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Callaway Plant

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September 30, 2004

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Stop P1-137
Washington, DC 20555-0001

ULNRC05048

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Ladies and Gentlemen:

DOCKET NUMBER 50-483
CALLAWAY PLANT UNIT 1
UNION ELECTRIC CO.
FACILITY OPERATING LICENSE NPF-30
STEAM GENERATOR CONDITION MONITORING REPORT

The enclosed Report is submitted in accordance with NEI 97-06 Revision 1 reporting requirements which state that if the results of a steam generator inspection indicate greater than one percent of the inspected tubes in any steam generator exceed the repair criteria, a Condition Monitoring report containing results of tube pulls and in situ testing is to be submitted to the NRC within 120 days after the Reactor Coolant System reenters Hot Shutdown conditions. There were no tube pulls or in-situ testing performed on steam generators at the Callaway Plant during Refuel 13. These portions of the reporting requirement are not applicable and thus not included in this Report.

This letter does not contain new commitments.

Sincerely,

Warren A. Witt

Warren A. Witt
Manager, Callaway Plant

Enclosure

A047

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ENGINEERING INFORMATION RECORD

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Title Steam Generator Condition Monitoring at RF 13

PREPARED BY:		REVIEWED BY:	
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Signature [signature]	Date 6/16/2004	Signature [signature]	Date 6/16/04

Technical Manager Statement: Initials [initials]

Reviewer is Independent.

Remarks:

This report provides the details of a Condition Monitoring evaluation of steam generator tubing degradation at Callaway at the RF 13 inspection.

TABLE OF CONTENTS

Section 1
INTRODUCTION

This report describes condition monitoring evaluations of steam generator tubing at Callaway. The observed severity of degradation at the end of cycle, outage RF 13, was evaluated to determine if structural and leakage integrity requirements were maintained. The scope of this evaluation included all the forms of tubing degradation observed at RF 13, specifically:

- Wear at AVB Tube Support Locations
- Expansion Transition Axial PWSCC
- Expansion Transition Axial ODSCC
- Expansion Transition Circumferential PWSCC
- Expansion Transition Circumferential ODSCC
- Combined Axial And Circumferential PWSCC at Expansion Transitions
- Circumferential PWSCC Within the Tubesheet
- Volumetric Degradation

The observed degradation at the RF 13 outage was evaluated in a manner consistent with NEI 97-06[1], and EPRI guidelines[2,3]. The observed degradation did not present serious challenges to the deterministic structural margin requirement at the end of the last cycle of operation. The limiting structural requirement is a 3ΔP differential pressure of 3900 psi.

In terms of an overview of repair scenarios:

- wear indications at tube supports are left in service if maximum depths are sized less than 40% of the wall thickness
- all other indications are repaired or plugged on detection.

The next section provides the results of condition monitoring evaluations for outage RF 13.

Section 2
CONDITION MONITORING

Condition monitoring evaluations relative to structural and leakage integrity are presented in this section. The following paragraphs present condition monitoring structural limits for axial cracks, circumferential cracks, volumetric degradation and wear scars for Callaway steam generator tubing. A discussion of leakage integrity then follows. Table 2.1 summarizes the number of indications of tubing degradation discovered at RF 13 and Table 2.2 summarizes structural and leakage integrity evaluation results.

In terms of an overview of steam generator tubing degradation at Callaway[4], axial and circumferential PWSCC has been observed at top of the tubesheet hydraulic expansion transitions for the past seven cycles of operation. This is the primary degradation mode. Occasional instances of ODSCC, both axial and circumferential, have been observed in this same region. Wear at AVB's is present. Approximately 1263 AVB wear indications among 574 tubes are present among the four steam generators. Wear growth rates are low leading to plugging several tubes per generator per inspection for each steam generator for depths exceeding the 40% TW limit. Small volumetric indications are observed on a sporadic basis. These indications are plugged on detection as are all other degradation modes with the exception of wear at AVB's.

The inspection scope at RF13 was as follows:

- 100% Plus Point TTS Inspection "+2/-X" in all SG Hot Legs, Distance X Depends on Location in the Tube Bundle, The Required Distance X to Demonstrate Leakage and Structural Integrity is Defined in WCAP-15932-P and Westinghouse analysis in Terms of Four Zones:

  Zone A, X = 5"
  Zone B, X = 7"
  Zone C and D X = 9"

- 100% Full Length Bobbin Exams In SGs A, B C and D
- 100% Rows 1 and 2 U-bend RPC in SG A
- 100 % Row 11 U-bends
- 50% Row 12 U-bends (100% in S/Gs A and D)
- 50% Row 17-21 U-Bends
- UT of all Electro-sleeves (26) in SG C H/L
- All Westinghouse Laser Welded Sleeves (43) in SG A
- 20% Plus Point Inspection of Dents and Dings >2V in all SGs at all Locations
- 100% Plus Point Inspection of Dents and Dings > 5V in all SGs
- Special Interest Plus Point Exams as Required

No degradation was detected in Electro-sleeves and laser welded sleeves. The first ten rows of tubes at Callaway are thermally treated Alloy 600 tubing. Thermal treatment was performed after fabrication of the U-bends. Since this improves both the residual stress state and material resistance to stress corrosion, no degradation was expected in the Row 1 and Row 2 U-bends and none was observed. No degradation was expected in higher row U-bends and none was observed. No degradation was observed in the sampling Plus Point inspection of dents and dings.

Detected instances of degradation, as listed in Table 2.1, follow the expectations from past experience at Callaway. The total number of tubes plugged at RF13 for each steam generator is also listed in Table 2.1. The next section discusses a quantitative evaluation of degradation trends. Due to regulatory concerns with leakage integrity from possible PWSCC deep within the tubesheet, inspection depth issues were analyzed in detail and bounding leak rates from possible undetected degradation were conservatively determined[5]. Leakage integrity was demonstrated via inspection and analysis as described in later paragraphs.

Structural limits for axial cracks, circumferential cracks, volumetric degradation and wear scars for steam generator tubing at Callaway are described in the degradation assessment[4] for RF 13. These structural limits provide the framework needed for condition monitoring evaluations and operational assessments.

The combinations of wear scar lengths and depths leading to a 3ΔP burst pressure of 3900 psi are shown in Figure 2.1 for Callaway steam generator tubing. The upper curve, termed the structural limit curve using the nomenclature of the EPRI Steam Generator Degradation Specific Flaw Handbook[6], is based on a best fit burst pressure equation and average, at temperature, material properties. The lower curve in Figure 2.1 is the Condition Monitoring Limit Curve. This curve includes NDE sizing uncertainties as well as uncertainties in material properties and in the burst pressure equation. The Condition Monitoring Limit curve shows the locus of NDE inferred degradation lengths and depths leading to a burst pressure of 3900 psi at 0.90 probability at 50% confidence. Indications with NDE inferred lengths and depths at or below the Condition Monitoring Limit Curve meet the required deterministic structural performance criteria for minimum degraded tube burst pressure. As is shown below, all instances of degradation at Callaway plot below CM curves and thus CM is met via NDE sizing and analysis.

In applying NDE measured degradation dimensions to infer structural integrity, systematic errors, measurement uncertainties, and shape effects must be considered. *Historically, most NDE depth measurements refer to maximum depth.* Figure 2.2 shows a plot of maximum wear scar depth from destructive examinations results versus NDE measured depths[7] using the eddy current technique applicable to Callaway. The best fit straight line shows an intercept of 2.92% TW and a slope of 0.96, resulting in a small systematic error. The scatter in actual depth about the best-fit line is normally distributed with a standard deviation of 3.52% TW. This value is termed the standard error of estimate in conventional straight-line linear regression evaluations. From Figure 2.2 it is seen that, at a measured NDE depth of 40% TW, the best estimate of actual maximum depth is 43.9% TW. Actual maximum depths will scatter about this value with a standard deviation of 3.52% TW. For wear indications the systematic sizing error is small. The slope value is about 1.0. This allows plotting of the best estimate structural limit and the CM curve on the same plot. The best estimate structural limit is a function of actual degradation length and depth. The CM limit curve is expressed as a function of NDE depth and NDE length readings. Often the systematic error in NDE sizing is such that NDE readings are significantly larger than the actual degradation depths and lengths. In these cases inclusion of both the best estimate structural limit curve and the condition monitoring limit curve on the same plot would lead to confusion since the CM curve, referring to NDE readings, could plot above the best estimate structural limit curve which refers to actual physical dimensions. When compared on an equal basis such as best estimate actual degradation dimensions, CM curves are below best estimate structural limit curves by about 1.5 times the NDE depth sizing standard deviation.

A summary of NDE sizing uncertainties[7] applicable to Callaway is listed in Table ~~2.4.~~ 2.3 BSC 8/17/04
The term modified in reference to ETSS 21409.1 indicates that sizing data for laboratory produced flaws were deleted and sizing uncertainties were recalculated using data which is representative of actual service degradation. Additionally, the curve fitting procedure used did not allow a non zero intercept value which would have led to a very unrealistic slope.

Structural integrity typically depends on average degradation depth, not maximum depth. Maximum degradation depths and total degradation lengths are conservative bounds to structurally significant depths and lengths. If more accuracy is required, crack depth versus length profiles need to be considered. The EPRI Flaw Handbook[6] provides a means of evaluating average depth from depth versus length profiles for predominantly axial degradation, whether crack-like or volumetric. Structurally significant lengths are also defined. For wear indications structural depth is conservatively estimated as equal to maximum depth and the structural length is conservatively set equal to the intersection length of the tube and support structure. If depth/length profiles are not available, pulled tube examination results show that stress corrosion cracks have a roughly semi-elliptical shape leading to a structural average depth equal to the maximum depth divided by a factor of 1.25^2.

Condition monitoring structural limit plots are shown in Figures 2.3 through 2.6 for AVB wear scars at Callaway. Figures 2.3 through 2.6 show plotted points representing AVB wear scars observed at RF 13. The length plotted is the bounding scar length for AVB wear which occurs when the tube and AVB do not have a perpendicular intersection. The plotted points fall well below the CM Limit curve. Required structural integrity is demonstrated. Since through wall tearing and burst will not occur at 3ΔP, leakage integrity at an FLB/SLB differential pressure of 2560 psi is also demonstrated.

Figure 2.7 illustrates that OD volumetric indications in steam generators B and C meet 3ΔP condition monitoring requirements. Of the total of 4 volumetric indications, 3 were located at tube support plates and 1 was located near the top of the tubesheet. All are low level indications in terms of extent, depth and signal amplitude. These indications meet both structural and leakage integrity requirements by a wide margin. The tube support indications are believed to be distorted wear indications and the OD indication near the top of the tubesheet is probably some combination of IGA and ODSCC.

Axial PWSCC indications were all located at the top of tubesheet expansion transition and all had very short lengths. The maximum indication length was 0.25 inches. Considering material property, burst equation and NDE sizing uncertainties an axial PWSCC crack can be 0.275 inches long and 100% TW and meet 3ΔP condition monitoring structural integrity requirements. All axial PWSCC indications thus meet condition monitoring structural integrity requirements. The same conclusion is evident from the distribution of Plus Point voltages shown in Figure 2.8. Only 2 axial PWSCC indications exhibited a voltage greater than the 1.5 volt threshold value in order to require NDE sizing. Figure 2.9 shows that the NDE measured length and depths demonstrate 3ΔP structural integrity.

Axial ODSCC indications were all located near expansion transitions. Figure 2.10 shows that all but 1 indication were below the Plus Point voltage threshold where NDE sizing was required. This confirms the low level of degradation severity for both OD and ID axial indications. Figure 2.11 illustrates that the NDE measured depth and length for the 1 OD indication above the structural sizing threshold demonstrates condition monitoring 3ΔP structural integrity.

Based on data in the EPRI Steam Generator In Situ Pressure Test Guidelines[2], axial PWSCC indications must exhibit a Plus Point voltage of 2.5 volts before leakage integrity at postulated FLB/SLB conditions becomes an issue or sizing is required. The maximum Plus Point voltage for all observed axial PWSCC indications was 1.73 volts. See Figure 2.8. Thus, leakage integrity is demonstrated. The same statement holds true of axial ODSCC indications. Figure 2.10 shows that the maximum observed Plus Point voltage is well below the 1.0 volt leakage threshold value.

A total of 33 circumferential PWSCC indications were found in the vicinity of the top of tubesheet expansion transitions. Only 3 circumferential PWSCC indications were found at some distance below the expansion transition as opposed to about 32 in the last inspection. All indications exhibited limited circumferential extent. The maximum NDE PDA value was 19 compared to the condition monitoring limits of 75 NDE PDA. Hence, the degradation found met condition monitoring structural integrity requirements by a large margin. Plus Point voltage levels were all below 1.0 volts satisfying both 3ΔP structural integrity and FLB/SLB leakage integrity requirements on a voltage threshold basis as described in the Callaway RF13 Degradation Assessment[4]. See Figure 2.12. Crack profiling of circumferential indications was performed even though not required. NDE PDA values are plotted on the x axis of Figure 2.13. The large margin to the CM limit of 75 NDE PDA is illustrated.

A total of 9 indications of OD circumferential cracking were found at RF13. All of these indications were in the vicinity of expansion transitions. As in the case of PWSCC circumferential indications, the circumferential extent, PDA values and Plus Point voltage level of ODSCC circumferential indications are small. The largest circumferential extent is 150 degrees, the largest PDA value is 9.8 versus a condition monitoring limit of 62 and the largest Plus Point voltage is 0.27 volts. The very mild nature of ODSCC circumferential degradation is illustrated in Figures 2.14 and 2.15. On a voltage basis alone, both 3ΔP structural integrity and FLB/SLB leakage integrity condition monitoring requirements are demonstrated.

There were two instances of combined axial and circumferential PWSCC indications near expansion transitions. Figure 2.16 and 2.17 present Plus Point terrain maps for the largest of the two occurrences of combined cracks. The configuration is essentially "L" shaped with some gap between the axial and circumferential cracks. The cracks are small and individual Plus Point voltages, 0.78 volts maximum, are well below the NDE sizing thresholds for either 3ΔP structural concerns or FLB/SLB leakage possibility for either axial or circumferential cracks. Additionally, there are extensive burst test data[8] for combined axial and circumferential cracks near expansion transitions. Figure 2.18 illustrates the very high burst pressures for small axial and circumferential ID cracks in close proximity. Burst pressures are about twice the 3ΔP value demonstrating a large margin of structural integrity.

Circumferential PWSCC sites may exist at depths within the tubesheet that have not been inspected with the Plus Point probe. There is no condition monitoring FLB/SLB leakage contribution from detected degradation or undetected degradation within inspected regions. A bounding accident leakage value for undetected degradation in regions that have not been inspected has been determined and reported in WCAP-15932-T[5]. This bounding value is 0.44 gpm.

In summary, condition monitoring structural and leakage integrity requirements are shown to have been met via analysis. The limiting structural integrity requirement of a minimum degraded tube burst strength of 3 ΔP is met. The bounding projected leak rate at limiting accident conditions is 0.44 gpm which is below the 1.0 gpm limit. The only degradation sites where leakage is possible was well within expanded regions deep in the tubesheet. Measured leakage at normal operating conditions was 0.09 gpd, well below the 75 gpd limit. Condition monitoring results are summarized in Table 2.2

Table 2.1

Summary of Indications at the RF 13 Inspection

Degradation Mechanism	SG A	SG B	SG C	SG D
AVB Wear	0 Plugged Tubes (249 Total Indications)	9 Plugged Tubes (352 Total Indications)	6 Plugged Tubes (343 Total Indications)	0 Plugged Tubes (319 Total Indications)
Expansion Transition Axial PWSCC	77 (1 mixed mode)	4	18 (1 mixed mode)	2
Expansion Transition Axial ODSCC	0	2	0	7
Expansion Transition Circumferential PWSCC	26 (1 mixed mode)	0	6 (1 mixed mode)	4
Expansion Transition Circumferential ODSCC	0	2	3	4
Circumferential PWSCC Deep within the Tubesheet Crevice	0	0	1	2
Volumetric Degradation	0	3	1	0
Total Tubes Plugged	100	19	32	17

Table 2.2

Summary of Condition Monitoring Results

Degradation Mechanism	Structural Integrity	Leakage Integrity Limiting S/G Leak Rate (gpm@RT)
Axial PWSCC at Expansion Transitions	Passed via Analysis	0
Axial ODSCC at Expansion Transitions	Passed via Analysis	0
Circumferential PWSCC At Expansion Transitions	Passed via Analysis	0
Circumferential ODSCC At Expansion Transitions	Passed via Analysis	0
Circumferential PWSCC Deep within the Tubesheet Crevice	Passed via Analysis	0.44 gpm maximum, bounding analysis for undetected degradation deep within the tubesheet
Volumetric Degradation	Passed via Analysis	0
Wear	Passed via Analysis	0

Table 2.3

NDE Sizing Relationships and Uncertainties Applicable to Callaway

Mechanism /Location	Technique (ETSS#)	Sizing Equations	NDE Uncertainty
Hot Leg TTS PWSCC Axial (Plus Point)	20511.1	Depth: y= 0.87x - 5.46	11.3
		Length: y=1.18x-0.01	0.16
		Average Depth: Y=0.36x+18.9	7.60
Hot Leg Circumferential PWSCC (Plus Point)	20510.1	Depth: y=0.60x+20.4	20.3
		Length: y=1.01x+0.17	0.29
		PDA: y=0.81x+3.80	7.69
Hot Leg TTS Axial ODSCC (Plus Point)	21409.1 (modified)	Maximum Depth: y=0.90x	31.6
		Length: y=1.15x+0.024	0.22
		PDA: y=0.89x	22.5
Hot Leg TTS Circumferential ODSCC (Plus Point)	EPRI 107197	PDA Y=1.0x	14.3
AVB Wear (Bobbin)	96004.3	Maximum Depth: y=0.96x+2.92	3.52
Volumetric OD Degradation (Plus Point)	21998.1	Maximum Depth: y=1.02x+5.81	6.28

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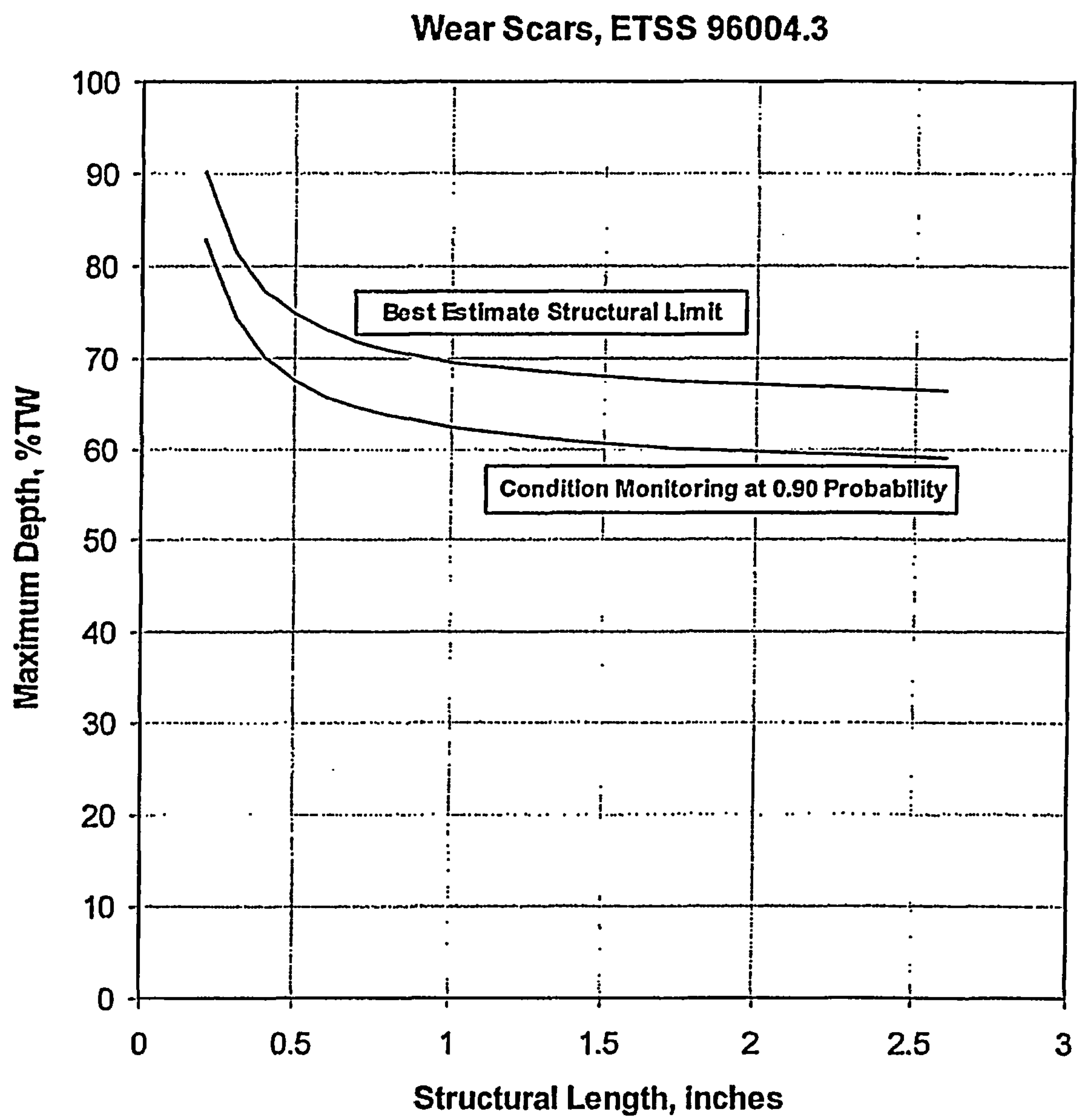

Figure 2.1 Structural Limit Curves Applicable to Wear Degradation

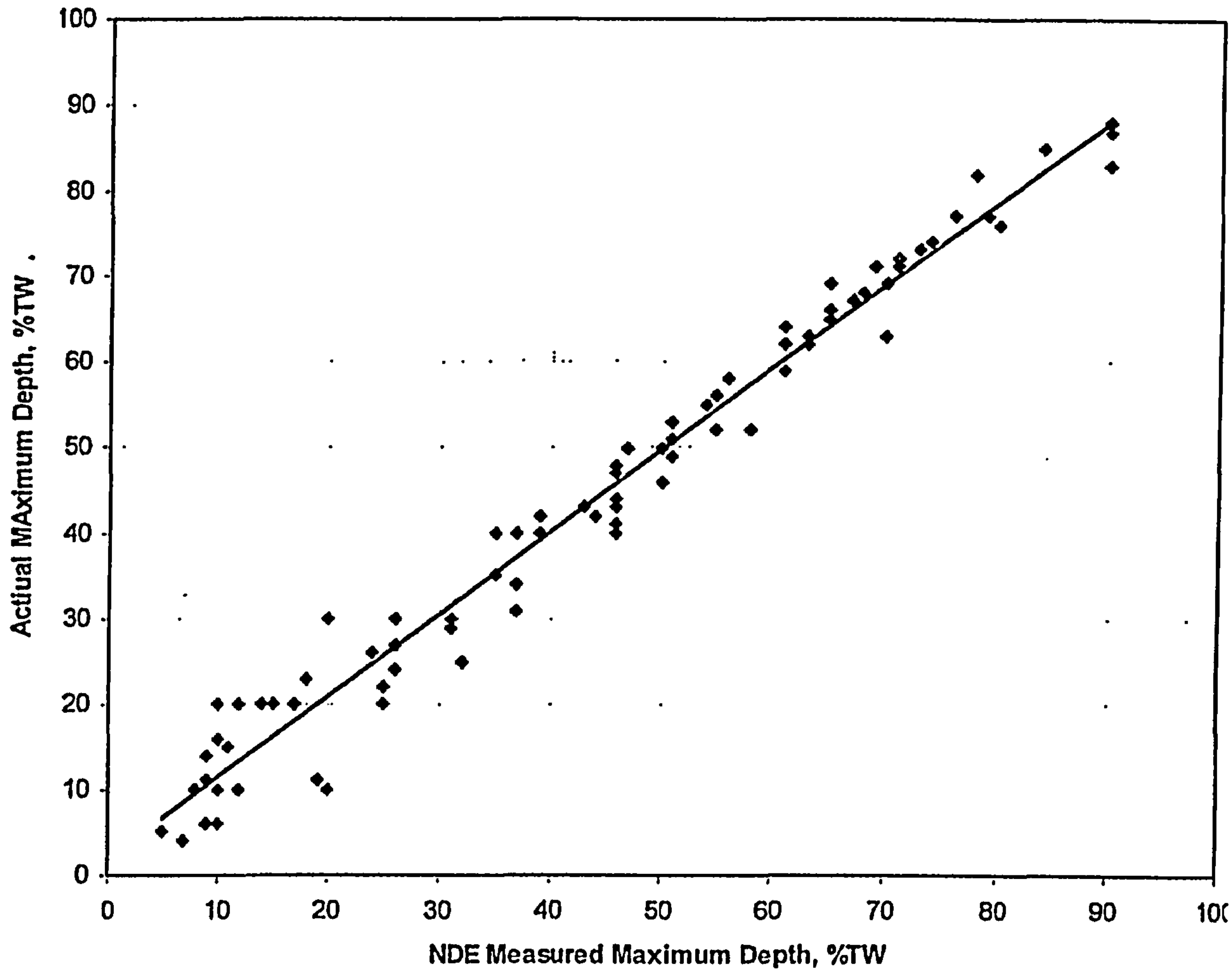

Figure 2.2 Actual Depth Versus NDE Measured Depth, Wear Scar Geometry ETSS 96004.3

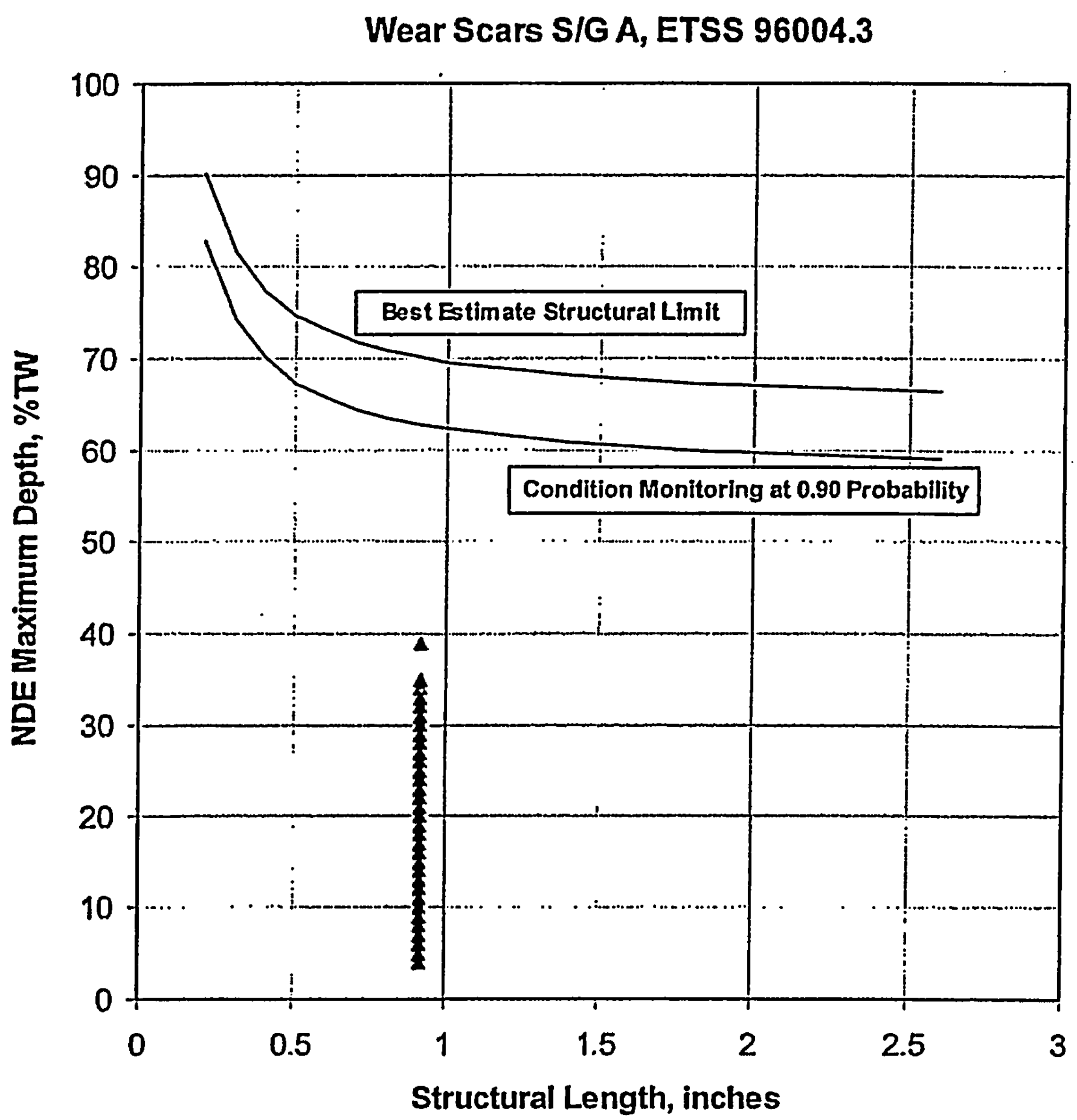

Figure 2.3 Structural Limit Curve for Wear Scars at Callaway for S/G A RF 13 Inspection Data

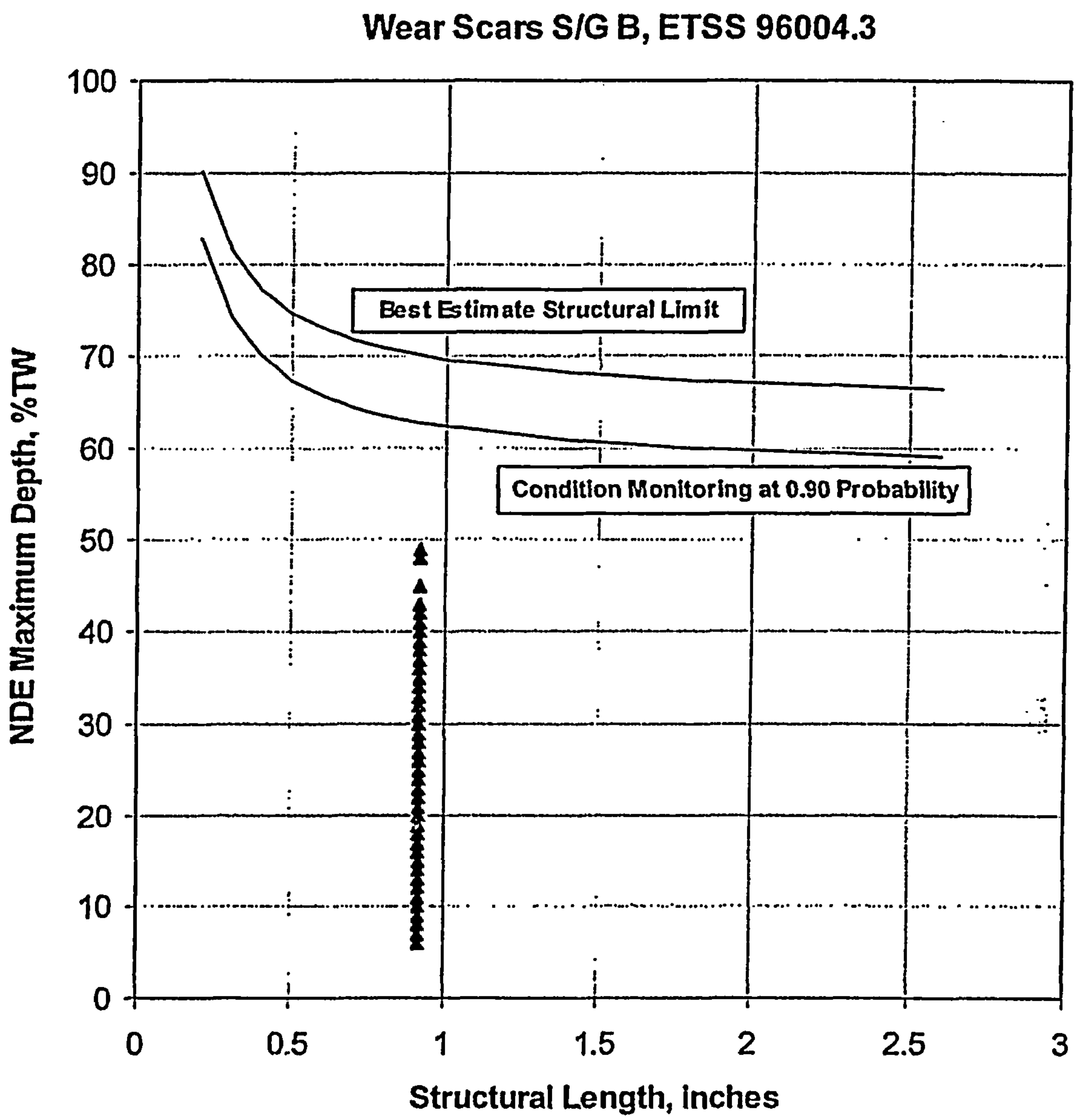

Figure 2.4 Structural Limit Curve for Wear Scars at Callaway for S/G B RF 13 Inspection Data

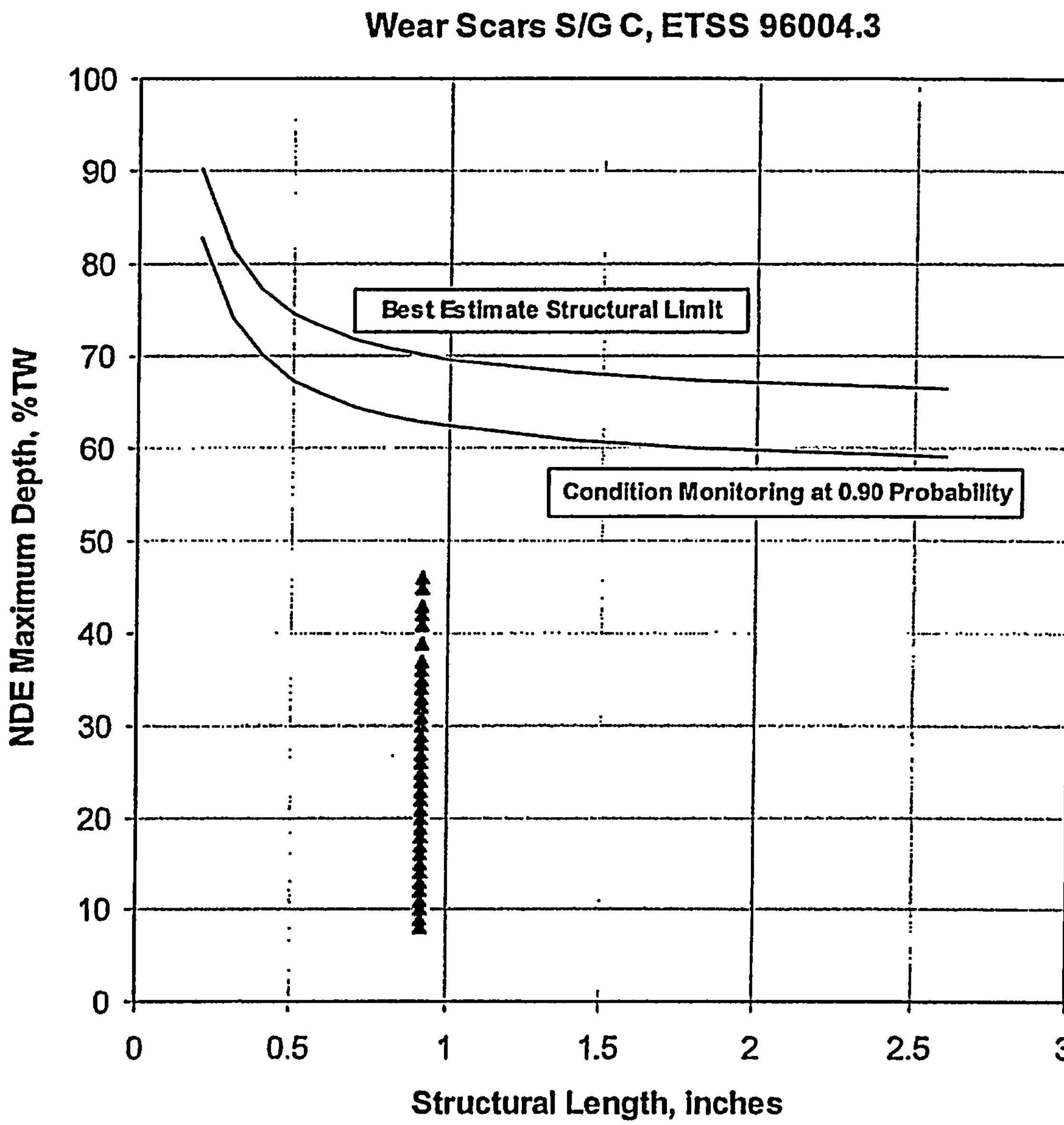

Figure 2.5 Structural Limit Curve for Wear Scars at Callaway for S/G C RF 13 Inspection Data.

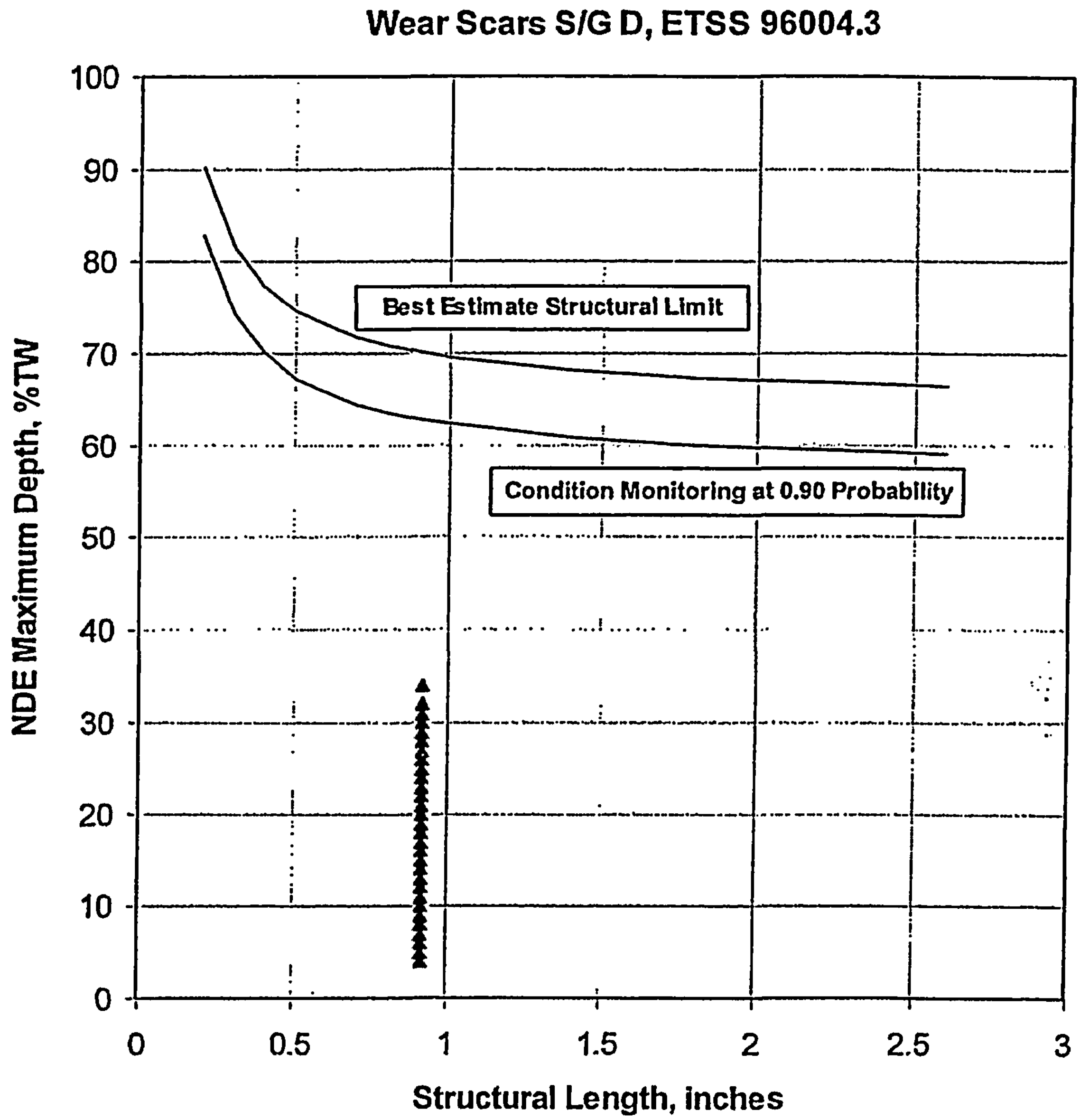

Figure 2.6 Structural Limit Curve for Wear Scars at Callaway for S/G C RF 13 Inspection Data.

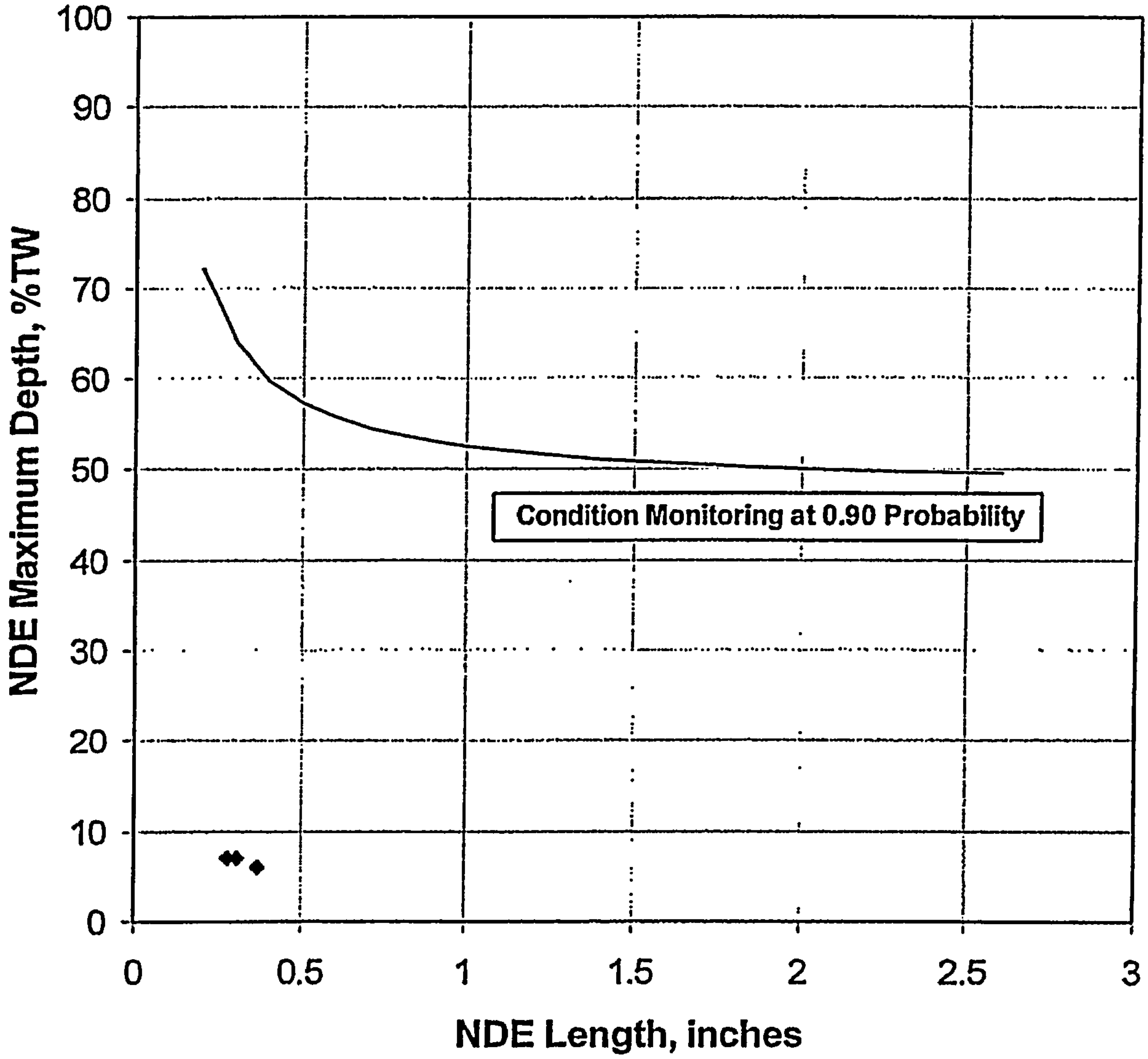

Figure 2.7 Condition Monitoring Plot For Volumetric Degradation

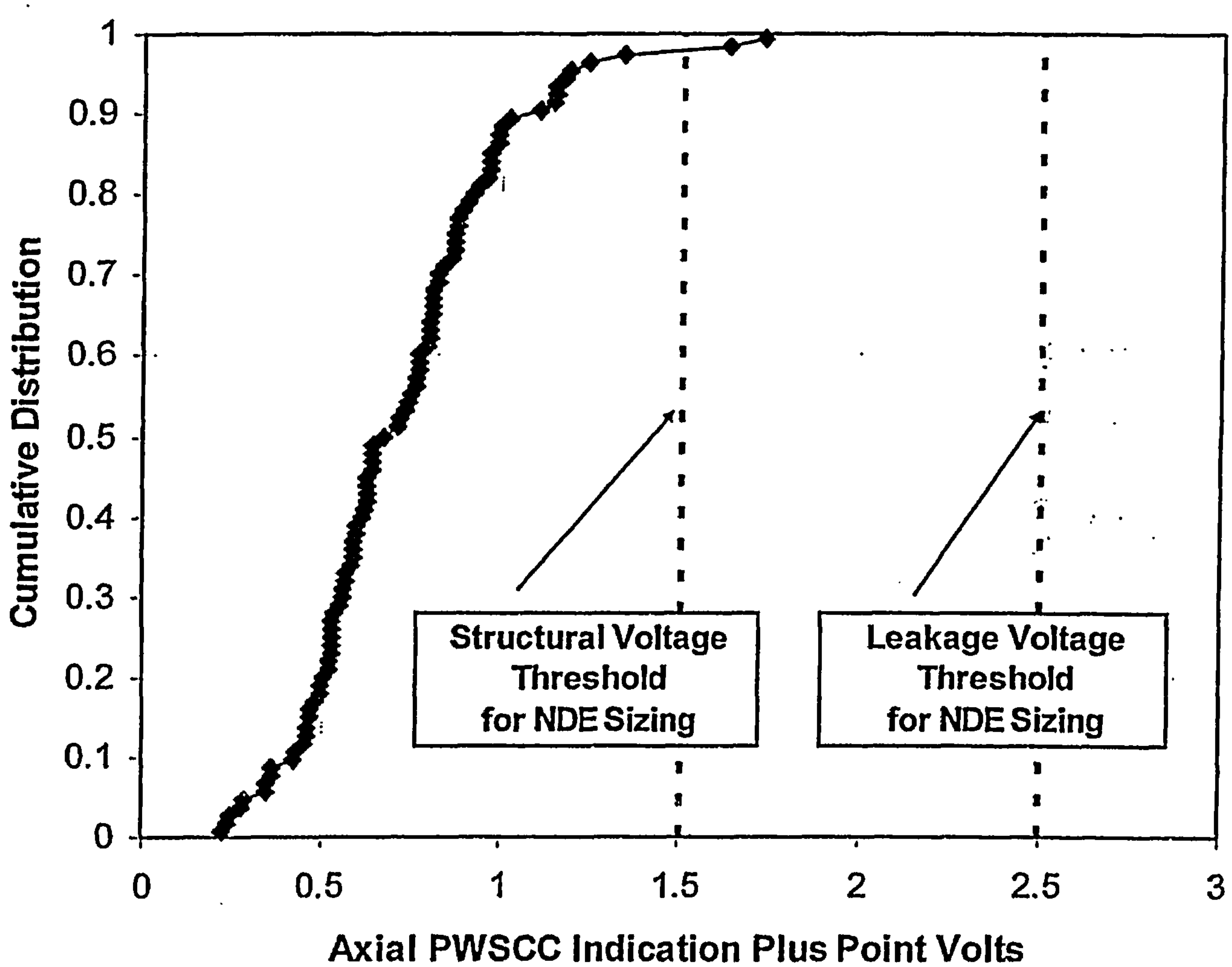

Figure 2.8 Distribution of Plus Point Voltages for Axial PWSCC Indications

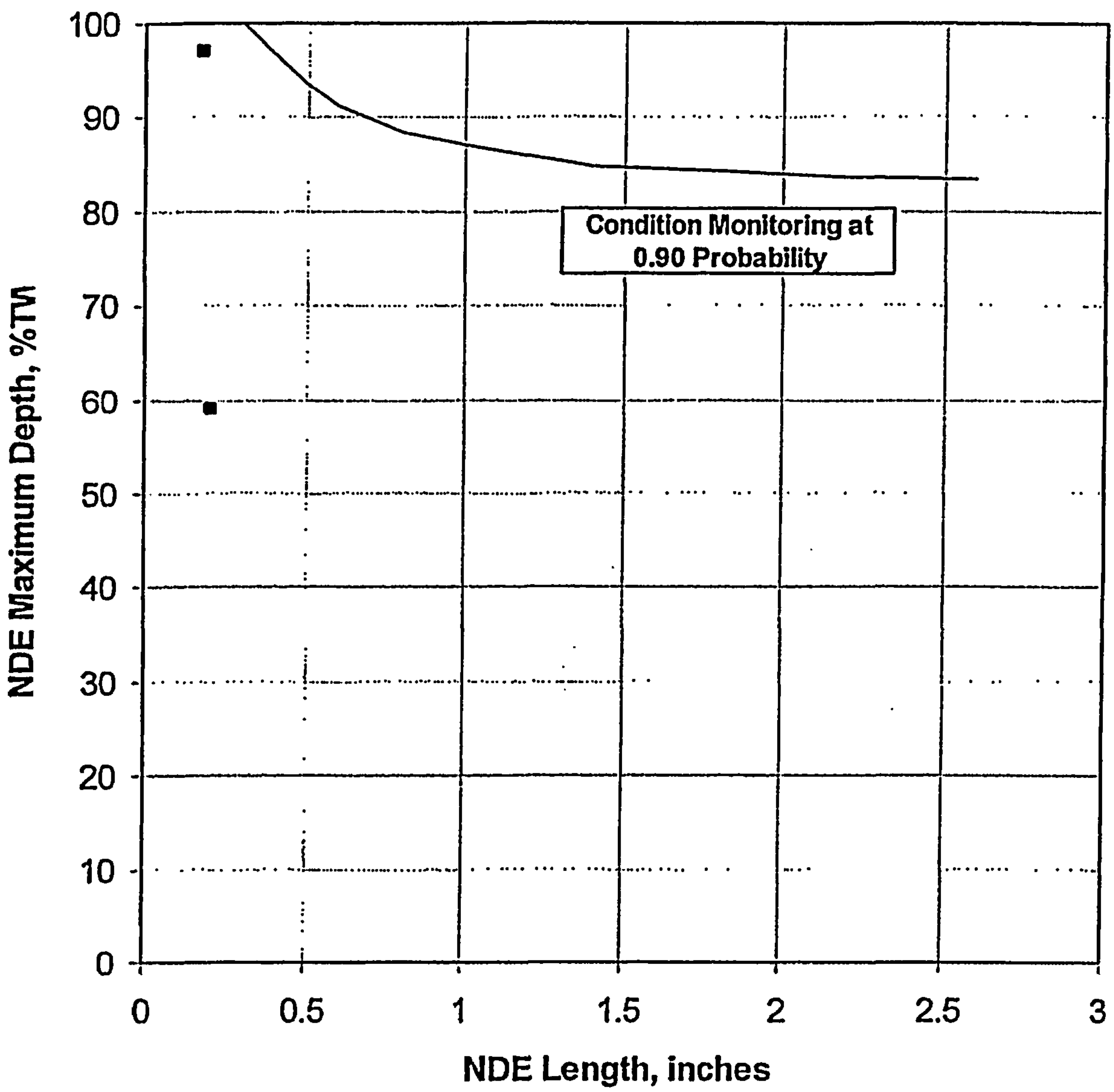

Figure 2.9 Condition Monitoring Plot for Axial PWSCC Indications

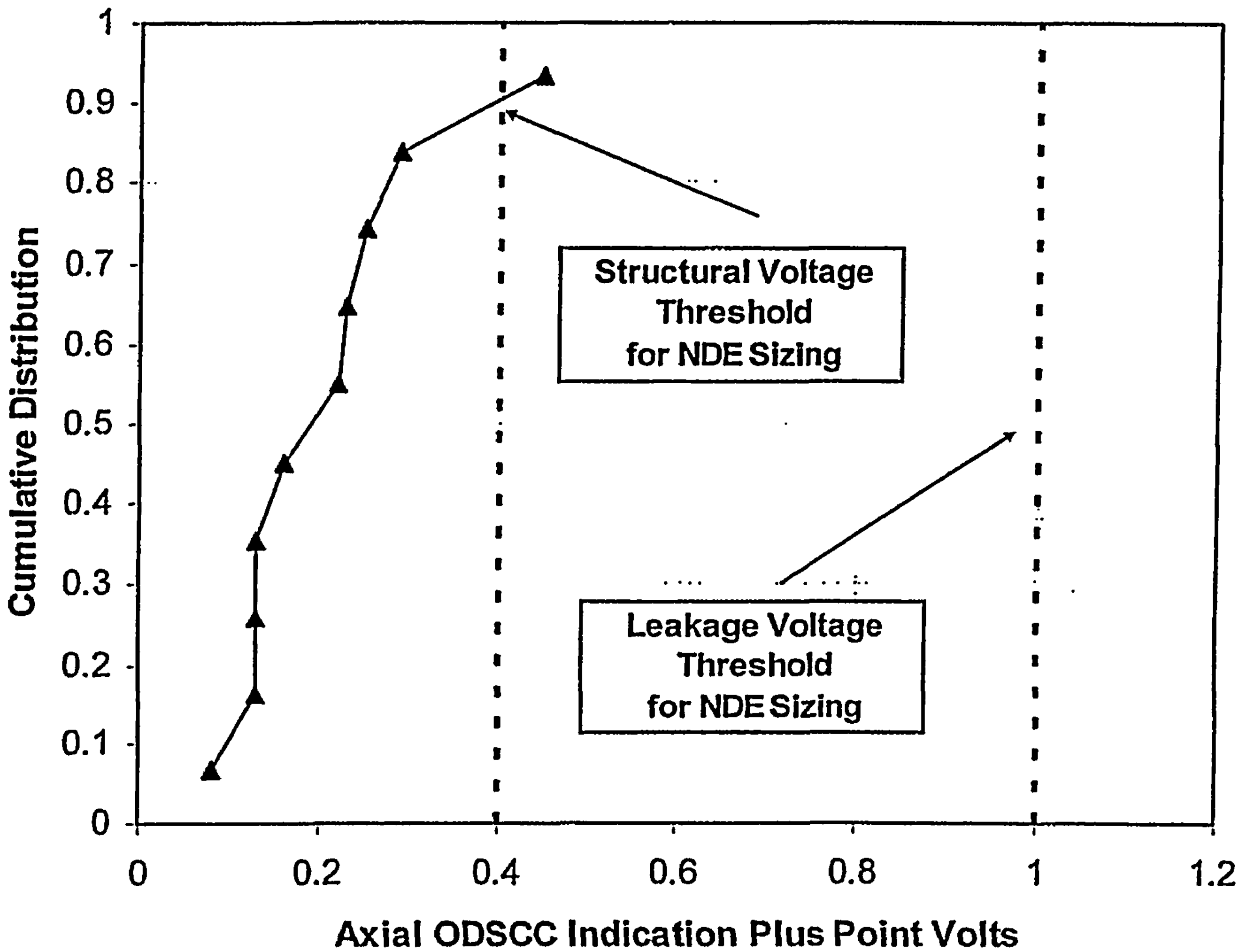

Figure 2.10 Distribution of Plus Point Voltages for Axial ODSCC Indications

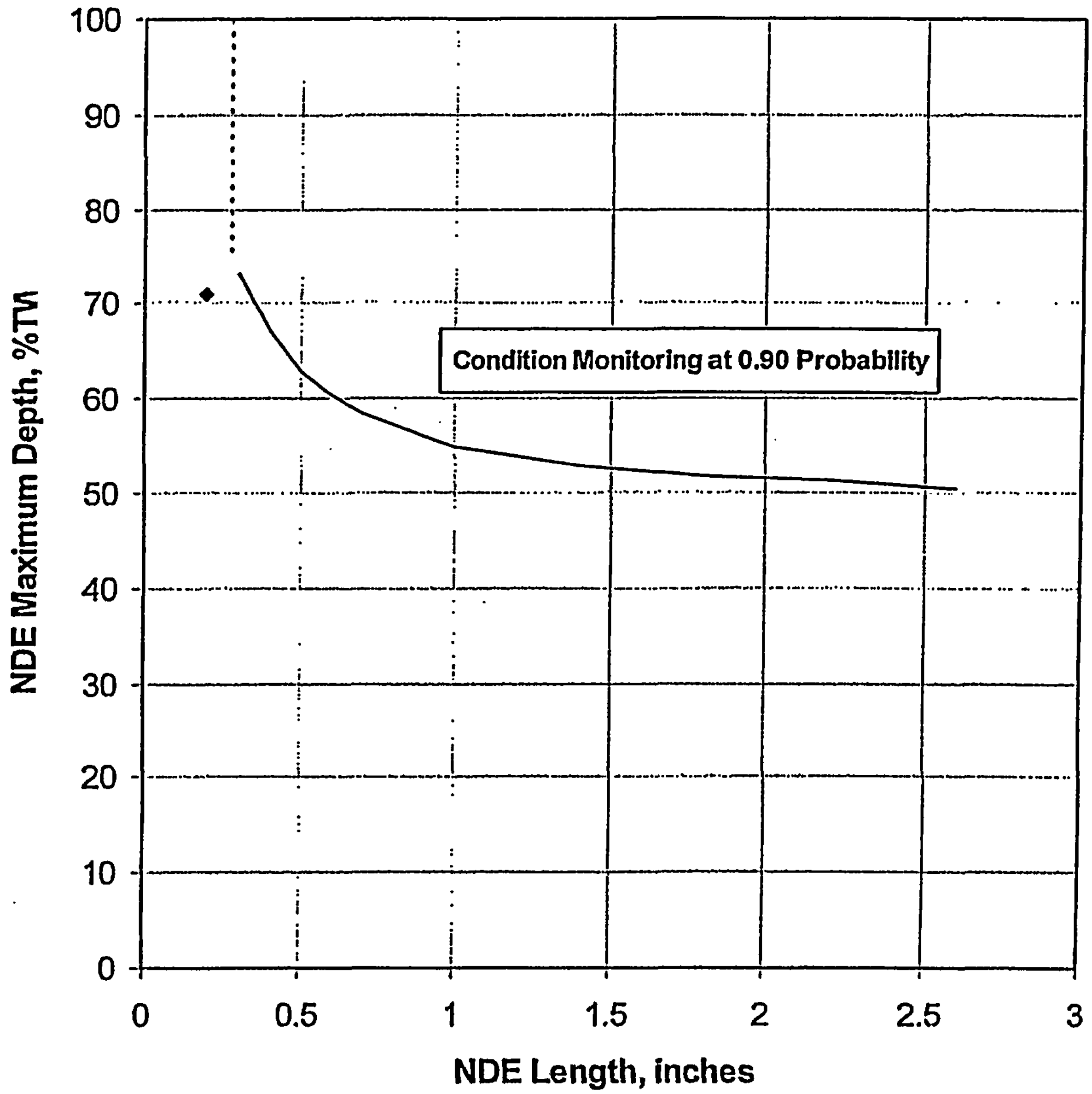

Figure 2.11 Condition Monitoring Plot for Axial ODSCC Indications

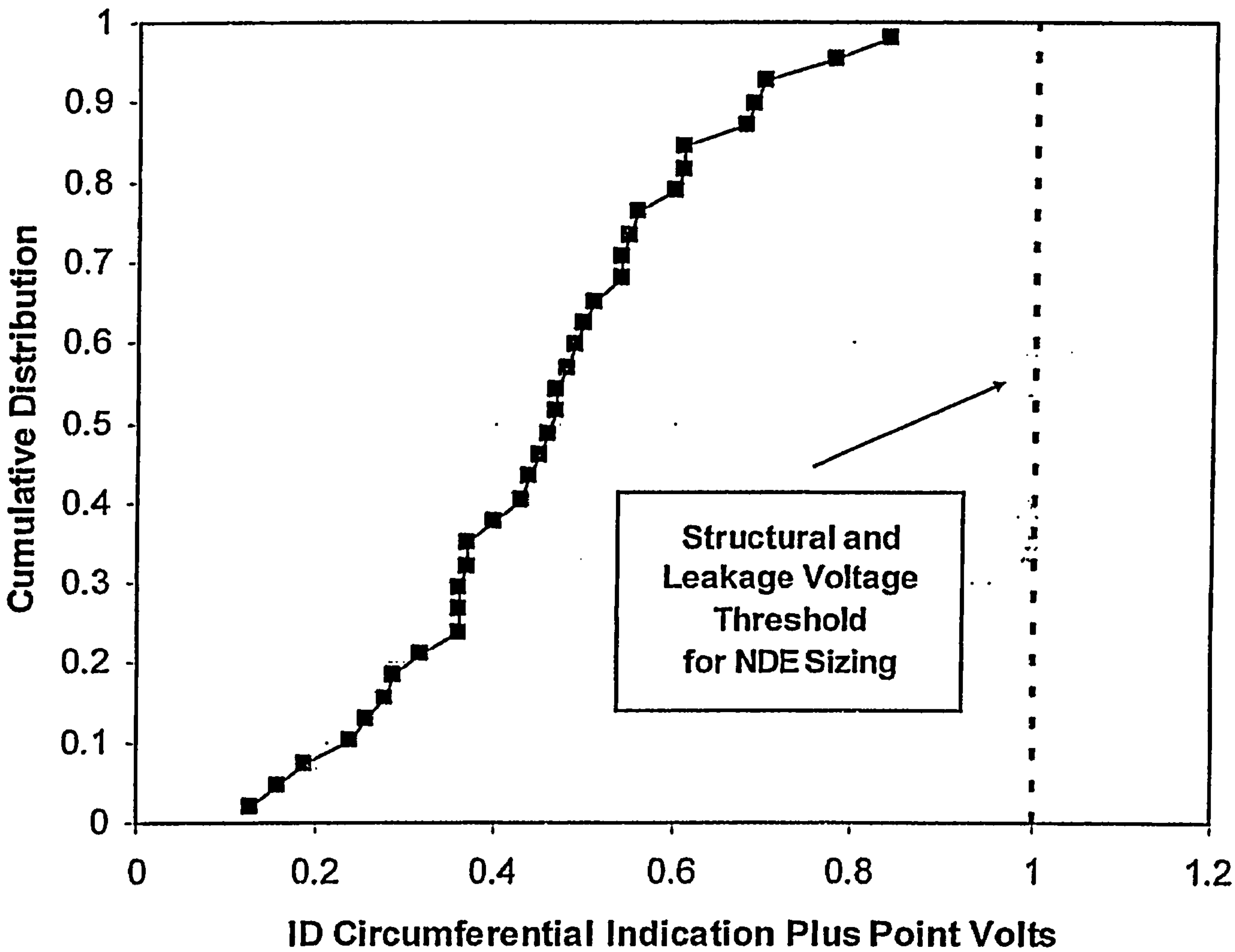

Figure 2.12 Distribution of Plus Point Voltages for Circumferential PWSCC Indications

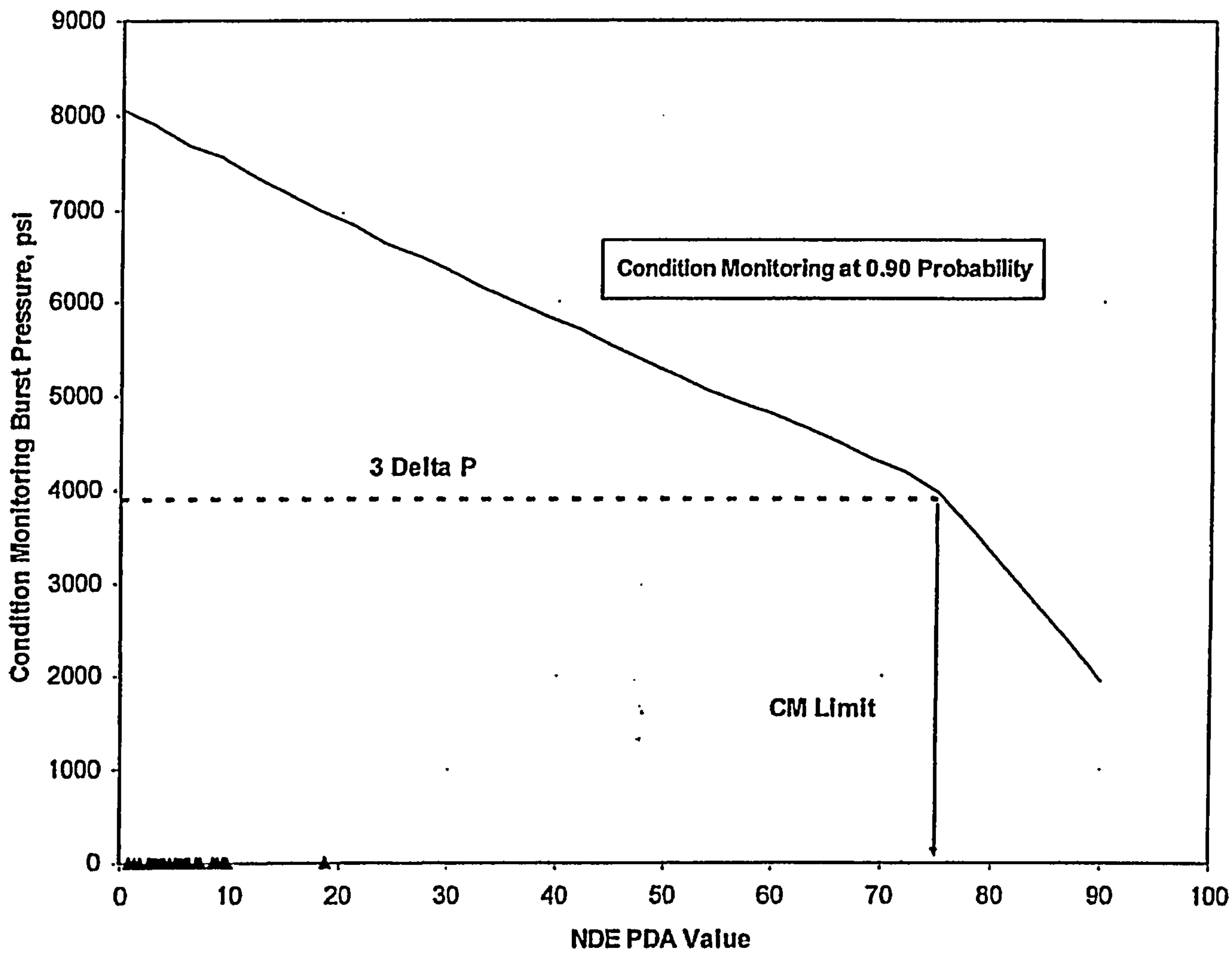

Figure 2.13 Condition Monitoring Burst Pressure versus NDE PDA Values for Circumferential PWSCC Indications

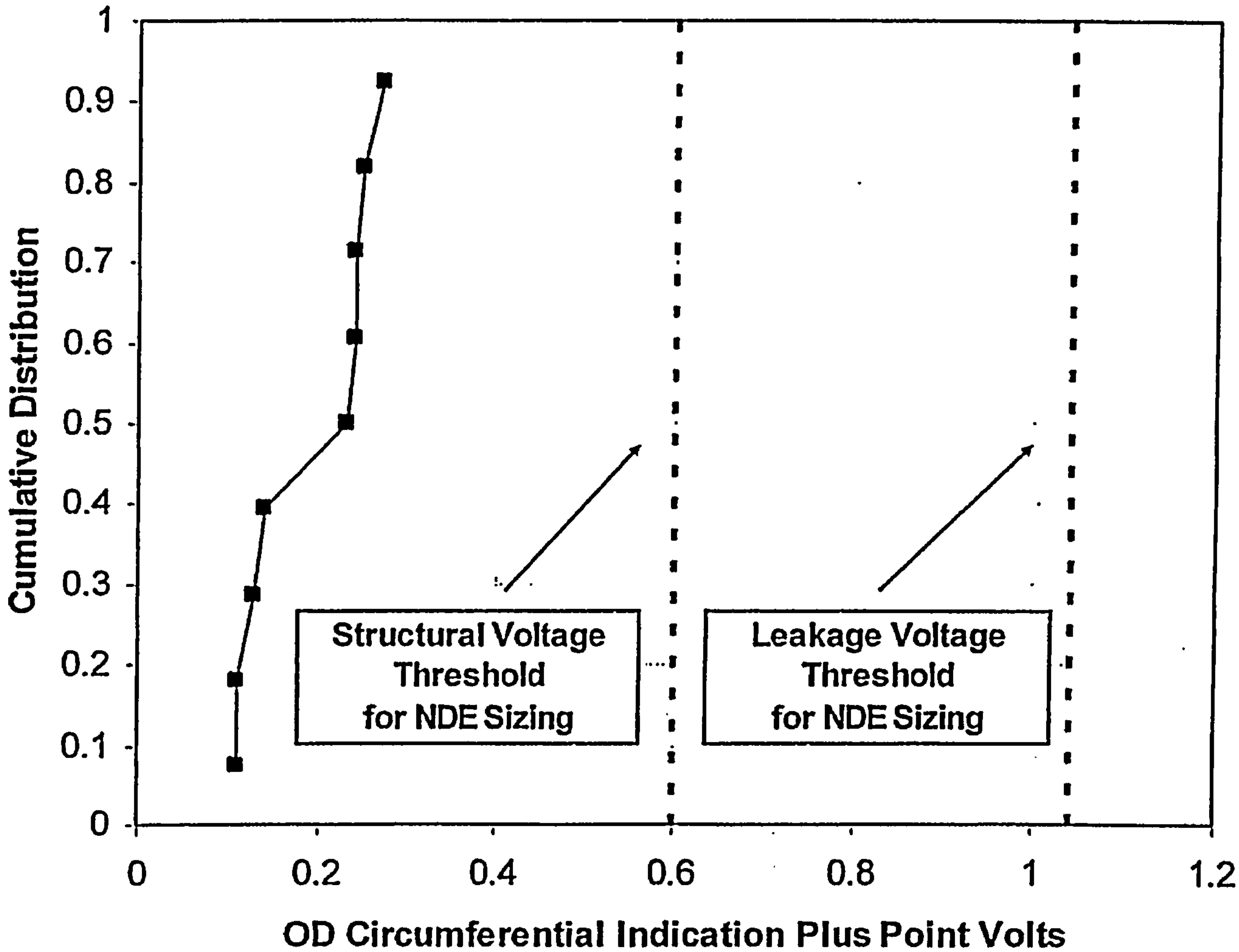

Figure 2.14 Distribution of Plus Point Voltages for Circumferential ODSCC Indications

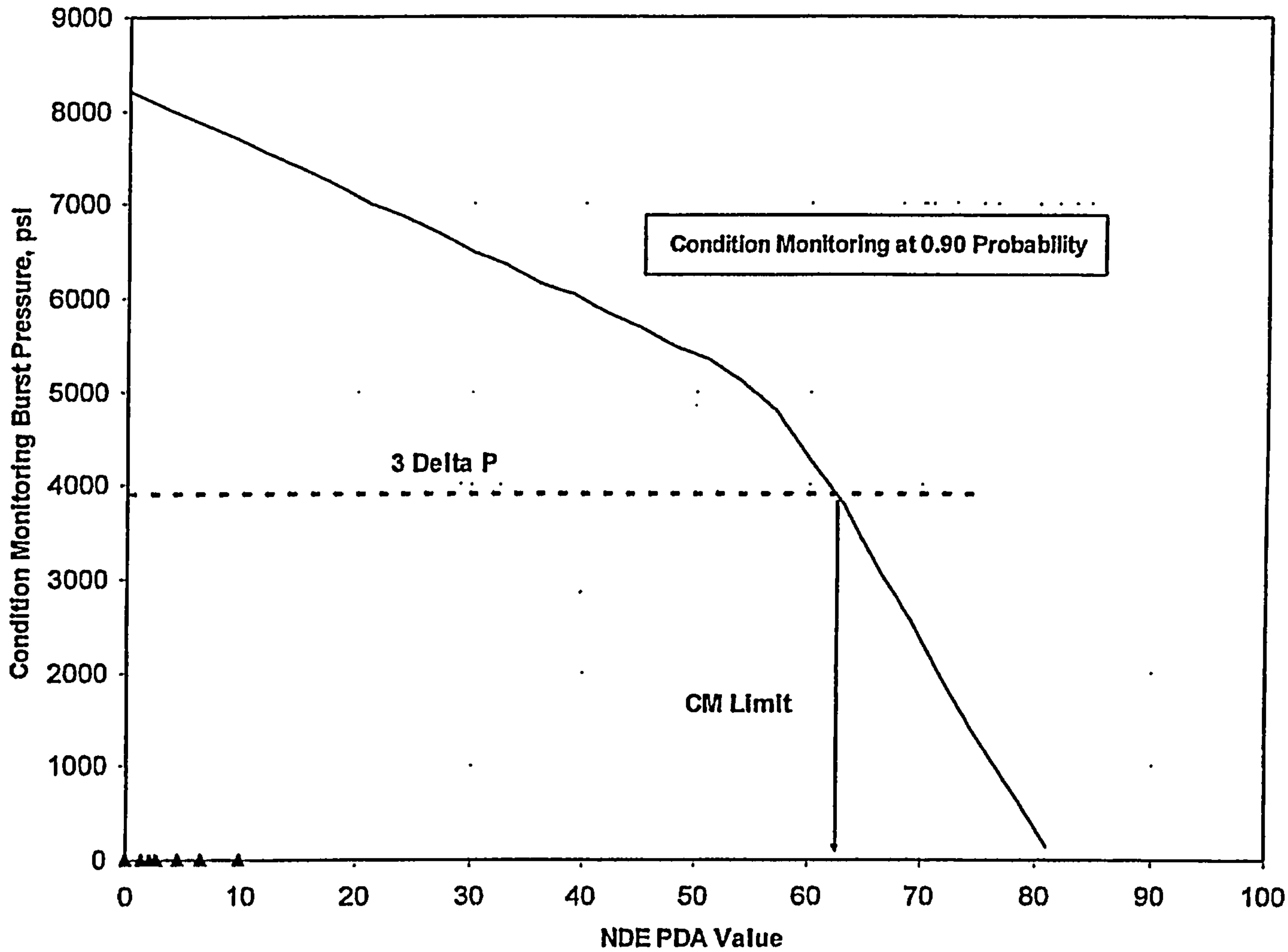

Figure 2.15 Condition Monitoring Burst Pressure versus NDE PDA Values for Circumferential ODSCC Indications

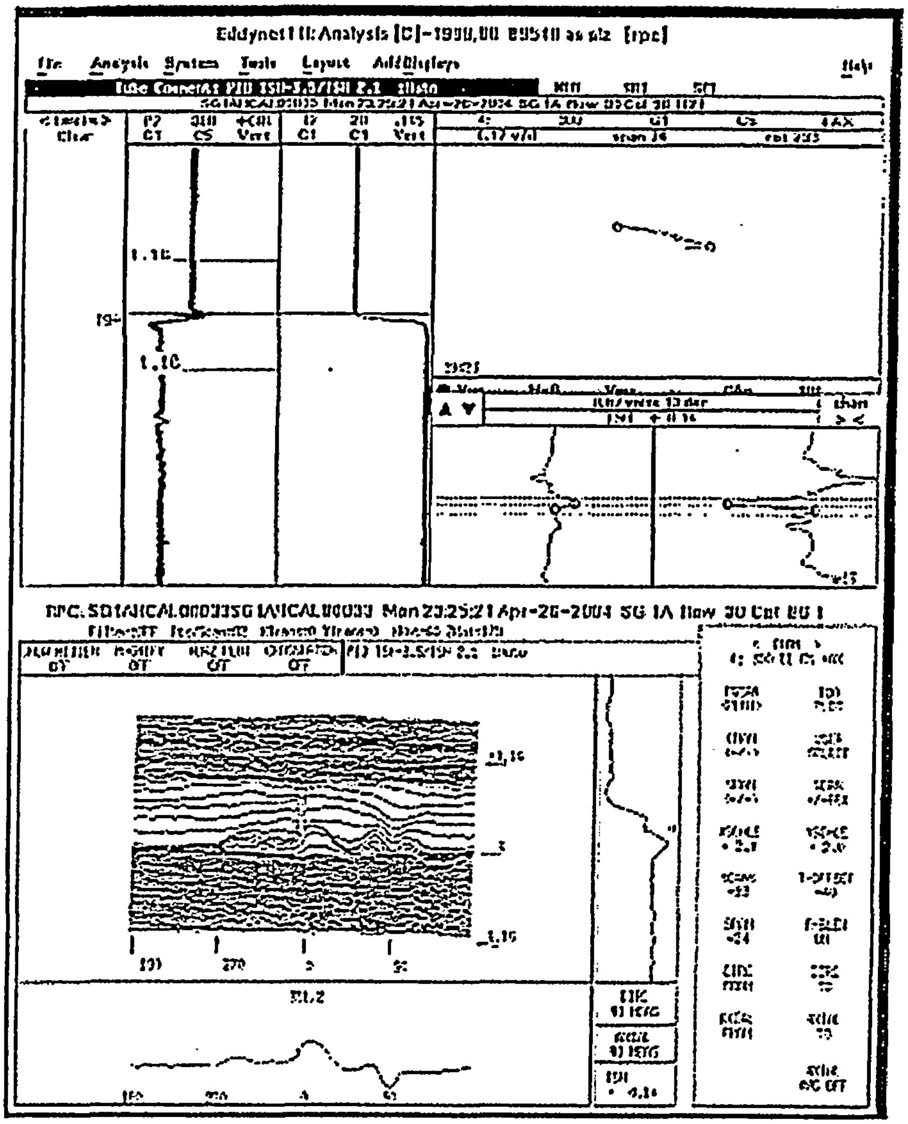

Figure 2.16 Plus Point Terrain Map for Combined Axial and Circumferential PWSCC Indications Near Expansion Transition, Axial Coil

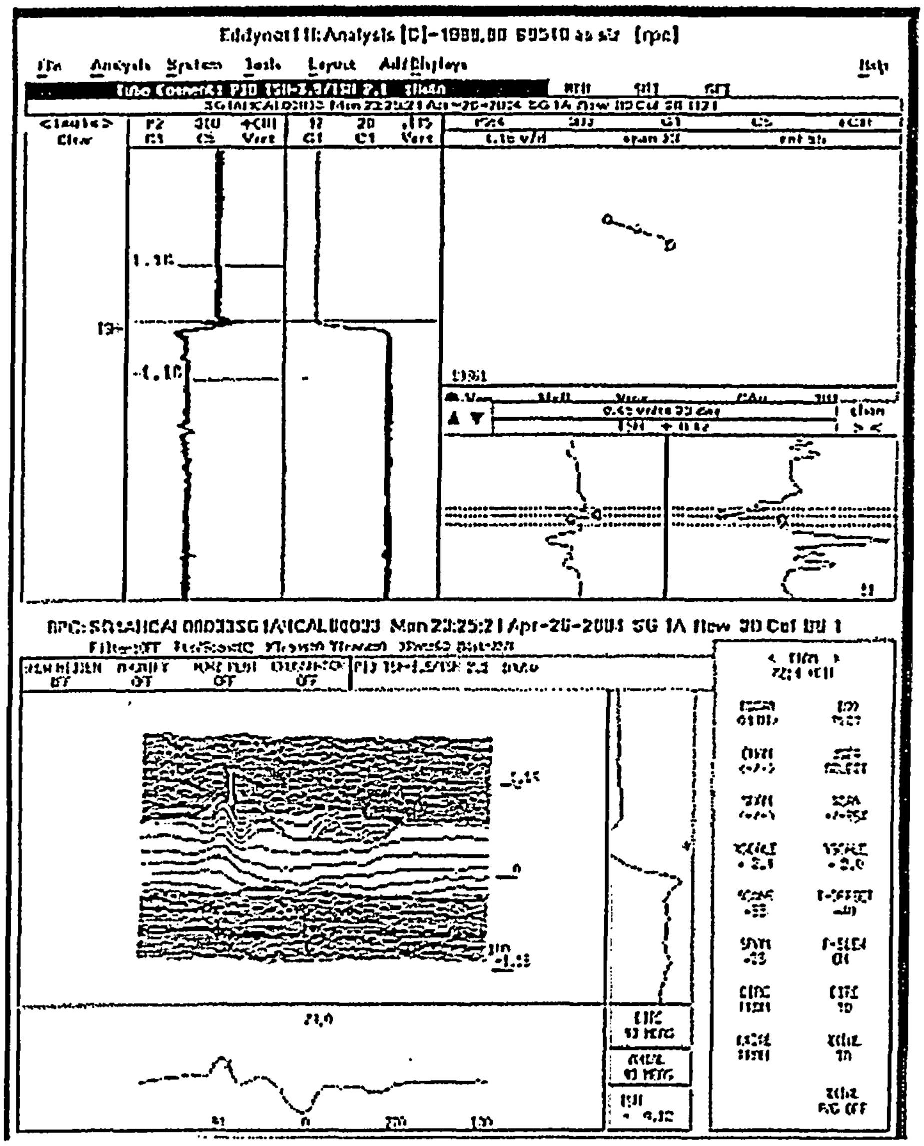

Figure 2.17 Plus Point Terrain Map for Combined Axial and Circumferential PWSCC Indications Near Expansion Transition, Circumferential Coil

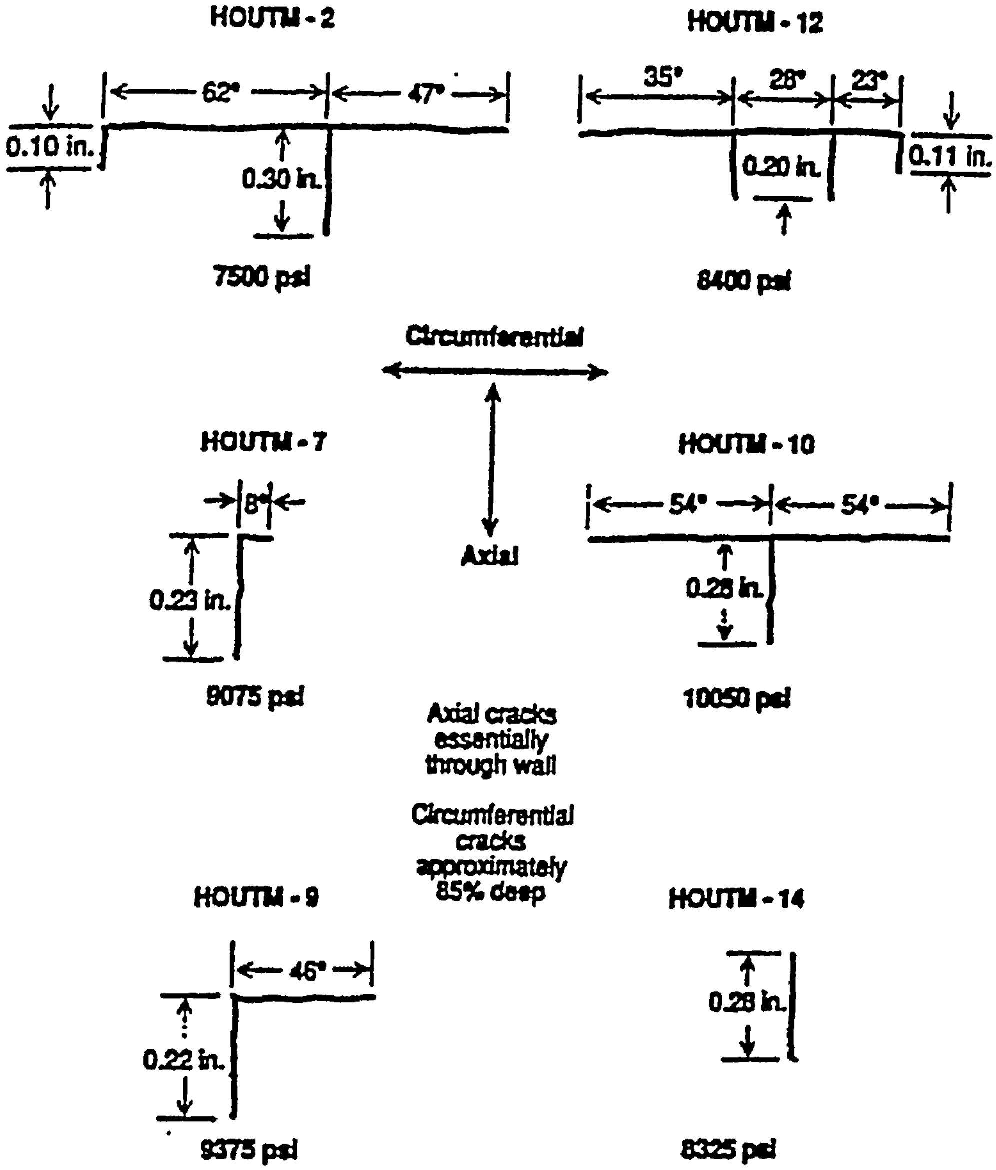

Figure I-8. Sketches of Axial and Circumferential Cracks in Westinghouse RP301-9 Specimens

Figure 2.18 Sketches of Combined Axial and Circumferential Cracks at Expansion Transitions Illustrating High Measured Burst Pressures.

Section 3
SUMMARY AND CONCLUSIONS

Condition monitoring evaluations of steam generator tubing at Callaway were performed using inspection results from outage RF13. The observed severity of degradation at the end of cycle was evaluated to determine if structural and leakage integrity requirements were maintained. The scope of this evaluation included all forms of tubing degradation:

- Wear at AVB tube Support Location
- Expansion Transition Axial PWSCC
- Expansion Transition Axial ODSCC
- Expansion Transition Circumferential PWSCC
- Expansion Transition ODSCC
- Combined Axial And Circumferential PWSCC at Expansion Transitions
- Circumferential PWSCC Within the Tubesheet
- Volumetric Degradation

Condition monitoring via analysis showed that 3ΔP deterministic structural margins and FLB/SLB leakage integrity were maintained during the last cycle of operation. Degraded tubes maintained a minimum burst pressure above 3900 psi. The worst case leak rate at postulatged accident conditions is 0.44 gpm compared to a 1.0 gpm limit. Measured leakage at normal operating conditions was 0.09 gpd compared to a 75 gpd administrative limit.

Section 4

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Appendix

Tabular Summary of Tube Degradation

ID Axial Flaws

SG_ID	Row	Column	Indication	Maximum Depth (%TW)	Axial Length (inches)	Elevation	Location (inches)	Plus Point Volts	Phase Angle (degrees)	Cal Group
1A	11	33	SAI	45	0.16	TSH	0.05	0.56	23	29
1A	11	48	SAI	71	0.16	TSH	0.06	0.81	21	34
1A	11	48	SAI	71	0.16	TSH	-0.35	0.81	22	34
1A	11	53	SAI	56	0.13	TSH	0.14	0.80	21	46
1A	11	54	SAI	33	0.16	TSH	0.10	0.59	12	46
1A	11	57	SAI	71	0.18	TSH	0.11	0.81	22	47
1A	12	59	SAI	56	0.13	TSH	0.08	0.36	22	49
1A	12	74	SAI	73	0.13	TSH	0.12	1.15	22	21
1A	12	96	SAI	42	0.15	TSH	0.00	0.87	18	1
1A	13	51	SAI	30	0.16	TSH	0.00	0.42	12	47
1A	14	60	SAI	43	0.13	TSH	0.10	0.64	17	49
1A	15	40	SAI	39	0.18	TSH	0.04	0.54	17	29
1A	16	55	SAI	56	0.13	TSH	-0.18	0.99	17	46
1A	16	57	SAI	97	0.16	TSH	0.10	0.57	34	47
1A	16	68	SAI	43	0.16	TSH	0.10	0.62	15	50
1A	17	36	SAI	71	0.16	TSH	0.06	1.02	25	29
1A	18	20	MAI	39	0.16	TSH	0.06	0.77	16	40
1A	18	47	SAI	63	0.21	TSH	0.06	1.14	22	27
1A	19	44	MAI	75	0.24	TSH	0.03	1.34	18	26
1A	19	50	SAI	45	0.18	TSH	0.05	0.63	17	27
1A	19	67	SAI	71	0.16	TSH	0.15	0.82	25	50
1A	19	86	SAI	29	0.20	TSH	0.09	0.75	15	9
1A	19	97	SAI	49	0.20	TSH	0.04	1.00	22	8
1A	19	100	SAI	39	0.17	TSH	-0.06	0.61	18	7
1A	20	67	SAI	36	0.13	TSH	0.12	0.48	14	16
1A	20	85	SAI	77	0.17	TSH	0.10	1.10	26	10
1A	21	36	SAI	71	0.16	TSH	0.09	0.74	21	23
1A	21	46	MAI	16	0.16	TSH	0.05	0.82	18	25
1A	21	52	MAI	59	0.21	TSH	0.09	1.63	23	28

Axial Flaws (continued)

	Row	Column	Indication	Maximum Depth (%TW)	Axial Length (inches)	Elevation	Location (inches)	Plus Point Volts	Phase Angle (degrees)	Cal Group
1A	22	38	SAI	39	0.11	TSH	0.15	0.56	15	26
1A	22	52	MAI	59	0.18	TSH	-0.09	0.79	22	27
1A	22	68	SAI	36	0.12	TSH	0.04	0.47	15	16
1A	22	71	MAI	86	0.15	TSH	0.07	0.53	30	13
1A	22	90	MAI	46	0.15	TSH	-0.03	0.97	19	8
1A	23	71	SAI	39	0.15	TSH	0.14	0.59	18	14
1A	23	88	SAI	49	0.17	TSH	-0.03	0.57	18	10
1A	23	94	MAI	32	0.15	TSH	0.09	0.63	22	7
1A	24	101	MAI	57	0.15	TSH	0.08	0.77	19	7
1A	25	66	MAI	26	0.12	TSH	0.10	0.46	21	16
1A	26	43	SAI	33	0.16	TSH	0.07	0.77	14	25
1A	26	52	SAI	56	0.13	TSH	0.11	0.35	16	27
1A	26	56	SAI	67	0.18	TSH	0.05	1.24	25	28
1A	26	72	SAI	23	0.12	TSH	0.06	0.80	12	11
1A	27	73	SAI	46	0.12	TSH	0.00	0.88	15	11
1A	27	75	SAI	46	0.15	TSH	0.06	0.64	16	12
1A	27	85	SAI	65	0.15	TSH	0.06	0.84	17	9
1A	27	88	SAI	73	0.15	TSH	0.03	0.94	22	9
1A	30	45	SAI	45	0.18	TSH	-0.02	0.59	19	25
1A	31	53	MAI	45	0.16	TSH	0.11	0.86	22	28
1A	33	100	SAI	36	0.20	TSH	0.03	0.46	13	7
1A	35	63	SAI	42	0.10	TSH	0.05	0.64	18	17
1A	35	108	SAI	46	0.20	TSH	0.05	0.73	20	5
1A	36	99	SAI	49	0.22	TSH	0.10	0.96	21	8
1A	36	102	SAI	82	0.18	TSH	0.10	0.63	24	6
1A	37	103	SAI	42	0.17	TSH	0.05	0.58	17	5
1A	38	89	MAI	26	0.17	TSH	0.11	0.55	19	7
1A	38	97	SAI	21	0.18	TSH	0.14	0.50	13	7
1A	39	89	SAI	42	0.20	TSH	0.04	0.92	18	8

ID Axial Flaws (continued)

SG_ID	Row	Column	Indication	Maximum Depth (%TW)	Axial Length (inches)	Elevation	Location (inches)	Plus Point Volts	Phase Angle (degrees)	Cal Group
1A	40	51	SAI	67	0.18	TSH	0.09	0.67	18	27
1A	40	53	SAI	71	0.16	TSH	-0.01	0.81	17	27
1A	40	58	SAI	45	0.15	TSH	0.03	0.53	16	29
1A	40	60	SAI	29	0.15	TSH	0.08	0.60	15	17
1A	41	85	SAI	53	0.15	TSH	0.10	0.99	19	10
1A	41	86	SAI	18	0.15	TSH	0.10	0.53	10	9
1A	42	54	SAI	52	0.16	TSH	0.04	0.45	16	28
1A	42	57	SAI	63	0.18	TSH	0.03	0.91	18	30
1A	44	54	MAI	59	0.16	TSH	0.06	0.97	17	28
1A	45	71	SAI	63	0.16	TSH	0.01	0.36	13	13
1A	45	74	MAI	46	0.18	TSH	0.08	1.19	31	11
1A	45	82	SAI	36	0.15	TSH	0.05	0.71	13	9
1A	50	61	MAI	86	0.13	TSH	0.06	1.15	26	18
1A	50	62	MAI	42	0.20	TSH	0.05	0.63	16	17
1A	51	55	SAI	45	0.13	TSH	-0.06	0.87	16	27
1A	54	61	SAI	45	0.16	TSH	0.11	0.72	16	33
1A	55	60	SAI	77	0.15	TSH	0.17	0.52	25	17
1A	55	61	MAI	95	0.15	TSH	0.14	1.17	24	18
1B	11	53	SAI	100	0.20	TSH	0.08	0.76	33	23
1B	13	103	SAI	81	0.17	TSH	0.04	0.35	29	5
1B	15	53	SAI	93	0.15	TSH	0.12	0.23	41	23
1B	39	61	SAI	96	0.17	TSH	0.12	0.89	39	19
1C	17	57	SAI	59	0.14	TSH	0.13	0.53	22	53
1C	17	97	SAI	44	0.16	TSH	-0.05	0.29	26	41
1C	19	52	SAI	97	0.14	TSH	0.06	0.76	38	51
1C	20	6	SAI	97	0.16	TSH	0.13	0.43	31	9
1C	20	24	SAI	93	0.16	TSH	0.20	0.80	42	10
1C	20	44	SAI	81	0.16	TSH	0.02	0.52	28	22
1C	25	17	SAI	100	0.13	TSH	0.09	0.60	35	10

ID Axial Flaws (continued)

SG_ID	Row	Column	Indication	Maximum Depth (%TW)	Axial Length (inches)	Elevation	Location (inches)	Plus Point Volts	Phase Angle (degrees)	Cal Group
1C	26	71	SAI	70	0.12	TSH	0.08	0.25	29	33
1C	28	33	SAI	99	0.11	TSH	0.04	0.24	29	21
1C	30	80	SAI	77	0.14	TSH	0.06	0.87	26	34
1C	31	74	SAI	50	0.14	TSH	0.00	0.47	15	34
1C	34	13	SAI	95	0.16	TSH	0.09	0.50	34	12
1C	40	52	SAI	99	0.18	TSH	0.13	0.97	31	18
1C	41	20	SAI	75	0.13	TSH	0.00	0.88	24	11
1C	41	62	SAI	93	0.16	TSH	0.11	0.64	43	31
1C	43	22	SAI	97	0.18	TSH	-0.02	1.73	38	12
1C	53	83	SAI	60	0.14	TSH	0.01	0.51	18	30
1D	11	67	MAI	68	0.13	TSH	0.14	0.53	29	31
1D	33	70	SAI	67	0.15	TSH	0.02	0.28	28	24

OD Axial Flaws

SG_ID	Row	Column	Indication	Maximum Depth (%TW)	Axial Length (inches)	Elevation	Location (inches)	Plus Point Volts	Phase Angle (degrees)	Cal Group
1B	11	53	SAI	100	0.20	TSH	0.35	0.23	92	23
1B	15	65	SAI	0	0.15	TSH	0.26	0.13	92	22
1B	49	39	SVI	7	0.28	TSH	0.11	0.13	82	33
1D	11	61	SAI	71	0.20	TSH	0.49	0.45	72	31
1D	11	66	SAI	47	0.19	TSH	0.32	0.22	90	30
1D	12	64	SAI	51	0.20	TSH	0.49	0.16	71	30
1D	13	63	SAI	51	0.15	TSH	0.38	0.08	104	50
1D	14	59	SAI	48	0.14	TSH	0.19	0.25	96	49
1D	14	60	MAI	36	0.16	TSH	0.24	0.13	81	28
1D	17	62	SAI	55	0.15	TSH	0.23	0.29	81	28

ID Circumferential Flaws

SG_ID	Row	Column	Indication	Maximum Depth (%TW)	Circumferential Extent (degrees)	PDA	Location	Elevation (inches)	Plus Point Volts	Phase Angle (degrees)	Cal Group
1A	16	65	SCI	94	35.1	5.4	TSH	0.18	0.29	25	50
1A	19	74	SCI	53	43.4	3.9	TSH	0.15	0.51	15	11
1A	20	52	SCI	18	33.8	0.8	TSH	0.08	0.54	10	27
1A	21	85	SCI	99	35.1	6.3	TSH	0.13	0.37	10	9
1A	23	71	SCI	57	35.1	3.1	TSH	-0.25	0.56	19	14
1A	23	83	SCI	28	52.7	1.8	TSH	0.02	0.32	17	10
1A	30	61	SCI	100	35.1	2.7	TSH	0.1	0.36	15	18
1A	30	96	MMI	86	52.6	7.5	TSH	0.11	0.78	16	8
1A	32	52	SCI	97	42.4	7.0	TSH	0.08	0.37	12	27
1A	32	61	SCI	88	35.2	4.7	TSH	-0.17	0.28	19	18
1A	32	93	SCI	99	17.5	1.9	TSH	0.06	0.54	13	8
1A	33	69	SCI	81	42.3	5.2	TSH	0.05	0.47	9	16
1A	35	53	MCI	35	67.7	3.0	TSH	0.11	0.50	17	28
1A	35	94	SCI	34	34.7	1.4	TSH	0.12	0.36	12	7
1A	38	91	SCI	57	35.1	3.2	TSH	0.13	0.48	8	7
1A	39	84	SCI	28	41.9	1.8	TSH	0.1	0.16	20	9
1A	41	62	MCI	53	117.1	4.1	TSH	0.11	0.44	20	17
1A	43	57	SCI	86	33.9	3.7	TSH	0.05	0.46	9	29
1A	43	62	SCI	40	34.7	1.4	TSH	-0.03	0.47	18	17
1A	44	50	SCI	79	33.9	4.6	TSH	0.04	0.70	18	28
1A	46	59	MCI	79	118.6	8.6	TSH	0.11	0.61	13	30
1A	46	74	SCI	97	34.7	5.4	TSH	0.11	0.49	19	12
1A	47	73	SCI	95	43.4	8.9	TSH	0.04	0.61	18	12
1A	49	66	SCI	95	26	3.1	TSH	-0.03	0.68	16	18
1A	51	62	MCI	100	156.2	18.7	TSH	0.06	0.60	27	18
1A	51	80	SCI	99	35.2	3.4	TSH	-0.13	0.40	10	12
1C	12	48	SCI	97	41.4	5.2	TSH	-0.09	0.26	94	51
1C	16	28	SCI	69	37.7	3.3	TSH	0.08	0.55	22	8

ID Circumferential Flaws (continued)

SG_ID	Row	Column	Indication	Maximum Depth (%TW)	Circumferential Extent (degrees)	PDA	Location	Elevation (inches)	Plus Point Volts	Phase Angle (degrees)	Cal Group
1C	28	72	SCI	94	41.4	5.7	TSH	0.15	0.45	20	34
1C	30	69	MMI	98	47.4	9.9	TSH	0.07	0.43	34	33
1C	40	52	SCI	97	49.7	9.4	TSH	0.14	0.19	21	18
1C	46	63	SCI	67	31.6	4.0	TSH	-7.99	0.84	24	31
1D	12	71	SCI	52	34.7	2.9	TSH	-6.26	0.24	37	31
1D	29	106	SCI	77	59.3	6.1	TSH	-0.08	0.13	35	38
1D	30	57	SCI	100	32	5.9	TSH	-1.55	0.69	24	45
1D	32	89	SCI	100	31.7	5.5	TSH	0.05	0.36	25	24

OD Circumferential Flaws

SG_ID	Row	Column	Indication	Maximum Depth (%TW)	Circumferential Extent (degrees)	PDA	Location	Elevation (inches)	Plus Point Volts	Phase Angle (degrees)	Cal Group
1B	12	70	SCI	66	25.1	2.4	TSH	-0	0.11	118	44
1B	12	71	SCI	88	41.9	2.4	TSH	-0.06	0.24	54	44
1C	12	61	SCI	98	48.6	9.8	TSH	0.01	0.13	78	37
1C	16	59	SCI	96	41.3	6.5	TSH	0.01	0.27	76	54
1C	20	56	SCI	59	32.8	1.3	TSH	0.05	0.23	108	51
1D	12	67	SCI	74	49.1	4.5	TSH	0.07	0.14	78	31
1D	13	44	SCI	89	32.7	2.0	TSH	0.51	0.11	89	46
1D	16	51	SCI	0	64.8	0	TSH	-0.04	0.25	98	49
1D	16	59	MCI	83	60.7	2.6	TSH	-0	0.24	76	49

Wear Indications 40% TW and Greater

SG_ID	Row	Column	Indication	Maximum Depth (%TW)	Location	Elevation (inches)	Bobbin Volts	Cal Group
1B	37	76	TWD	41	AV3	0.07	2.72	77
1B	40	64	TWD	40	AV3	-0.25	2.42	78
1B	40	83	TWD	48	AV5	0	4.13	76
1B	40	83	TWD	49	AV4	0	4.52	76
1B	42	24	TWD	40	AV4	0	2.49	55
1B	47	45	TWD	41	AV4	0.14	2.69	59
1B	47	45	TWD	43	AV3	0.02	2.92	59
1B	47	59	TWD	48	AV4	0.09	4.24	61
1B	47	59	TWD	40	AV3	0.09	2.37	61
1B	48	98	TWD	41	AV4	0	2.6	89
1B	48	98	TWD	42	AV3	0	2.74	89
1B	50	86	TWD	42	AV5	0.14	2.74	83
1B	50	86	TWD	40	AV4	0	2.46	83
1B	54	61	TWD	45	AV2	0.07	3.44	80
1C	28	8	TWD	43	AV1	0.2	2.99	109
1C	34	15	TWD	43	AV2	0.16	2.97	109
1C	40	100	TWD	42	AV5	0.02	2.75	82
1C	44	71	TWD	41	AV5	0.11	2.69	85
1C	44	71	TWD	41	AV4	-0.02	2.63	85
1C	47	87	TWD	45	AV5	0.24	3.27	84
1C	47	93	TWD	46	AV5	0.39	3.79	81