P1 and (c) pancake coil ch. 1. Based on +Point response, the signal is characterized as an ID-originated 44^o extent SCI located ~0.74-in. above hot-leg tube-end in tack expansion region with maximum amplitude of 1.92v and phase angle of 24^o corresponding to ~74%TW depth.



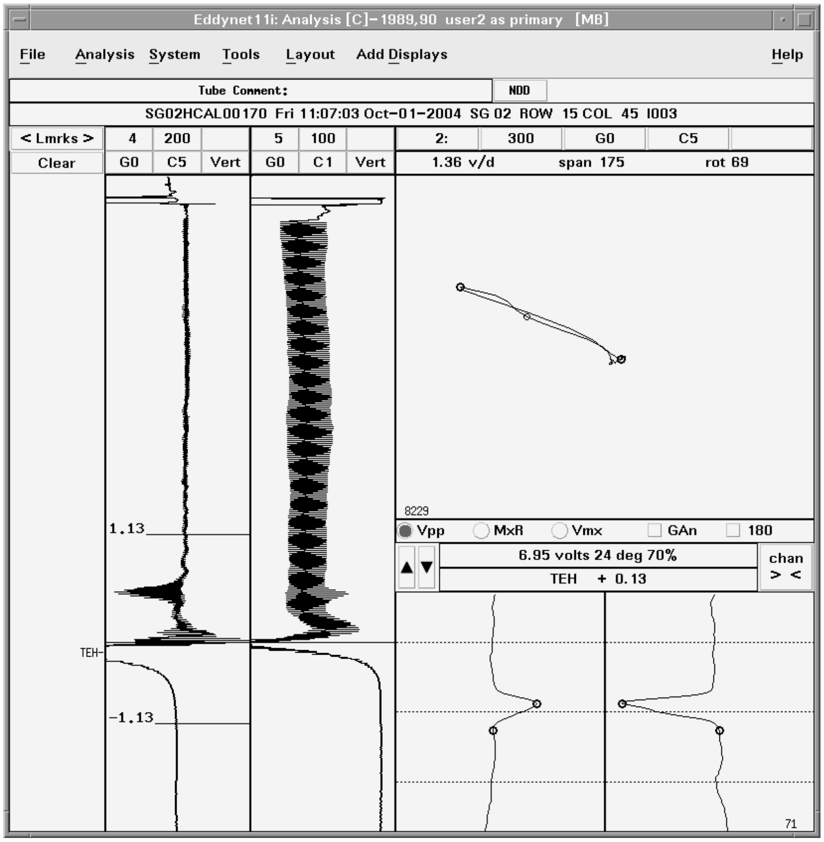
(a)





(b) (c)

Figure 14. Data analysis results for tube R03C45. Graphics show (a) the main Eddynet window for +Point ch. P1 and terrain plots of degraded zone using (b) ch. P1 and (c) pancake coil ch. 1. Based on +Point response, the signal is characterized as an ID-originated 28^{o} extent SCI located ~0.68-in. above hot-leg tube-end in tack expansion region with maximum amplitude of 0.71v and phase angle of 20^{o} corresponding to ~58%TW depth.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Help
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200
G0
C5
Vert
5
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G0
C1
Vert
2:
300
G0
C5
1.36 v/d
span 175
rot 69
1.13
TEH
-1.13
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Vpp
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Vmx
GAn
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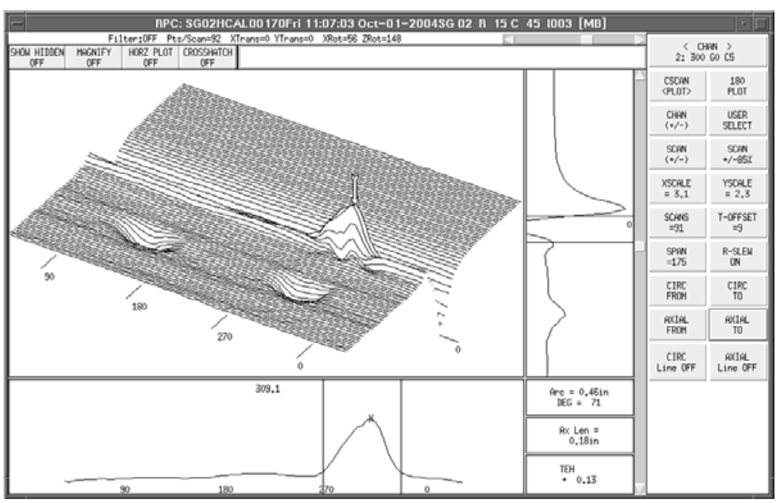
TEH + 0.13
chan
71

(a)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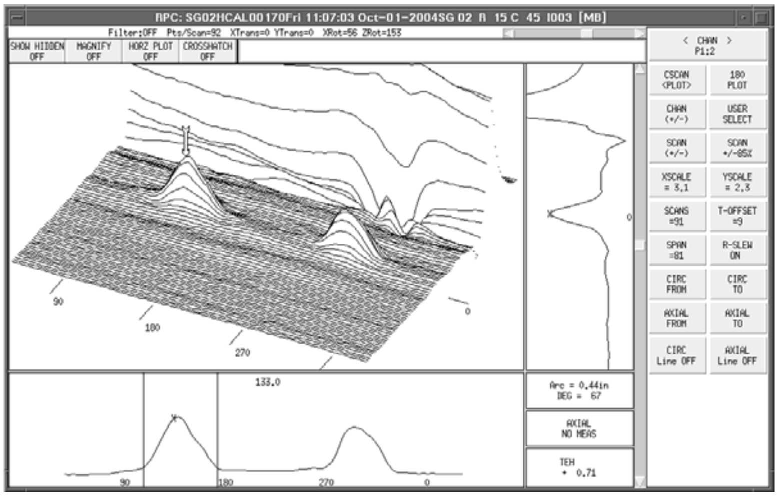
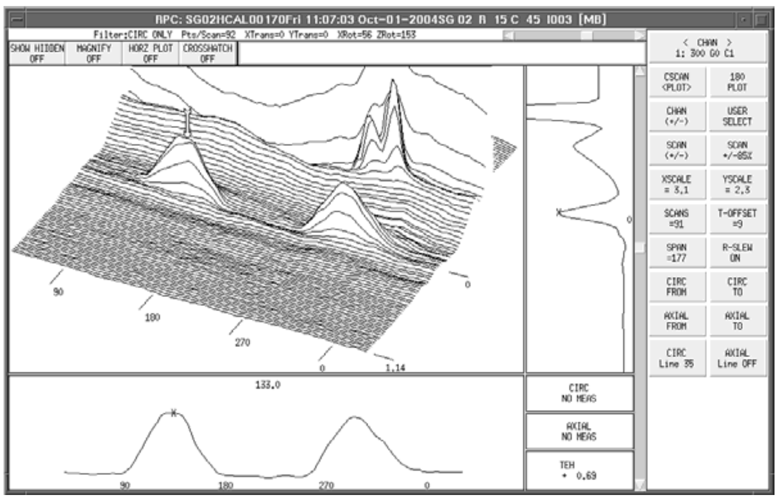
(b)

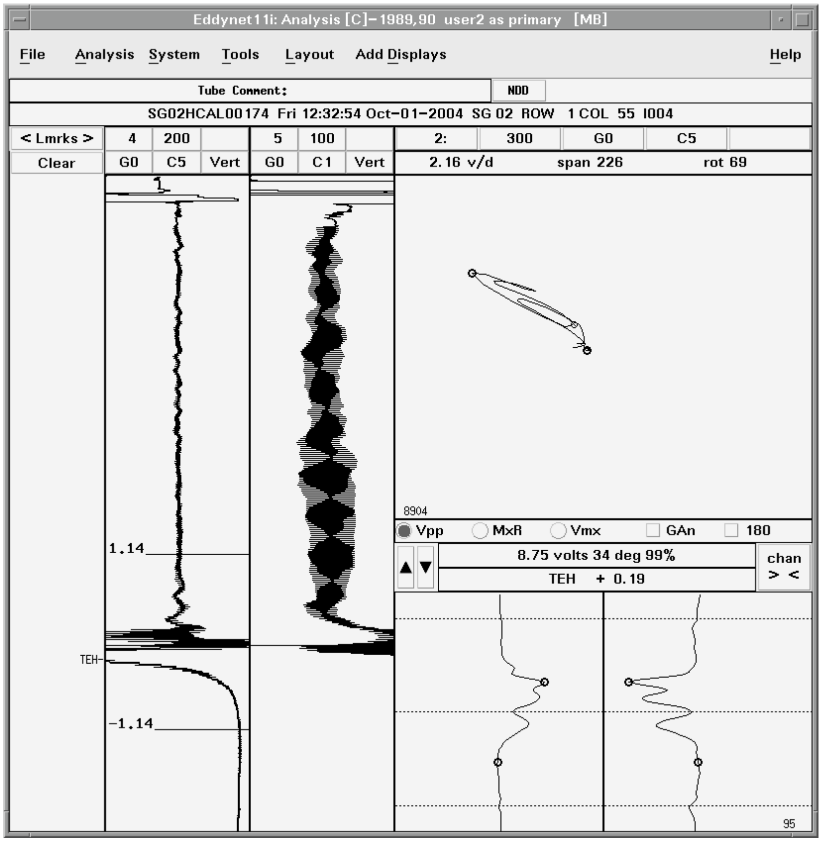


(c)



(d)

Figure 15. Data analysis results for tube R15C45. Graphics show (a) the main Eddynet window for +Point ch. 2 and terrain plots of degraded zone using (b) ch. 2, (c) ch. P1 and (d) pancake coil ch. 1. Based on +Point response, the signals are characterized as ~0.15-in.-long ID-originated SAI located ~0.13-in. above hot-leg tube-end and MCI located ~0.7-in above hot-leg tube-end in tack expansion region with the larger signal having 67^o circumferential extent. The maximum amplitude of SAI is 6.95v with phase angle of 24^o corresponding to 70%TW depth. The maximum amplitude of MCI is 2.77v with phase angle of 28^o corresponding to 91%TW depth.


Eddynet11i: Analysis [C]-1989,90 user2 as primary [MB]
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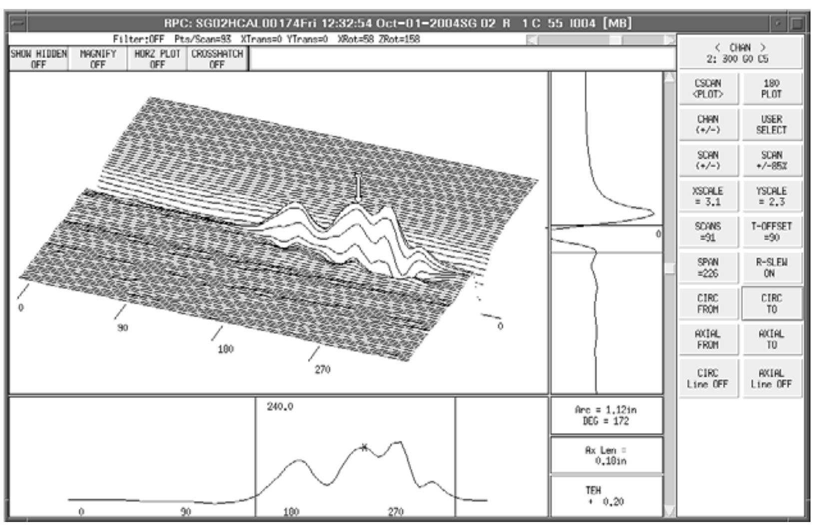
G0 C5 Vert
5 100
G0 C1 Vert
2: 300 G0 C5
2.16 v/d span 226 rot 69
8904
Vpp MxR Vmx GAn 180
8.75 volts 34 deg 99%
TEH + 0.19
chan
1.14
TEH
-1.14
95

(a)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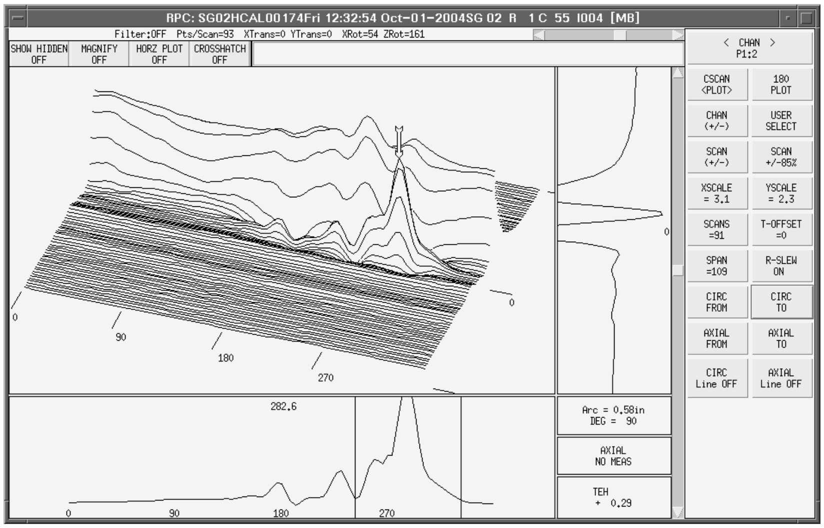
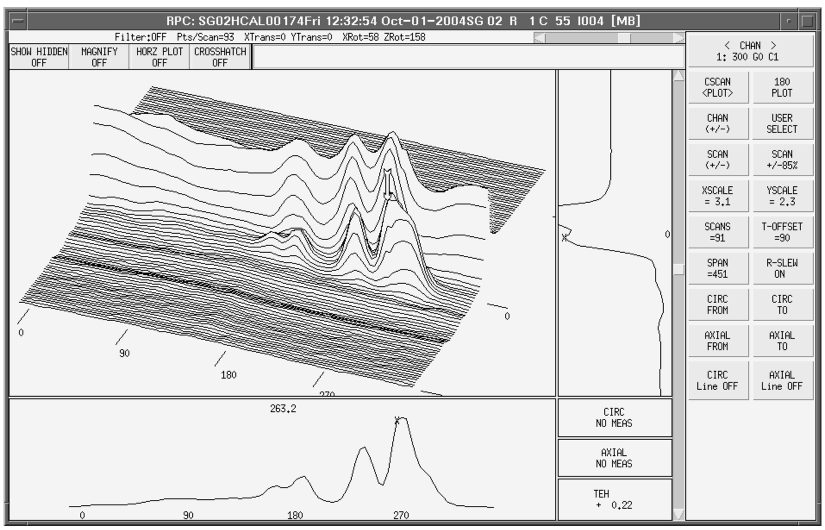
(b)

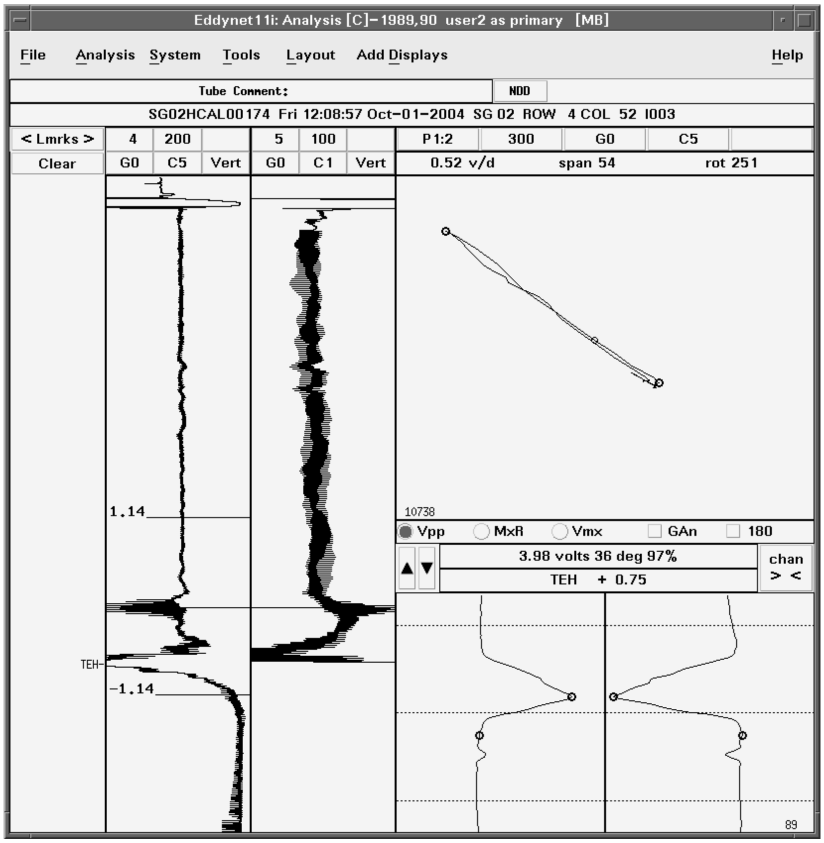


(c)

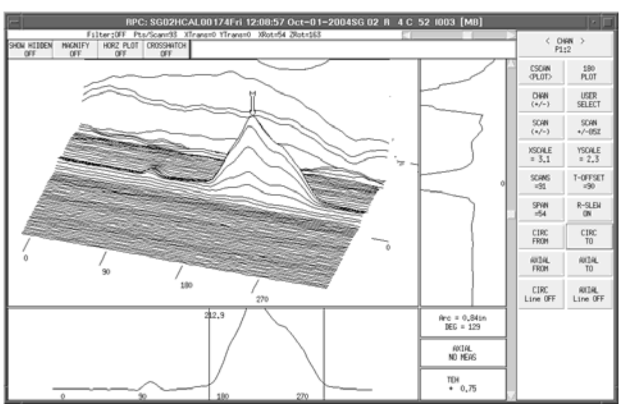


(d)

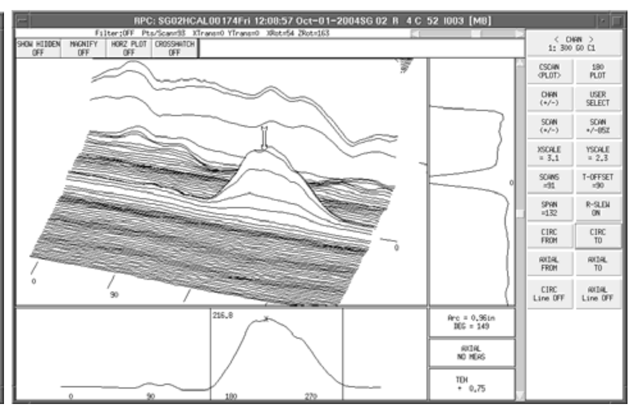
Figure 16. Data analysis results for tube R01C55. Graphics show (a) the main Eddynet window for +Point ch. 2 and terrain plots of degraded zone using (b) ch. 2, (c) ch. P1 and (d) pancake coil ch. 1. Based on +Point response, the signals are characterized as ~0.15-in.-long ID-originated MAI located ~0.18-in. above hot-leg tube-end and OD-originated MCI located ~0.29-in above hot-leg tube-end region with the largest segment having 90^o circumferential extent. The maximum amplitude of MAI is 8.75v with phase angle of 34^o corresponding to ~100%TW depth. The maximum amplitude of MCI is 6.65v with phase angle of 42^o corresponding to 93%TW.



(a)

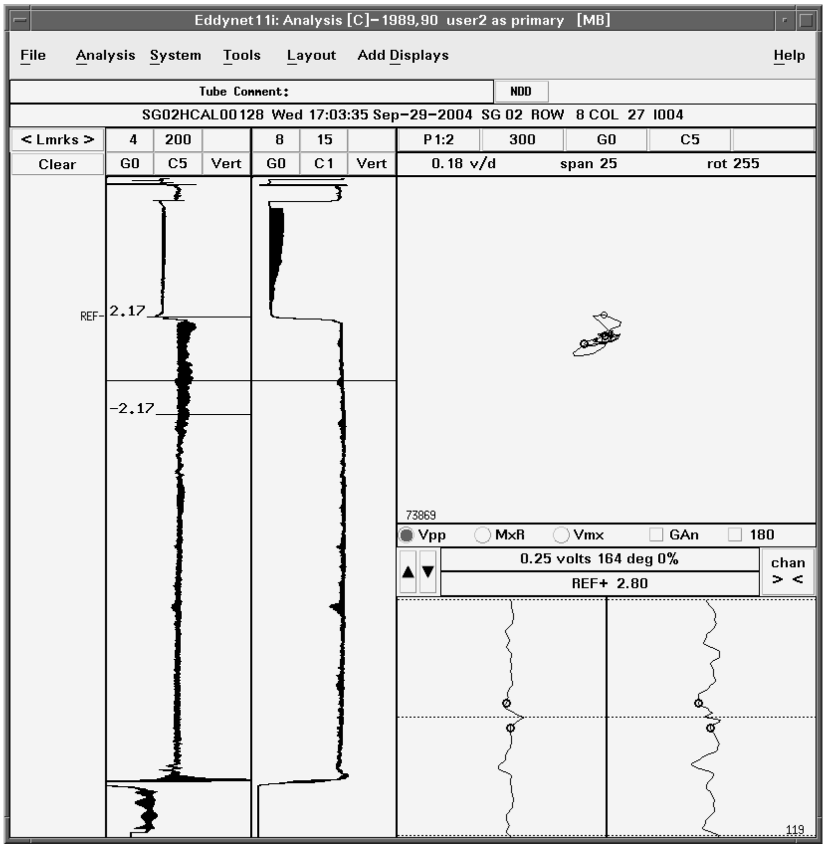


(b)

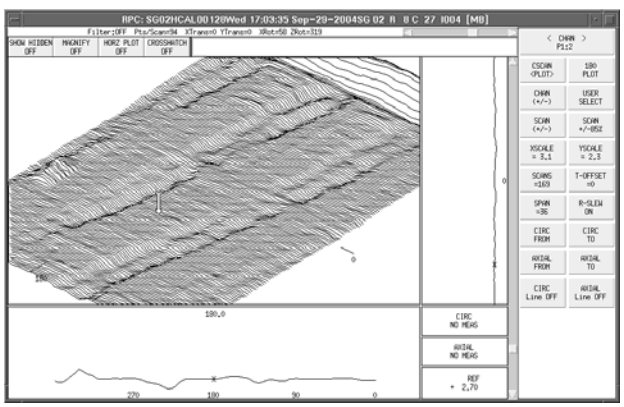


(c)

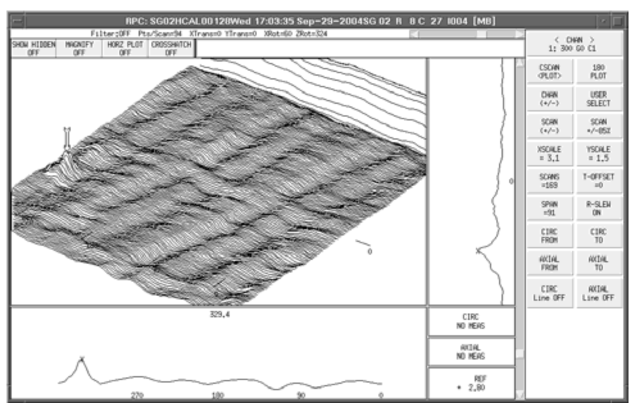
Figure 17. Data analysis results for tube R04C52. Graphics show (a) the main Eddynet window for +Point ch. P1 and terrain plots of degraded zone using (b) ch. P1 and (c) pancake coil ch. 1. Based on +Point response, the signal is characterized as an OD-originated 129^{o} extent SCI located ~0.75-in. above hot-leg tube-end in tack expansion region with maximum amplitude of 3.98v and phase angle of 36^{o} corresponding to ~97%TW depth.



(a)

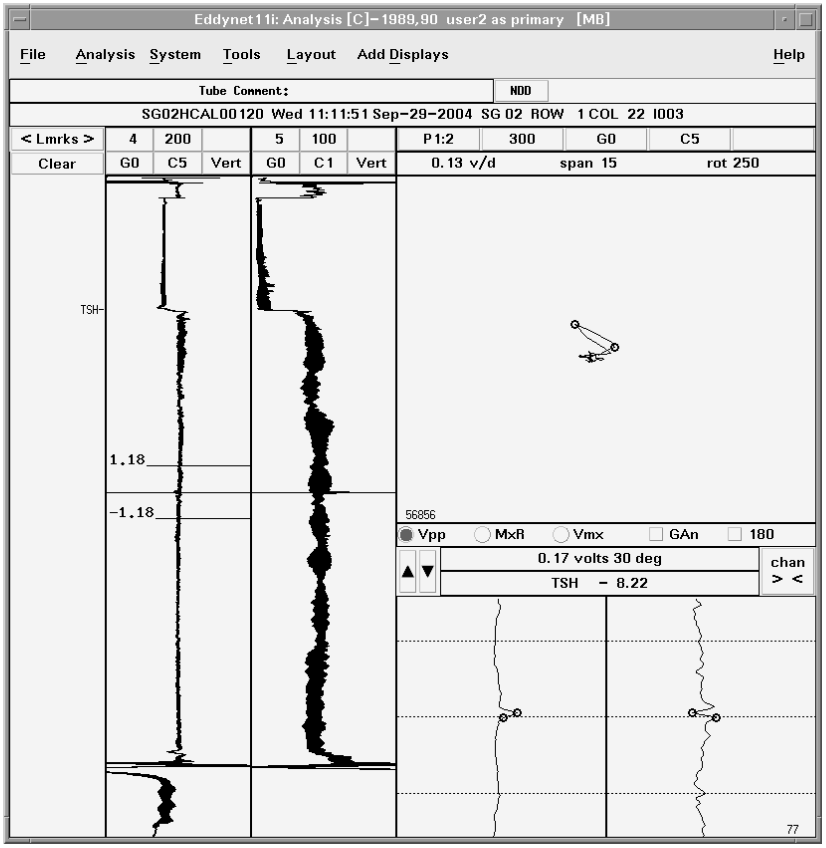


(b)

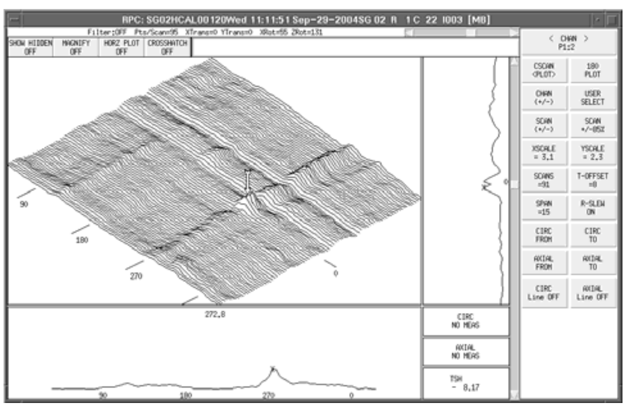


(c)

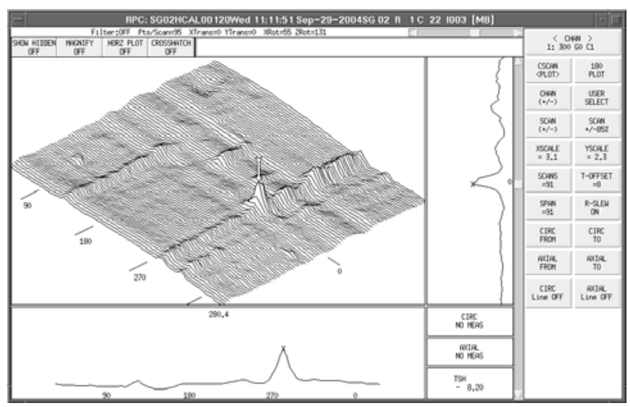
Figure 18. Example of a tube with higher level of eddy current noise in the upper portion of the tubesheet than those found in other tubesheet sections in the database.



(a)



(b)



(c)

Figure 19. Example of a low-amplitude indication in TS over-expanded region of tube R01C22 indicative of potential incipient cracking. Graphics show (a) main Eddynet window for +Point channel P1 and terrain plots of (b) ch. P1 and (c) pancake coil ch. 1.