SG-99-04-005, Revision 3

South Texas Project
1RE08 Outage Condition Monitoring Report
and
Final Operational Assessment

August 1999

SG-99-04-005 Revision 3

Attachment to ST-WN-NOC-990091

South Texas Project
1RE08 Outage Condition Monitoring Report and Final Operational Assessment

August 1999

Prepared by: W K Cullen 8/18/99

W. K. Cullen

Approved by: T A. Pitterle 8/18/99

T. A. Pitterle

Westinghouse Electric Company LLC

South Texas Project 1RE08
Condition Monitoring and Final Operational Assessment

1.0 INTRODUCTION

Per NEI 97-06, a condition monitoring assessment which evaluates structural and leakage integrity characteristics of SG eddy current indications is to be performed following each inspection. This evaluation provides an assessment of the South Texas Project Unit 1 steam generator tube structural and leakage integrity based on the 1999 EOC-8 eddy current inspection results. Condition monitoring is "backward looking" and compares the observed EOC-8 steam generator tube eddy current indication parameters against structural and leakage integrity commensurate with RG 1.121. Additionally, an operational assessment, or "forward looking" evaluation is used to project the inspection results and trends to the next inspection to determine primarily if tube structural or leakage integrity will be challenged at EOC-9. This report documents the condition monitoring and operational assessment of the NDE results from the South Texas Project 1RE08 Refueling Outage and inspection, performed in April 1999. The South Texas Project Unit 1 SGs are Westinghouse Model E2 SGs with mill annealed Alloy 600 tubing, full depth mechanical (hardroll) expanded tube to tubesheet joints, and carbon steel tube support plates with drilled tube holes and drilled flow holes

2.0 OVERALL CONCLUSIONS

During the South Texas Project 1RE08 steam generator tube inspection, no indications exceeding the structural integrity limits for either axial or circumferential degradation (i.e., burst integrity > 3 times normal operating primary to secondary pressure differential across SG tubes) were detected; therefore, no tubes were identified to contain eddy current indications that could potentially challenge the Reg. Guide 1.121 tube integrity recommendations. Similarly, it is shown that all operational assessment structural and leakage integrity requirements are expected to be satisfied at EOC-9 for the degradation mechanisms observed at EOC-8. Based on the observed indications at 1RE08, the STP Unit 1 SGs are expected to meet all structural and leakage integrity requirements at 1RE09. The 1RE08 inspection of the STP Unit 1 SGs is the last ISI of these SGs prior to replacement.

3.0 PRE-OUTAGE EVALUATION OF SG DEGRADATION STATUS

STP 1RE08 Inspection Plan

The STP 1RE08 inspection plan exceeded both the Technical Specification minimum requirements as well as the recommendations of EPRI TR-107569-V1R5, PWR Steam Generator Examination Guidelines: Revision 5, Volume 1: Requirements. The 1RE08 initial inspection plan included;

1) 100% full length bobbin examination in all 4 SGs
2) 100% hot leg top of tubesheet (TTS) RPC examination, with a 43% cold leg TTS RPC sample in SGs A, and B
3) 100% Row 1 and 2 U-bend Plus Point examination in all 4 SGs
4) Rotating probe examination of mixed residuals (> 1.5 volts as measured by bobbin) and dented intersections > 5 volts (as measured by bobbin) according to the requirements of GL 95-05.
5) Rotating probe examination of freespan bobbin coil indications for flaw confirmation and

characterization.

6) 100% +Pt inspection of hot leg, U-bend, and cold leg freespan dings > 5 volts
7) Tube plug visual inspection

The inspection plan was developed to specifically address the areas of active degradation as well as areas expected to be affected based on recent industry experience as well as experience from the STP 1RE07 outage in September 1997.

Pre-Outage Degradation Assessment

A pre-outage degradation assessment pursuant to EPRI GC-107621 was performed for STP 1RE08. This degradation assessment identified the degradation modes which could occur at STP Unit 1 and evaluated the adequacy of the eddy current techniques applied for detection and sizing of these mechanisms.

Per EPRI TR-107569-V1R5, "PWR Steam Generator Examination Guidelines: Revision 5 Volume 1: Requirements", an active degradation mechanism is:

1. A combination of ten or more new indications of degradation (≥ 20% TW) and previous indications of degradation which display an average growth rate ≥ 25% of the repair limit per cycle in any one SG or,

2. One or more new or previously identified indications of degradation, including cracks, which display a growth rate equal to the repair limit in one cycle of operation.

Based upon the likelihood of indications, the degradation assessment classified degradation mechanisms as active, relevant, or potential, with correspondingly decreasing likelihood of initiation and potential impact upon SG tube integrity. The degradation assessment concluded that the following degradation mechanisms were active (as defined by EPRI TR-107569-V1R5) in the STP Unit 1 SGs.

Axial ODSCC at TSP intersections
Axial PWSCC at the TTS expansion transition down to F*
Circumferential ODSCC at the TTS expansion transition
Axial ODSCC in cold leg freespan dings

Degradation Structural Limits

The STP 1RE08 pre-outage degradation assessment identified length and depth based structural limits for freespan axial and circumferentially oriented degradation. While an analysis to determine the depth based structural limit (remaining wall thickness) for AVB wear which satisfies RG 1.121 has not been specifically performed for STP Unit 1, a lower bound value was established in the degradation assessment. The degradation assessment provides the structural limits and NDE uncertainties to support the condition monitoring and operational assessments of this report.

3.1 1RE08 Identified Degradation Mechanisms

Indications suggestive of the following degradation mechanisms were detected in the STP 1RE08 inspection:

- Axial ODSCC at TSP intersections
- Axial PWSCC Hot Leg TTS expansion transition (<1" above TTS) down to F*
- Axial PWSCC in the expanded tube within the tubesheet
- Axial *and circumferential* ODSCC at freespan dings
- Circumferential ODSCC at the Hot Leg TTS expansion transition
- Freespan Volumetric indications
- AVB wear
- Wear at non-expanded preheater baffle intersections

The evaluation for axial ODSCC at TSP intersections is documented in a separate ARC report, as part of analyses required per NRC Generic Letter 95-05. Identified axial PWSCC and circumferential ODSCC indications at the TTS were, in general, not sufficient in magnitude to warrant in situ testing, however, some testing at this location was performed. In general, the voltage magnitudes and arc lengths of identified circumferential degradation at the TTS were consistent with or below previously observed limiting indication levels. This may be partly attributed to increased secondary side chemistry control as well as an effect of T_{hot} reduction. Axial ODSCC at freespan dings was reported, as well as three tubes with reported circumferential indications at freespan dings. The maximum AVB wear depth reported was 26% TW in SG A and SG D. The maximum tube wear depth reported at non-expanded preheater baffles was 10% TW in SG B.

Table 1 presents a summary of the number of repaired tubes in each SG and identifies the mechanism which necessitated the repair. Table 2 presents a summary of each type of degradation mechanism observed at STP Unit 1 during the 1RE08 inspection. The values in Table 2 are for individual indications, and the number of tubes containing these indications will be less than the number of indications since some tubes have multiple indications. With regard to Table 2, the number of +Point confirmed indications in the TTS RPC inspection zone (1" above to 2" below the TTS) are provided. Bobbin indications well below F*, are not included in Table 2. A summary of all repaired tubes, including tubes plugged, and tubes permitted to remain in service by application of the alternate repair criteria approved for STP Unit1, TSP ODSCC per GL95-05, and F*, is provided in Table 2.

<u>Disposition Techniques for Identified Degradation Mechanisms</u>

Depth measurement of AVB wear indications and non-expanded preheater baffle plate wear using the bobbin coil is qualified per EPRI Appendix H standards, and these indications were sized against the 40% depth repair criteria. ODSCC indications at the TSP intersections were sized based on voltage using the bobbin coil according to guidance contained in GL 95-05. Indications greater than 1 volt by bobbin were RPC inspected for flaw confirmation. Indications identified in exclusion zones related to tube collapse potential near TSP wedges are RPC inspected, and if confirmed, are repaired regardless of voltage. Mixed residual indications >1.5 volts by bobbin were RPC inspected. All crack-like indications in the freespan, and in the expansion transition down to the F* distance were repaired upon detection since depth sizing techniques are not qualified and no ARC is applied to these regions. Location verification of indications below the TTS or hard roll contact point, whichever is lower, for F* application is performed using the 115 mil pancake coil. Indications located greater than the F* distance below the TTS or hard roll contact point, whichever is lower in elevation, may remain in service. An eddy current uncertainty value is included in the specified F* distance for STP Unit 1 of 1.70" to determine acceptability for continued operation of indications below the TTS or hardroll contact point, whichever is lower.

To reduce the potential for an axially oriented ODSCC indication to be obscured by baffle wear, all preheater baffle wear indications were RPC inspected. No hidden ODSCC was detected. Also, 20% of the AVB wear indications were RPC inspected for the same reason. No ODSCC was detected.

Indications previously called volumetric have in the past been reviewed following the inspection, and determined to be attributed to deposits, MBMs, dings and bulges, or tube material property changes that sometimes occur after power operation. SVI calls by RPC, which did not have a corresponding bobbin MBM signal in the baseline, or could not be tracked through history, were conservatively repaired at 1RE08.

Additionally, permeability variations were repaired based on maximum voltage of the PVN, and its potential to mask a 1 volt DSI at a support plate. PVNs > 1volt in the freespan were also repaired. The repair of these signals is considered conservative.

More significant than the mechanisms identified are the mechanisms *not* identified. These include:

- Freespan axial ODSCC at non-dinged areas and hot leg sludge pile
- Small radius U-bend PWSCC

The absence of freespan ODSCC may be attributed to improved secondary side chemistry control and very low sludge and tube scale levels. The lack of small radius U-bend PWSCC is related to the in situ heat treatment of the Row1 and 2 U-bends in 1RE01.

Table 1:
Summary of STP 1RE08 Plugging Repair Statistics: Number of Tubes Repaired for Observed Degradation Only

Degradation Mode	HL sludge pile (>1" above TTS)	HL TTS Exp. Transition down to F*	CL TTS Exp. Transition down to F*	Hot Leg TSP	Cold Leg Dings	Hot Leg Dings	Wavy Tubes	U-bend	Baffle Wear	Freespan	Total
SG A											
Axial ODSCC	0	0	0	6	2	0	0	0	0	0	8
Axial PWSCC	0	1	0	0	0	0	1	0	0	0	2
Circ. ODSCC	0	1	0	0	0	0	0	0	0	0	1
Wear	0	0	0	0	0	0	0	0	0	0	0
Volumetric	0	0	0	0	0	0	0	0	0	6	6
Sub Total	0	2	0	6	2	0	1	0	0	6	17
SG B											
Axial ODSCC	0	0	0	5	2	1	0	0	0	0	9
Axial PWSCC	0	5	0	0	0	0	0	0	0	0	4
Circ. ODSCC	0	3	0	0	0	0	0	0	0	0	3
Wear	0	0	0	0	0	0	0	0	0	0	0
Volumetric	0	0	0	0	0	0	0	0	0	8	8
Sub Total	0	8	0	5	2	1	0	0	0	8	24
SG C											
(1) Two tubes had both a repairable indication due to axial ODSCC at a cold leg ding and a cold leg volumetric indication. Tubes counted in axial ODSCC at cold leg ding category											
Axial ODSCC	0	0	0	19	7	0	0	0	0	0	26
Axial PWSCC	0	0	0	0	0	0	0	0	0	0	0
Circ. ODSCC	0	16	0	0	2	0	0	0	0	0	18
Wear	0	0	0	0	0	0	0	0	0	0	0
Volumetric	0	1	0	0	0	0	0	0	0	2	3
Sub Total	0	17	0	19	9	0	0	0	0	2	47 (1)
SG D											
Axial ODSCC	0	0	0	8	5	0	0	0	0	0	13
Axial PWSCC	0	3	0	0	0	0	0	0	0	0	3
Circ. ODSCC	0	4	0	0	1	0	0	0	0	0	5
Wear	0	0	0	0	0	0	0	0	0	0	0
Volumetric	0	0	0	0	0	0	0	0	0	3	3
Sub Total	0	7	0	8	6	0	0	0	0	3	24

Table 2
Summary of Repaired Indications and Indications Justified for Continued Operation by Application of ARCs: STP 1RE08, April 1998
Values Apply to 1RE08 Inspection Only

SG	Tubes Repaired by Plugging	Tubes Repaired for Crack-like Defects	Tubes Repaired for Volumetric Signals	Tubes Preventively Plugged	Tubes Permitted to Remain in Service by TSP ARC	Tubes Permitted to Remain in Service by F*	Total Tubes Permitted to Remain in Service by ARCs
A	41	11	6	24	242	0	242
B	31	16	8	7	224	1	225
C	59 (1)	44 (1)	3 (1)	12	460	1	461
D	35	21	3	11	342	1	343
Total	166	92	20	54	1268	3	1271

(1): Two tubes had both a repairable indication due to axial ODSCC at a cold leg ding and a cold leg volumetric indication. Tube plugging attribution accounted for in Crack Like Defects Category

NOTE: The tube count for tubes left in service due to application of the voltage based plugging criteria was reduced due to plugging for a repairable indication at another elevation in the tube.

4.0 CONDITION MONITORING EVALUATION

4.1 Condition Monitoring Evaluation of Active Degradation Mechanisms as Classified by the Pre-Outage Degradation Mechanism

4.1.1 TTS Circumferential Flaw ODSCC Condition Monitoring Evaluation

Screening of indications for selection as in situ test candidates is performed at STP Unit 1 using a methodology which is consistent with EPRI Draft Report TR-107620, "Steam Generator In Situ Pressure Test Guidelines", dated December 1998. Since the publishing of these guidelines, the burst correlation for circumferential indications has been updated as documented in EPRI TR-107197, "Depth Based Structural Analysis Methods for SG Circumferential Indications". The updated burst curve was used to develop the critical crack angle value of 277° for STP Unit 1 at 3ΔP conditions.

For in situ testing purposes, screening limits are applied to identify the most relevant subset of indications for testing. For proof test screening of circumferential indications, the first screen is crack angle ≥ 237°, and the second screen is average voltage (in Eddynet multiscan mode), or voltage integral, ≥ 0.35 volts. Indications exceeding both screens are depth profiled to determine percent degraded area (PDA). Indications with PDA ≥ 29% are proof tested. For leak test screening, the first screen is maximum voltage in multiscan mode ≥ 1.25 volts for PWSCC, 1.00 volts for ODSCC, while the second screen is max depth ≥ 80% for PWSCC, 75% for ODSCC. Indications exceeding both screens are depth profiled to determine the arc length at depth ≥ the second screen depth limit value. Indications with arc length ≥ 20° at the second screen depth limit are leak tested. If no indications exceed the 1st screens, the indications with the largest reported angles and largest voltages are evaluated against the second screens to ensure that all relevant indications are adequately evaluated. For circumferential indications, those that exceeded two of the three screening values were conservatively tested due to the small reported +Pt voltages.

The limiting circumferential arc length for a single, 100% TW flaw, which would be expected to provide structural integrity at RG 1.121 guidelines for STP Unit 1 was identified in the degradation assessment as 277°. The in situ testing screening limit of 237° represents the limiting crack angle of 277° reduced for measurement uncertainty.

Table 3 presents a summary of the largest circumferential flaws in each SG at 1RE08. A total of 25 circumferential indications were identified. Based on phase angle analysis, all were judged to be representative of ODSCC. A total of 75 circumferential indications at the hot leg TTS were identified at 1RE07. The observed indications at 1RE08 represent a significant decrease in the number of observed indications.

At 1RE07, two circumferential ODSCC indications at the hot leg TTS were in situ pressure tested. The eddy current parameters for these indications were comparable to the 1RE08 circumferential flaw parameters. The arc lengths of the indications in situ tested at 1RE07 were 175° and 274°; the maximum depths were 51% and 86%, and PDA values were 11.6% and 38.6%. The voltage integral values were 0.19 and 0.18.

PDA values for the largest 1RE08 indications with regard to circumferential extent are provided in Table 3. The in situ test screening limit for PDA of 29% represents a 100% TW flaw of 104° arc. All flaws with a reported arc length of > 104° and voltage integral > 0.2 had PDA values calculated. All others represent PDA values significantly below the screening value limit.

Taking the results of the circumferential depth profile, the calculated burst pressure of the limiting expansion transition indication, R26 C57 in SG C, is 5052 psi, using LTL material properties at 650° F. The depth and voltage profile of this indication is provided in Figure 1. The depth and voltage profile suggests that non-degraded ligaments may be present between about 200° and 220°, which, if present, have a significant strengthening effect upon the actual burst capability of the flaw. The depth and voltage profile characteristics may also suggest that if non-degraded ligaments are not present in this arc length range, the reported peak depths are likely significant depth overcalls.

Table 3
Summary of Circumferential Flaws: STP 1RE08 Inspection
Largest Reported Values for Each Parameter Given
Values in **BOLD** Represent Indications Which Exceeded a Screening Limit

SG	Tube	Angle (from Profile Analysis)	Max Volts (+Pt)	Avg. Volts (Voltage Integral)	Max Depth (from Profile Analysis)	PDA	Proof Test Screen Exceeded	Leak Test Screen Exceeded
[illegible]		Screening Limits						
[illegible]		237°	1.25 (ID) 1.00 (OD)	0.35	80% (ID) 75% (OD)			
[illegible]								
A	R31 C68	72°	0.19	0.12	84%		No	No
No SG A indications exceeded any single screening value								
B	R22 C39	141°	0.2	0.10	**91%**		No	No
B	R23 C41	43°	0.23	0.19	**88%**		No	No
B	R26 C68	72°	0.28	0.26	34%		No	No
No SG B indications selected for testing								
C	R3 C36	56°	0.3	0.14	**93%**		No	No
C	R23 C42	56°	0.16	0.17	51%		No	No
C	R18 C43	102°	0.26	0.23	73%		No	No
C	R22 C45	64°	0.28	0.09	**100%**		No	No
C	R20 C47	34°	0.13	0.12	0%		No	No
C	R24 C47	43°	0.2	0.17	32%		No	No
C	R26 C53	69°	0.39	0.26	73%		No	No
C	R26 C56	69°	0.27	0.16	49%		No	No
C	R26 C57	**260°**	0.45	0.26	**99%**	**51%**	Yes	Yes
C	R23 C58	103°	0.26	0.23	**80%**		No	No
C	R22 C73	99°	0.34	0.2	25%		No	No
C	R23 C73	**271°**	0.29	0.29	64%	24%	No	No
C	R21 C75	56°	0.14	0.11	12%		No	No
C	R22 C77	123°	0.25	0.20	45%	<5%	No	No
C	R2 C88	127°	0.27	0.21	**88%**	<5%	No	No
C	R13 C104	26°	0.16	0.11	49%		No	No
R26 C57 leak and proof tested: 0 leakage reported, no burst reported								
D	R23 C66	80°	0.28	0.17	**94%**		No	No
D	R26 C68	42°	0.37	0.15	28%		No	No
D	R19 C74	33°	0.14	0.11	0%		No	No
D	R48 C79	199°	0.44	0.24	43%	14%	No	No
No SG D indications selected for testing								

4.1.2 Expansion Transition Axial Flaw PWSCC Condition Monitoring Evaluation

With regard to freespan axial indications the in situ screening procedure for burst is as follows. The first two screens are crack length ≥ 0.49" and maximum depth ≥ 70%. Indications that exceed both screens are depth profiled. The average depth over the crack length is determined from the depth profile. Average depth vs. length is compared against a table of limiting crack length and average depth relationships provided in the degradation assessment, which provide for structural integrity at RG 1.121 recommendations. The freespan screening flaw length of 0.49" provides for burst integrity at RG 1.121 recommendations for a single flaw morphology of 100% TW depth. The screening parameters for proof testing are developed using lower tolerance limit (LTL) material property values. For transition region indication leakage screening, the first screen is maximum +Point field evaluation voltage ≥ 2.50 volts for ID indications, 1.5 volts for OD indications, and the second screen is max depth ≥ 70%. Freespan OD indications were screened using a +Pt voltage limit of 1.0 volt. If the second screen is exceeded the indication is depth profiled to determine length at max depth. Indications with ≥ 0.1" length at the second screen max depth limit are leak tested. Axial indications located below the TTS do not represent a potential for burst. If the 1st leak test screen is not exceeded for all indications, the largest voltage indications are evaluated against the second screen to ensure that all relevant indications are adequately evaluated. The F* criterion developed for STP by Framatome concludes that a SLB leakage allowance should be considered for F* tubes. As only 3 F* tubes were left in service, the SLB leakage contribution is considered insignificant.

At STP during the 1RE08 inspection, the longest reported indication at the TTS was in R46 C49 SG B, at 0.34" long. Based on the comparison of the 1RE08 axial indication NDE values against the in situ screening parameters, it is concluded that no axial indications identified at 1RE08 challenged structural integrity, and none would have been expected to leak at SLB conditions.

A total of 20 axial PWSCC indications were detected at 1RE07. A total of 10 axial PWSCC indications were observed at 1RE08 (9 indications in the transition, 1 indication ~7" below the TTS in a wavy tube). As with the observed number of circumferential ODSCC indications at the TTS, the number of reported axial PWSCC indications has significantly decreased from 1RE07. No axial PWSCC indications at the TTS were in situ tested at 1RE07 or 1RE08. Inspection and analysis techniques were consistent for both inspections.

4.1.3 TSP ODSCC Condition Monitoring Evaluation

A total of 39 indications (38 tubes) exceeding 1.0 volt were confirmed by RPC, and therefore, were plugged. The largest bobbin DSI voltages for each SG are provided below in Table 4:

Table 4
TSP ODSCC Degradation Summary

	SG A	SG B	SG C	SG D
Number Ind.	305	241	645	427
Largest Voltage	3.75	1.49	3.77	1.78
Number ≥ 1 volt	14	8	32	20
Max 1RE07 Voltage	1.8	0.8	1.7	1.1

This data shows that SG C appears to be the most susceptible SG with regard to ODSCC initiation and growth.

The voltage based structural limit for TSP ODSCC indications is 4.79 volts for a SLB ΔP of 2560 psi and 5.8 volts for a SLB ΔP of 2405 psi, where pressurizer PORVs are available (with safety factor applied).

Mixed residual indications with a bobbin voltage > 1.5 volts were RPC inspected. A less than 1 volt bobbin indication was detected in a MRI of 1.57 volts. The MRI RPC sample was expanded to 20% of the MRIs >1.3 volts but < 1.5 volts. The initial MRI RPC sample totalled approximately 190 intersections. The MRI RPC expansion included an additional 100 intersections. No indications were detected in the MRI RPC expansion program.

4.1.4 Freespan ODSCC Condition Monitoring

Other than at dings, no freespan ODSCC was reported at STP Unit 1 for the 1RE08 outage.

4.1.5 ODSCC at Freespan Dings

Axially Oriented Indications:

Axial ODSCC at freespan dings was detected in the 1RE07 outage and at the last two Unit 2 outages at cold leg dings only. As this mechanism was classified as active for the cold legs, all freespan dings required to be inspected using a qualified detection technique. Qualification of the bobbin probe as a detection tool was performed by Westinghouse, and this program achieved a POD of 90% at 90% confidence for flaws ≥ 60% depth, for freespan dings ≤ 5 volts. Qualification was performed using a data set comprised entirely of laboratory cracked specimens. All hot leg, U-bend, and cold leg dings > 5 volts were inspected by +Pt, even though this mechanism was classified as active in the cold leg only.

A total of 30 DNI (distorted ding with indication) bobbin calls were made, and a total of 16 axial indications at dings were confirmed by +Pt. A total of 139 NQI (non-quantifiable indication) in the freespan were also reported by bobbin, all of which were +Pt inspected. Some of these NQI calls may have been made at dings. No +Pt axial indications with a ding voltage of < 5 volts by bobbin were missed by the bobbin. The one SAI at a ding, which was not called by bobbin, was located in a 5.2 volt ding. Only one ding SAI exceeded the freespan screening limit of 0.49". This indication (R40 C74 SG C, 0.59" long, 100% max depth, 82% average depth, 0.49" length at depth > 75%) was in situ leak and proof tested. No leakage or burst was reported. A sizing evaluation was also performed using the laboratory samples developed for the bobbin qualification program. Flaw lengths were substantially overcalled against the destructive exam lengths. A profile adjustment technique was established which considered only those depth points with coincident voltage ≥ 0.3 volts, for flaw maximum voltages ≤ 1 volt by +Pt, as valid depth points. The adjustment technique conservatively estimated flaw lengths when compared against destructive exam data. Using this adjustment technique, the adjusted length of the SAI in R40 C74 SG C was 0.29", maximum depth of 97%, and length at max depth > 75% of 0.22". The unadjusted flaw lengths for all other axial ODSCC at dings was bounded by 0.41". The calculated burst pressure of R40 C74 using the unadjusted depth profile was 3336 psi, for assumed LTL material properties. No burst was reported at a maximum test pressure of 4150 psi. Two additional axial indications at dings were in situ tested. Flaw characterization parameters and testing results are provided in Table 7.

Two cold leg axial ODSCC indications were in situ pressure tested at 1RE07. One was at a ding, 2.51" above the 11C TSP. One was not reported at a coincident ding. The indication not reported at a ding had a total length of 2.37" (by NDE), maximum depth of 91%, average depth of 64%, and maximum voltage of 1.96, using the 115 mil diameter pancake coil, 0.86 volts using the +Pt coil. The calculated burst pressure at operating conditions using the as reported depth profile was 3298 psi, using a 0.3 volt cutoff, was 3726 psi. No leakage (2840 psi leak test pressure) or burst (4070 psi proof test pressure) was reported. The reported indication at a ding had a reported length of 0.62", maximum depth of 99%, average depth of 76%, and maximum +Pt voltage of 1.03. Maximum leakage of 0.0033 gpm was reported. At such low levels, the validity of the positive leakage condition is uncertain. This leak rate was reported for the normal operating condition test. The leak rates for the elevated pressure test values were found to be less than this value, questioning the validity of the reported leak rate. The reported leak rate is at the lowest operating range of the leak test equipment.

In the 1RE07 inspection, 7 axial freespan indications at dings were reported by bobbin and confirmed by RPC. The bobbin technique employed for the 1RE08 inspection represents a significant increase in detection capability compared to the technique utilized for 1RE07. Using the 1RE08 technique, all 1RE07 freespan ding axial ODSCC indications would have been detected at 1RE06.

Circumferentially Oriented Indications:

The total ding population (>0.75 volts by bobbin) for STP Unit 1 is 8297 dings, and includes cold leg, hot leg, and U-bend dings. The number of dings > 5 volts is 475. All dings > 5 volts were +Pt inspected. A circumferential indication was reported in a 3.91 volt ding, located about 2.1" below the bottom of the top cold leg TSP, in tube R43 C42 in SG D. A second circumferential indication was reported in tube R42 C68, located about 14" below the bottom of the top cold leg TSP, SG C. This indication was observed in a 0.77 volt ding. Both were detected while traversing from the 11C cold leg TSP to a ding to be inspected near the 12C TSP. The NRC agreed that a 20% RPC sample of all dings was a sufficient sampling program, and requested that all reported circumferential freespan indications be in situ pressure tested. A total of approximately 815 dings were +Pt inspected as part of the initial program scope. The +Pt ding inspection was expanded to include 20% of the total ding population, or approximately 1700 dings. One additional circumferential indication was detected in R37 C55, SG C at 6.5" below the 11C TSP as part of the expansion program. The NRC was informed of this condition, since detection of freespan circumferential indications represents a new degradation mechanism. Based on the manufacturing details, it was judged that the most likely location of such indications would be within about 25" of the bottom of the upper TSP, in Rows 30 and greater. All dings in this region in SG C were +Pt inspected. All freespan circ indications were leak and proof in situ pressure tested to 5000 psi, or approximately 16% greater than the 3ΔP based circumferential flaw proof test pressure of 4315 psi. There was no reported change in the +Pt characteristics of these flaws following proof test to 5000 psi. This suggests that either the flaws are smaller than indicated by the depth profiles or could possibly be false calls. A summary of the pre and post in situ test NDE results are provided in Table 5 for these flaws. A graphical representation of the pre and post NDE depth profiles for these larger indications is provided in Figures 2, 3, and 4.

Figure 2 shows that for the case of R42 C68, that the depth profile suggests that the deepest reported depths at the edges of the indication may be overcalled. The voltage response indicates the peak voltage at the center of the indication arc involvement, however, the deepest reported depths are called at the edges of the indication, where the voltage is essentially zero. This trend is also evidenced in R43 C42 and R37 C55, but is not as apparent as for R42 C68. For indications with voltages as small as these, the sizing and repeatability error can be large. This is shown by comparison with the results of R43 C42. The post in situ test PDA is 15.14%, while the pre in situ test PDA is 23.85%. The post in situ voltage is reduced to 0.51 volts from 0.53 volts pre in situ. The slight apparent PDA growth for R42 C68 (0.5%) is certainly within repeatability bounds. If any change were expected, it would be most likely to occur in R43 C42 or R37 C55, which had substantially larger reported indications compared to R42 C68. Another abnormal characteristic of these indications is the shape of the voltage profiles. The voltage profiles exhibit nearly identical shapes for all three reported circumferential indications at freespan dings. When compared with the voltage profile for R26 C57 (hot leg TTS circumferential indication) shown in Figure 1, it is seen that the voltage profile for this indication, representative of degradation confirmed by tube pull, is significantly different from the voltage profiles of the freespan circumferential indications. For both of the larger indications, the PDA value was reduced following in situ testing. Although the expansion program performed for circumferentially oriented cracking in freespan dings did not meet the Table 3-2 expansion criteria of the EPRI Rev. 5 ISI guidelines, the expansion program, coupled with in situ testing was judged satisfactory by the NRC.

The bobbin ding voltages for R42 C68 and R37 C55 were 0.77 and 2.15 volts, respectively. The bobbin ding voltage for R43 C42 was 3.91 volts. These voltages are similar to the pre-crack +Pt ding voltages of the bobbin qualification samples. It is expected for flaws of this reported depth (at or near 100%), that significant voltage response increase would be encountered. The pre vs. post crack +Pt data for the bobbin qualification samples showed that for those samples at the threshold of bobbin detection, that the post crack +Pt data voltage was approximately twice the pre crack +Pt voltage. These contributing factors tend to show that if these indications are representative of true degradation, that the degradation depths are grossly overestimated by the NDE process.

Table 5
Summary of Pre vs. Post In Situ Test NDE Characteristics for Freespan Circumferential Indications at Dings
(as reported from circumferential direction depth profiles)

Tube	Pre In Situ				Post In Situ			
	Max Volts	Max Depth	Avg. Depth	Arc Length	Max Volts	Max Depth	Avg. Depth	Arc Length
R42 C68 SG C	0.19	99%	8.9%	49°	0.23	99%	9.5%	49°
R37 C55 SG C	0.19	100%	26.4%	117°	0.24	100%	23.6%	114°
R43 C42 SGD	0.53	100%	23.9%	112°	0.51	98%	15.1%	117°

4.2 Condition Monitoring Evaluation of Degradation Modes Classified as Relevant in the Degradation Assessment

The degradation assessment concluded that the following mechanisms did not meet the criteria to be classified as active mechanisms, and therefore were categorized as relevant mechanisms.

- AVB wear
- Tube wear at non-expanded preheater baffles
- Small radius U-bend PWSCC
- Axial ODSCC at dented TSPs > 5 volts
- Tube wear due to foreign objects/loose parts

Condition monitoring of relevant mechanisms indicates that no indications were present at 1RE08 that represented a challenge to structural integrity or leakage integrity.

The AVB wear mechanism at STP Unit 1 is rather benign. A total of only 19 AVB wear indications were reported, with a maximum reported depth of 26% TW. The average AVB wear growth rate for previously reported indications is 1.6% TW/cycle, with a 95% cumulative probability growth of 11%TW/cycle. No new AVB wear indications were reported.

No small radius U-bend PWSCC indications were reported.

No tube wear due to foreign object wear was reported.

Tube wear at non-expanded baffles represents a very low growth mechanism. The largest reported depth at 1RE08 was 10% TW. The average growth rate for all indications combined is 0%, while the largest reported growth is only 3% TW.

4.3 Condition Monitoring Evaluation of Degradation Modes Classified as Potential in the Degradation Assessment

The final degradation class addressed in the degradation assessment is potential degradation modes. Potential degradation modes are those not seen in STP Unit 1, but do represent a potential to occur based on experience at other plants or in laboratory testing.

The only degradation mode classified as potential for STP 1RE08 is cold leg TTS SCC. A 43% RPC sample inspection was performed in the cold legs of SGs A and B. No indications were reported.

4.4 Summary of Limiting Indications

The following Table 6 presents a summary of the limiting indications for the 1RE08 inspection.

Table 6
Summary of Limiting Indications

Mechanism	Max Length	Max Depth	Avg. Depth	Calculated Burst Pressure	SLB Leakage gpm (95%,Nom,BestEst)
Circ ODSCC at hot leg TTS	258°	99%	51%	6038 psi *	0 (in situ test)
Axial PWSCC at TTS	0.34"	100%	79.7%	5052 psi	0.854, 0.086, 0.033
ODSCC at dings	0.59"	100%	86%	3336 psi **	0 (in situ test)
AVB Wear	0.4" (assumed)	26%	26%	9800 psi	0
Circ ODSCC at freespan dings	117°	99%	24% (360° basis)	7500 psi ***	0 (in situ test)

*: Successfully proof tested at a test pressure of 4315 psig. No leakage reported at 2925 psig.

**: Successfully proof tested at a test pressure of 4150 psig. No leakage reported at 2841 psig.

***: Successfully proof tested at a test pressure of 5000 psig. No leakage reported at 2925 psig. Post in situ +Pt examination indicated that no change in indication characteristics was observed.

4.5 SLB Leakage Discussion:

For other than TSP ODSCC indications, any potential for SLB leakage at end of Cycle 8 conditions is judged negligible. The circumferential ODSCC indications at the TTS are of sufficiently low magnitude that no leakage contribution is expected. This was confirmed by in situ test of the limiting circ flaw at the TTS. No leakage was reported at a maximum pressure of 2925 psi. The limiting axial flaw at the TTS had a 115 mil pancake coil maximum voltage of 3.58 volts (estimated +Pt volts of 2.15 volts) and length at depth >80% of 0.25". The lead-in/lead-out effects of the coil tend to overestimate the flaw length. Using a 1 volt cutoff representing depth >80%, the best estimate length with respect to leakage potential is approximately 0.2". The limiting axial ODSCC flaw at a ding had a maximum +Pt voltage of 0.64 volts and length of 0.59". The lead-in/lead-out effects are well documented in the ding qualification report, SG-99-03-005, and indicate that a voltage cutoff of 0.3 volts can be used to accurately assess true flaw length. The total flaw length is estimated to be 0.29", with a length at depth >75% of 0.22".

For the leakage estimates of Table 6, the unadjusted flaw length and depth profiles are used to calculate the 95% confidence SLB leakage and mean leak rates. The adjusted flaw lengths exceeding the leakage threshold depths are used with the mean leakage correlation to assess SLB leakage against the FSAR value of 1.0 gpm total, 0.35 gpm in the faulted SG.

SG A:

Only one indication in SG A was judged to have a potential to contribute primary to secondary leakage during a postulated SLB event. This tube, R14 C73, had 4 axial indications located at ~7.25" below the TTS. The lengths and maximum voltages (115 mil pancake coil) of the four indications was 0.37", 4.52 volts, 0.38", 3.55 volts, 0.41"/ 4.93 volts, and 0.48", 7.72 volts. Based solely on the reported lengths, assuming the flaws existed in the freespan, SLB leakage at 95% confidence and using mean values are 7.483 gpm and 1.338 gpm for these four flaws combined. Using a voltage cutoff of 4 volts for assessment of TW length, the estimated TW lengths for the four flaws are 0.13", 0.0", 0.17", and 0.27". If located in the freespan, these four flaws would have expected leakage during a postulated SLB event of about 0.06 gpm using mean leak rates, 0.8 gpm at 95% confidence. These flaws were identified in a "wavy" tube (as termed by STP). These tubes have reported abnormal expansion profiles from RPC testing, which could suggest that the tube is not in contact with the tubesheet over the entire circumference. The F* criterion is not applied to wavy tubes. It is expected that some leakage restriction capabilities in these wavy tubes is present, but cannot be quantified. Normal operation leakage from these flaws for freespan conditions is expected to be about 0.006 gpm using mean leak rates and about 0.08 gpm at 95% confidence. As virtually non-measurable (<1/2 gpd or $<3.5 \times 10^{-4}$ gpm) primary to secondary leakage was measured during the cycle, the leakage restriction in the wavy tubes is judged to be substantial.

SG B:

One axial PWSCC indication at the TTS in SG B, R46 C49 was judged to have a high probability of leakage at SLB conditions, however, its likelihood to provide leakage at normal operating conditions is judged low. The maximum voltage of this indication was 3.58 volts (115 mil pancake coil voltage), maximum reported depth of 100%, and total length of 0.34". The flaw average depth was 79.7% TW. As the reported length of this indication is considerably less than the flaw length that provides burst capability at the 3ΔP value for an assumed 100% TW flaw, TW over the entire length of the flaw, structural integrity is expected to be provided. Using a voltage cutoff of 4 volts for assessment of TW length, this flaw would not be expected to leak at SLB conditions. The restraint provided by the hardroll process acts to reduce the potential leakage from axial flaws in the transition by preventing the lower crack tip from opening. Roll transition axial PWSCC flaws at similar plants with +Pt voltages up to about 4 volts (about 6 volts for 115 mil pancake coil) did not leak at SLB conditions.

One axial flaw at a ding in SG B (R47 C30), was judged to have a limited leakage potential. This flaw had a maximum +Pt voltage of 1.19 volts. Based on the lab samples generated as part of the bobbin qualification program for detection of axial ODSCC in freespan dings, this +Pt voltage is representative of degradation of about 85% TW. If the flaw were assumed TW over the entire reported length of 0.3", the SLB leakage at 95% confidence would be about 0.5428 gpm, and about 0.0585 gpm using mean leak rates. Using the length adjustment procedure described above, the flaw length at > 0.3 volts is 0.22". If the flaw were assumed TW over the entire adjusted length of 0.22", the SLB leakage at 95% confidence would be about 0.206 gpm, and about 0.036 gpm using mean leak rates. Based on the reported maximum +Pt voltage of 1.19 volts, SLB leakage would not be expected from this indication.

One F* tube was identified in SG B. The SLB leakage contribution of a single F* tube is on the order of 2.3×10^{-6} gpm, and will not have an impact to estimated leakage. Therefore, F* tube leakage will not be considered in the final leakage evaluation.

Therefore, no SLB leakage contribution from indications in SG B, other than at TSP intersections, is expected.

SG C:

No axial indications were observed in SG C at the hot leg TTS. Only two axial ODSCC indications at freespan dings were judged to represent a leakage potential; these indications were located in R40 C74 and R37 C43. The +Pt voltages for these two flaws were 0.64 and 0.79 volts. Both flaws were in situ leak tested with no reported leakage. The indication in R40 C74 was also proof tested. No structural failure was noted.

One F* tube was reported in SG C.

SG D:

Of the 4 axial PWSCC indications at the hot leg TTS, the maximum reported voltage using the 115 pancake coil was 1.18 volts. The maximum depth and depth profile do not support leakage for this indication. Only two axial ODSCC indications at freespan dings were judged to represent a leakage potential; these indications were located in R42 C19 and R32 C39. R32 C39 was in situ leak tested with no reported leakage. The indication in R42 C19 was reported in a 52 volt ding and was not in situ tested due to the interference of the ding upon installation of the leak testing mandrel. The maximum voltage of the indication was 0.58 volts, with 100% depth calls extending for approximately 0.2" of the total flaw length. The influence of such a large dent suggests that the depth profile may be unreliable. Assuming the flaw was throughwall over the entire length, the 95% confidence and mean leak rates at SLB conditions are 1.316 gpm and 0.159 gpm. If the voltage response of R42 C19 is accurate, SLB leakage is not supported, as more limiting indications (with respect to flaw voltage) were in situ leak tested both at 1RE07 and 1RE08.

One F* tube was reported in SG D.

Comparison Against NEI 97-06 Leakage Allowance:

The total estimated SLB leakage at 95% confidence from indications detected but not in situ tested is 0.8 gpm for SG A, 0.0 gpm for SG B, 0.0 gpm for SG C, and 1.316 gpm for SG D. The total estimated SLB leakage using mean leak rates from indications detected but not in situ tested is 0.06 gpm for SG A, 0.0 gpm for SG B, 0.0 GPM for SG C, and 0.159 gpm for SG D.

Per NEI 97-06, postulated SLB leakage should remain below the site specific leakage allowance corresponding to offsite dose consistent with the 10 CFR Part 100 guidelines, and calculated in a manner consistent with NUREG-0800, the Standard Review Plan. The site specific dose allowance for STP Unit 1 is 15.4 gpm in the faulted loop. The largest SLB leakage contribution from non-ARC degradation mechanisms not in situ tested is postulated for SG D, and is approximately 1.316 gpm using 95% confidence leak rates. The projected SLB leakage contribution for SG D for TSP ARC indications is less than 4.4 x 10^{-3} gpm, which is the TSP ODSCC SLB leakage contribution for the limiting SG (SG C) for TSP ODSCC. Therefore, the accident condition leakage requirements for dose considerations are satisfied.

Currently, it is also required that FSAR leakage limits be satisfied for nominal leak rate calculations. The FSAR limit is 0.35 gpm in the faulted loop, 1 gpm total. This allowable limit exceeds the largest predicted nominal leak rate of 0.159 gpm for SG D.

The current licensing basis for STP with regard to non-ARC leakage sources during a postulated SLB event is 0.35 gpm in the faulted loop, 0.65 gpm in the intact loops. The referenced leak rate is an average value over the total release time, therefore, comparison against average postulated leak rates from non-ARC mechanisms is acceptable. As the maximum projected SLB leak rate for non-ARC mechanisms is 0.159 gpm in SG D, and is far less than the allowable limit of 0.35 gpm.

In Situ Testing Summary:

The in situ testing performed for the 1RE08 outage helps to support the conclusion that postulated SLB condition primary to secondary leakage will remain below 1 gpm for all SGs. A summary of the leak and proof testing parameters is provided in Table 7.

5.0 1RE08 CONDITION MONITORING CONCLUSION and FINAL OPERATIONAL ASSESSMENT

As the original STP Unit 1 SGs will be replaced in Spring 2000, the 1RE08 inspection was the last ISI of the original STP Unit 1 SGs. Based on the STP 1RE08 inspection results, no tubes contained indications which represented a challenge to structural or leakage integrity and all condition monitoring requirements are satisfied. The relative severity levels of the observed degradation were substantially below the levels associated with the 1RE07 inspection. Based on the apparent decreased or non-increasing expansion transition ODSCC and PWSCC growth and initiation rates, it is unlikely that a substantial increase in either number of indications or growth rates would be encountered during Cycle 9. The Cycle 9 operating period is a maximum of 333 EFPD, vs. 525 EFPD operating period for Cycle 8. As no degradation mechanisms challenged structural or leakage integrity at 1RE08, the likelihood of an indication posing a challenge to structural or leakage integrity at the end of the Cycle 9 operating period is considered negligible. The number of circumferential ODSCC indications at the hot leg TTS reported at 1RE08 was 3 times less (25 vs. 75) than the number of circumferential ODSCC indications reported at 1RE07. The number of axial PWSCC indications at the hot leg TTS reported at 1RE08 was half (10 vs. 20) of the number of axial PWSCC indications reported at 1RE07. The number of confirmed axial ODSCC indications at freespan dings increased from 1RE07 (16 vs. 7), however, the enhanced bobbin inspection technique utilized at 1RE08 accounts for this increase. All of the axial ODSCC freespan indications at cold leg dings reported at 1RE07 would have been identified at 1RE06 had this technique been utilized in 1996. The observance of suspected circumferential ODSCC indications at freespan dings between the 11C and 12C TSPs did not represent a challenge to structural or leakage integrity. Assuming these indications are representative of true degradation, the minimum burst pressure for these reported indications is approximately 7500 psi. As in situ testing of the limiting indications at 1RE08 showed no leakage for leak test pressures ranging from 2841 psi to 2925 psi, and showed no evidence of structural failure at proof test pressures of 4150 psig to 5000 psig, structural and leakage integrity requirements of NEI 97-06 were met using deterministic methods.

Despite the apparent confirmation that structural and leakage integrity consistent with NEI 97-06 and the current STP licensing basis, growth rates for the observed SCC mechanisms were evaluated for the Cycle 8 operating period. Assessments of growth are provided in the following section. In general, the growth rates appear to be decreasing compared to previously performed analyses. This observance, coupled with a Cycle 9 operating cycle of only 333 EFPD (compared to a 525 EFPD operating length for Cycle 8), can be used to deterministically conclude that the SG tubes will continue to meet all industry and regulatory structural and leakage integrity requirements at EOC-9.

5.1 Growth Assessment of Limiting 1RE08 Indications and Operational Assessment Evaluation

Circumferential ODSCC at the TTS

The 4 largest arc length circumferential indications (> 100° arc) and one with a reported depth of 100% from profile analysis reported at the hot leg TTS were reviewed for arc length growth. The 1RE07 hot leg TTS RPC data (115 mil pancake coil) was reviewed to determine if these flaws were present; all were determined to be observed using the 1RE07 data, based on the knowledge of a somewhat larger flaw being present at the 1RE08 inspection. As only 115 mil pancake coil data was available from the 1RE07 inspection, the 115 mil pancake coil data from 1RE08 was used for the growth evaluation. Plots of circumferential extent vs. depth for the 1RE08 and 1RE07 115 mil pancake data are provided in Figures 5 thru 9. This data is developed from circumferential direction depth profile analysis. Based on the growth evaluation, the average and maximum arc length growths are 22°, and 42°, while the average and maximum PDA growths are 3.4% and 6.4%. It should be noted these values apply to the largest indications at 1RE08. The average and maximum, max depth growths are 13% and 55%.

A total of 29 tubes with circumferential indications from STP Unit 1, 1RE06 and 1RE05 inspections are included in the growth database of EPRI TR-107197. The average PDA growth for the 115 mil pancake coil was 16.1%, with a maximum value of 68.9%. The Cycle 7 circ flaw growths were evaluated in the 1RE07 condition monitoring report. This evaluation, totalling 35 flaws, showed the largest PDA growth using the 115 mil pancake coil was 11.22%. Considering all PDA growths, the average value is 0.6%. Using positive PDA growths only, the average value is 3.4%. Therefore, these growth data suggest that the growth characteristics have been reduced or constant in the most recent cycles.

From Figures 5 thru 9, the Cycle 8 growth appears to be modest. The circ flaw in R48 C79 SG D (Figure 9) appears to show essentially no change. The only feature of note is that the 115 mil pancake coil data of 1RE07 indicates ID phase angles over the entire profiled length, whereas the 1RE08 115 mil and +PT data indicates OD phase angles over the entire profiled length.

Table 8 provides the growth data for the 115 mil pancake coil data for Cycle 8. All data is developed from circumferential direction depth profile analysis, with the exception of the flaw voltage, which is the reported peak from the production data. Table 8 also provides +Pt data from profile analysis and compares these values against the 1RE08 and 1RE07 115 mil pancake coil data from profile analysis. Even though this mix of coils would be expected to overestimate growth rates due to the increased +Pt detection threshold, the growth rates are modest and support conclusions from the 115 mil pancake coil data. In general, the +Pt and pancake coil data are similar. Two flaws however are not similar. Substantial differences in PDA are seen when there is a large difference in arc length, and most likely attributed to shallow tail detection by +Pt. One (R26 C57) of the two indications with large disparities between the +Pt and 115 mil pancake coil arc lengths has about 90° of flaw length at the tails which produce ID phase angles, and could be overcalls. The other flaw with large PDA variances between the +Pt and 115 mil pancake data has a reported +Pt PDA of only 24%.

PDA is the controlling parameter considering burst capability of circumferential flaws. From the 115 mil pancake coil data, maximum PDA growth of 6.4% was reported. Plus Point coil PDA evaluation from 1RE08 indicates that only 1 indication (R26 C57) had a reported PDA value exceeding 25%, and that this flaw may include overcalls at the tails of the indication in the evaluation based on the reported ID phase angle at the ends of the flaw. Assuming a PDA detection threshold of 20%, the maximum PDA value at 1RE09 is expected to be approximately 27%, far less than the 77% PDA limit for a single 100% TW circumferential flaw. When the Cycle 9 length of 333 EFPD is considered, a maximum PDA assessment for EOC-9 of about 25% is obtained. Per EPRI TR-107197, the maximum PDA uncertainty for the STP Unit 1 pulled tubes using the 115 mil pancake coil is about 30%. Therefore, considering PDA measurement uncertainty at 1RE08, a maximum, actual PDA of about 55% is estimated for EOC-9.

Pulled tube data from the 1995 inspection shows that circ cracking of max depth 55%, PDA 31% was readily detected using both the 115 mil pancake coil and +Pt coils. Circ cracking of max depth 41%, PDA 19% was not detected in the field using the 115 mil pancake coil. Ligament corrected PDA for the detected flaw is 15.3%. Ligament corrected PDA for the non-detected is not available. Therefore, use of a PDA detection threshold of 20% is reasonable.

As the limiting circumferential flaw at the expansion transition was in situ leak and proof tested with no evidence of leakage or burst, and more limiting indications have been leak tested in the past with no evidence of leakage, circumferential ODSCC at the TTS is not expected to contribute to SLB conditions leakage at EOC-9.

Axial PWSCC at the TTS

By far, the largest, and only axial PWSCC flaw with a leakage potential was R46 C49, SG B. The following table presents the growth data for Cycle 8.

As no flaws with length approaching the freespan 100% TW flaw length of 0.49" were reported at 1RE08, a consistent result is expected following the Cycle 9 period. Assuming an undetected flaw length equal to the coil field, approximately 0.12", a maximum flaw length of 0.31" would be expected at 1RE09, and therefore, structural integrity would not be challenged. Pulled tube destructive exam data for axial PWSCC at the TTS has consistently shown the NDE to overestimate the flaw length. Therefore, no axial PWSCC flaws at the TTS are expected to approach the 100% TW axial flaw critical length of 0.49".

STP Unit 1 Axial PWSCC at TTS Growth Rates: 115 mil pancake coil						
	1RE08			1RE07 (Lookback Analysis)		
	Length	Max Depth	Max Volts	Length	Max Depth	Max Volts
R46 C49	0.34"	100%	3.58	0.17"	20% (1)	0.60
R36 C53	0.19"	100%	0.71	0.15"	40%	0.40
R28 C52	0.25"	80% (1)	1.18	NDD	NDD	NDD
Growth	Length		Max Depth		Max Volts	
R46 C49	0.17"		80%		2.98	
R38 C53	0.04"		60%		0.31	
R28 C52	0.13" (2)		74% (3)		1.18	
(1): Depth at max volts. Best estimate of max depth is about 40% TW.						
(2): Length growth based on detection threshold equal to coil field of 0.12"						
(3): Depth growth based on detection threshold of 20%						

Axial PWSCC Within the Tubesheet in Wavy Tubes

The bobbin data for R14 C73, SG A was reviewed for 1RE07 and 1RE06. Bobbin parameters are provided in Table 9. This data shows the indication was present in 1RE06, and would also suggest that some measure of growth occurred since 1RE06. The voltages were measured using the max rate function, and therefore, may underestimate the voltage if measured on a peak to peak basis. The bobbin graphics show an increasing progression of expansion or opening of the lissajous figures, also suggesting that some growth occurred over this period. As with roll transition regions, the flaw length at roll overlap regions is expected to be limited based on the limited available stress field axial length. This is shown by the reported flaw lengths. At the TTS, the longest reported flaw was 0.34", whereas the flaw lengths for the 4 separate indications in R14 C73 at 7" below the TTS ranged from 0.37" to 0.48". Three of the four flaws were comparable to the flaw in R46 C49 in length, max depth, and max volts. As no reliably measurable leakage was reported in SG A, it can be concluded that only the largest flaw had any leakage potential at SLB conditions, and that only about 0.20" of this length is considered to potentially leak. As the bobbin data for R14 C73 indicates the flaw was present since 1RE06, the growth is considered in depth only.

Table 9
R14 C73 Axial PWSCC within tubesheet in wavy tube

Bobbin Data Parameter	1RE08 (max rate)	1RE07 (max rate)	1RE06 (max rate)
Mix Volts	7.80	6.81	5.82
Mix Depth	89%	84%	63%
550kHz Volts	7.08	5.42	6.27
550 kHz Depth	87%	79%	59%
130 kHz Volts	4.99	4.01	1.08
130 kHz Depth	50%	43%	29%

This data suggests that additional growth occurred during the period from the 1RE06 to the 1RE08 inspections. Based on bobbin data alone, it cannot be determined if the growth occurred in length, depth, or a combination of both.

Ding ODSCC

The bobbin data from 1RE07 were reviewed for the two ding ODSCC flaws that were in situ tested. Both indications would have been reported at 1RE07 had the new ding inspection technique been utilized at 1RE07. The 1RE07 low frequency differential (130 kHz) voltage and phase responses for these two indications were 0.97 volts, 107°, and 0.56 volts, 91°. Low frequency differential response for the first flaw at 1RE08 was 0.94 volts, 103°. The second flaw was called using the mix. The 1RE07 mix response was 1.28 volts, 160°, the 1RE08 mix response was 1.34 volts, 142°. As the 1RE07 data for these flaws indicates detectability (i.e., max depth > 50 to 60%) and the reported +Pt depths from 1RE08, a bounding estimate of max depth growth is ~30% TW/Cycle. Adjusted for the Cycle 9 length of 333 EFPD, a bounding estimate of max depth growth is approximately 19% TW.

The bobbin qualification program showed that the length of the ding flaws was bounded by 0.375". Therefore, ding flaw lengths are not expected to approach the freespan critical flaw length of 0.49".

Use of the new bobbin technique has been shown to provide an enhanced detection capability compared to previous inspections. Laboratory testing has shown the ding flaws to be limited in axial length due to the limited stress field in the axial direction.

5.2 Operational Assessment Conclusions

The condition monitoring analysis of the limiting 1RE08 indications has concluded that all flaws had burst capability exceeding the 3ΔP requirement, and maximum SLB condition primary to secondary leakage of 0.159 gpm in SG D was below the FSAR analyzed limit of 0.35 gpm for non-ARC mechanisms. As all pertinent operating parameters are expected to remain unchanged for Cycle 9, and considering the shortened Cycle 9 operating period of approximately 333 EFPD, it is expected that all structural and leakage integrity requirements will be met at EOC-9. This conclusion is further supplemented by the growth analysis of non-ARC mechanisms which suggest the degradation mechanisms observed for the recent inspections at STP Unit 1 do not indicate an increasing growth rate. Therefore, it is concluded that all structural and leakage integrity requirements are expected to be met at EOC-9.

6.0 Potential New Degradation Mechanism Assessment

During the STP 1RE08 inspection, a total of 9 SVI calls were reported at TSP intersections. At STP, a SVI call is a RPC indication that cannot be resolved as axial or circumferential in nature. SVI calls are typically accompanied by bobbin indications suggestive of degradation (NQI), and this bobbin signal triggers the RPC inspection. Of the 9 SVI calls mentioned above, 7 had corresponding bobbin NQI calls, 1 associated with a dent, and the remaining SVI (R40 C74 at 18C) had no corresponding bobbin indication in history. A bobbin DNI (distorted ding indication) was reported in this tube (R40 C74) at approximately 2" above the 18C plate. +PT inspection confirmed axial ODSCC at the DNI call (2" above the plate). For all of these NQI/SVI calls, the bobbin voltage exceeded the +Pt voltage. The range of bobbin to +Pt voltage ratios was 1.0 to 6.7 with an average ratio of 2.74, and is typical of axial ODSCC at TSP intersections. The average and maximum bobbin mix channel amplitudes of these NQI/SVI calls was 0.55 volts, and 0.80 volts, respectively. The maximum +Pt voltage for these indications was 0.69 volts. These maximums both occurred in R1 C14, SG B, at 14C -0.37".

The bobbin data for all other (not at TSPs) SVI calls were reviewed to determine coincidence of NQI, DNI, DNG, or DNT calls. For those with corresponding NQI calls, the bobbin amplitude exceeded the +Pt voltage, with the maximum bobbin amplitude for the mix channel estimated to be 2.61 volts based on a reported 130 kHz differential voltage of 0.81. The corresponding +Pt amplitude for the 2.61 volt (estimated) NQI was 0.27 volts, while the maximum +Pt amplitude of 1.02 volts was associated with a NQI amplitude of 1.15 volts by bobbin in the mix channel. The range of bobbin to +Pt amplitude ratios was 1.1 to 9.6 with an average of 3.48. The average bobbin amplitude (mix channel) for these SVI/NQI calls (not at TSPs) was 1.09 volts. The average +Pt voltage was 0.41 volts. In general, these SVI/NQI indications not at TSP intersections had similar bobbin to +Pt amplitude ratios, but had slightly larger individual channel amplitudes.

Several +Pt SVI calls were associated with dings or dents. The maximum +Pt amplitude for these indications was 0.28 volts, while the ratio of bobbin (mix) to +Pt amplitudes ranged from 9.39 to 29.82 with an average of 16.84. Based on data developed during the bobbin qualification for dings, the minimum +Pt voltage reported for detected axial ODSCC was about 0.6 volts. Therefore, it can be inferred from this data that if the SVI calls represent true degradation, this degradation poses no challenge to structural or leakage integrity, and such indications would not be expected to contribute to primary to secondary leakage during SLB conditions. For the SVIs at TSPs and in the freespan which were associated with dings or dents, no DNI call was made, suggesting that if ODSCC were present, it was below the detection threshold. One of these had a bobbin amplitude > 5 volts and was inspected as part of the ding ODSCC program. The others, as well as R40 C74 SG C, which had no associated bobbin call, were inspected during the traverse of the +Pt probe from a known structure to a freespan indication to be inspected.

The bobbin/+Pt voltage relationship was also investigated for VOL calls. VOL calls at STP are typically MBMs (which exist in the baseline) or AVB or baffle wear indications that were RPC inspected at one point in time and therefore included in the STP indication database. The +Pt voltage of these indications was generally much larger than the SVI calls. Bobbin voltages were also much larger. With MBMs, shallow (< 5% TW) OD surface abrasions may be developed during removal of surface defects. The dissimilarity of +Pt and bobbin voltages between SVI/NQI and VOL/MBM indications suggest that the SVI calls are not representative of MBMs, volumetric wall loss which may be associated with MBMs, or true volumetric wall loss, such as thinning or wear.

Finally, the majority of the SVI calls at TSPs were reported at cold leg intersections. The axial ODSCC at TSP intersections at STP is almost entirely confined to the lower hot leg TSP intersections. If these SVI/NQI indications are early indications of a new damage mechanism, such as IGA or cellular corrosion, which are driven by chemistry and temperature conditions, the incidence would be expected to be predominantly restricted to the lower hot leg TSPs.

In conclusion, if these SVI/NQI indications at TSP intersections are representative of true degradation, they may be closely spaced patches of axial ODSCC with no associated structural or leakage integrity implications. Alternatively, these indications may be associated with low level (<0.75 volt by bobbin) dings/dents or possibly attributed to sludge/scale accumulation or non-invasive, particulate type foreign material. As the true nature of these signals cannot be determined, they are not included in the EOC projections as part of the voltage based repair criteria for axial ODSCC at TSP intersections per GL 95-05. Based on the observations provided above, it is unlikely that these SVI/NQI signals at TSP intersections represent a new damage mechanism.

STP Unit 1;
1RE08
inspection
SVI / NQI Data Analysis
(values in italic are the SVIs at TSPs)

SG D

		+Pt				Bobbin		Bobbin/+Pt Amplitude Ratio
Row	Col	Call	Volts	Elev.	Call	Volts	Channel	(Mix channel basis)
2	*46*	*SVI*	*0.38*	*14C -0.3*	*NQI*	*0.69*	*P1(Mix)*	*1.82*
7	*49*	*SVI*	*0.15*	*14C -0.37*	*NQI*	*0.65*	*P1*	*4.33*
18	84	SVI	0.2	2H +8.41	DNG	2.25	P1	11.3

SG C

		+Pt			Bobbin			
Row	Col	Call	Volts		Call	Volts	Channel	
37	*43*	*SVI*	*0.28*	*14C +0.33*	*DNT*	*2.63*	*P1*	*9.39*
39	88	SVI	0.17	17C +1.57	DNG	5.07	P1	29.82
40	*74*	*SVI*	*0.27*	*18C +0.47*	*NO DATA*			
47	75	SVI	0.27	22C +1.13	NQI	0.87	5 (130kHz Diff)	9.67

SG B

		+Pt			Bobbin			
Row	Col	Call	Volts		Call	Volts	Channel	
1	*14*	*SVI*	*0.69*	*14C -0.37*	*NQI*	*0.8*	*P1*	*1.16*
2	21	SVI	0.15	15C +42.07	NQI	0.22	5	4.4
16	65	SVI	0.12	6H +40.85	NQI	0.18	5	4.5
28	29	SVI	0.71	12C +3.7	NQI	0.39	5	1.65
35	28	SVI	1.02	17C +14.41	NQI	0.35	5	1.03
36	22	SVI	0.34	15C +10.52	NQI	0.26	5	2.29
38	24	SVI	0.37	6H +23.03	NQI	0.51	5	4.14
38	44	SVI	0.43	5H +6.07	NQI	0.37	5	2.58

SG A

		+Pt			Bobbin			
Row	Col	Call	Volts		Call	Volts	Channel	
3	*29*	*SVI*	*0.1*	*14C -0.3*	*NQI*	*0.67*	*P1*	*6.7*
10	39	SVI	0.29	16C+34.42	NQI	0.32	P1	1.1
48	*42*	*SVI*	*0.38*	*7H +0.29*	*NQI*	*0.52*	*P1*	*1.37*
48	*47*	*SVI*	*0.2*	*7H +0.35*	*NQI*	*0.38*	*P1*	*1.9*
48	*78*	*SVI*	*0.16*	*8H -0.33*	*NQI*	*0.45*	*P1*	*2.81*

SVIs Reported at TSP Edge from Field Service Report

Row	Col	Call	+Pt Volts	Elev.	Call	Bobbin Volts	Channel
SG D							
2	46	SVI	0.38	14C -0.3	NQI	0.69	P1
7	49	SVI	0.15	14C -0.37	NQI	0.65	P1
SG C							
37	43	SVI	0.28	14C +0.33	DNT	2.63	P1
40	74	SVI	0.27	18C +0.47	NO DATA		
SG B							
1	14	SVI	0.69	14C -0.37	NQI	0.8	P1
SG A							
3	29	SVI	0.1	14C -0.3	NQI	0.67	P1
48	42	SVI	0.38	7H +0.29	NQI	0.52	P1
48	47	SVI	0.2	7H +0.35	NQI	0.38	P1
48	78	SVI	0.16	8H -0.33	NQI	0.45	P1

Table 8

1RE08 Circumferential Flaw Growth Data

115 pancake coil data

Tube	1RE08 Arc Length (2)	1RE07 Arc Length (2)	Arc Length Growth	Max Volts 1RE08	Max Volts 1RE07	Max Volts Growth	PDA 1RE08 (2)	PDA 1RE07 (2)	PDA Growth (2)	Max Depth 1RE08 (2)	Max Depth 1RE07 (2)	Max Depth Growth (2)
R26 C57 SGC	122° (3)	80°	42°	0.28	0.25	0.03	10.7%	13.7%	-3%	80%	99%	-19%
R23 C73 SGC	55°	25°	30°	0.34	0.21	0.13	6.4%	0%	6.4%	60%	5%	55%
R22 C77 SGC	136°	43° 26°	37° (4)	0.44	0.25	0.19	9.1%	5.7%	3.4%	55%	56%	-1%
R22 C45 SGC	60°	31°	29°	0.33	0.10	0.23	6%	2%	4%	56%	45%	11%
R48 C79 SGD	195°	223°	-28°	0.17	0.45	-0.28	29.4%	23.2%	6.2%	81%	62%	19%
			Avg. 22°						Avg. 3.4%			Avg. 13%

+Pt coil data vs 115 pancake coil data from circumferential depth profile analysis

	Arc Length 1RE08: +Pt	Arc Length 1RE08: 115 pc	PDA 1RE08: +Pt	PDA 1RE08: 115 pc	PDA 1RE07: 115 pc	PDA Growth +Pt – 1RE07 115 pc	Max Depth 1RE08: +Pt	Max Depth 1RE08: 115 pc	Max Depth 1RE07: 115 pc	Max Depth Growth +Pt – 1RE07 115 pc
R26 C57 SGC	258°	122°	51%	10.7%	13.7%	37.3%	99%	80%	99%	0%
R26 C57 OD phase portion	148°	122°	35%	10.7%	13.7%	21.3%	99%	80%	99%	
R23 C73 SGC	246°	55°	24%	6.4%	0%	24%	64%	60%	5%	59%
R22 C77 SGC	<120° (3 segments)	136°	<5%	9.1%	6%	0%	45%	55%	56%	-11%
R22 C45 SGC	47°	60°	9.4%	6%	2%	7.4%	100%	56%	45%	55%
R48 C79 SGD	199°	195°	14%	29.4%	23.2%	-9%	43%	81%	62%	-19%
						Avg 12%				Avg 17%

(1): From phase analysis of production RPC data

(2): From circumferential direction depth profile

(3): Flaw represented by two segments of 64° and 26°, separated by a 32° non-degraded length to form a total length of 64 + 32 + 26 = 122°

(4): Reported growth considers non-degraded section between 43° and 26° segments in 1RE07 data

Table 7
STP 1RE08 In Situ Testing Summary

Tube	SG	Degradation Mode	Location	Flaw Length	Max Depth	+Pt Volts	Leak Test Pressure	Proof Test Pressure	Leakage	Burst
R42 C68	C	Circ ODSCC	11C –14.2"	49°	99%	0.18	2925	5000	No	No
R37 C55	C	Circ ODSCC	11C –6.5"	117°	100%	0.19	2925	5000	No	No
R26 C57	C	Circ ODSCC	HL TTS	258°	99%	0.26 (VI)	2925	4315	No	No
R40 C74	C	Axial ODSCC	18C +2.2"	0.59"	100%	0.64	2841	4150	No	No
R37 C43	C	Axial ODSCC	14C +1.38"	0.38"	84%	0.79	2841	N/A	No	N/A
R43 C42	D	Circ ODSCC	11C –2.1"	114°	100%	0.53	2925	5000	No	No
R32 C39	D	Axial ODSCC	14C –8.5"	0.41"	89%	0.56	2841	N/A	No	N/A
R22 C15	D	Axial ODSCC	15C +22.3"	0.38"	94%	0.25	2841	N/A	No	N/A

VI: Voltage Integral analysis using Eddynet software

Figure 1

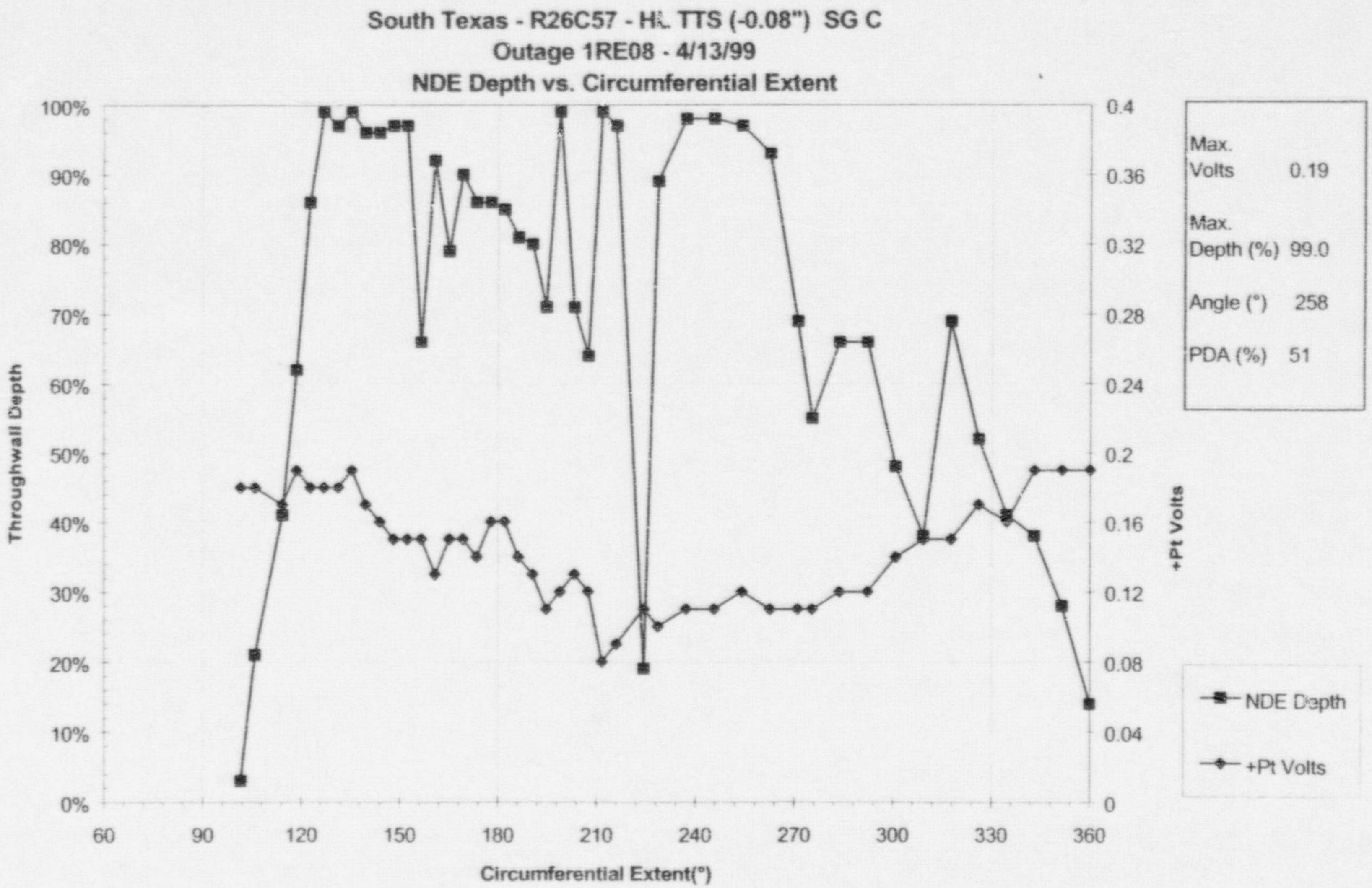

South Texas - R26C57 - HL TTS (-0.08") SG C
Outage 1RE08 - 4/13/99
NDE Depth vs. Circumferential Extent
Throughwall Depth
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
60
90
120
150
180
210
240
270
300
330
360
Circumferential Extent(°)
0.4
0.36
0.32
0.28
0.24
0.2
0.16
0.12
0.08
0.04
0
+Pt Volts
Max. Volts 0.19
Max. Depth (%) 99.0
Angle (°) 258
PDA (%) 51
NDE Depth
+Pt Volts

Figure 2

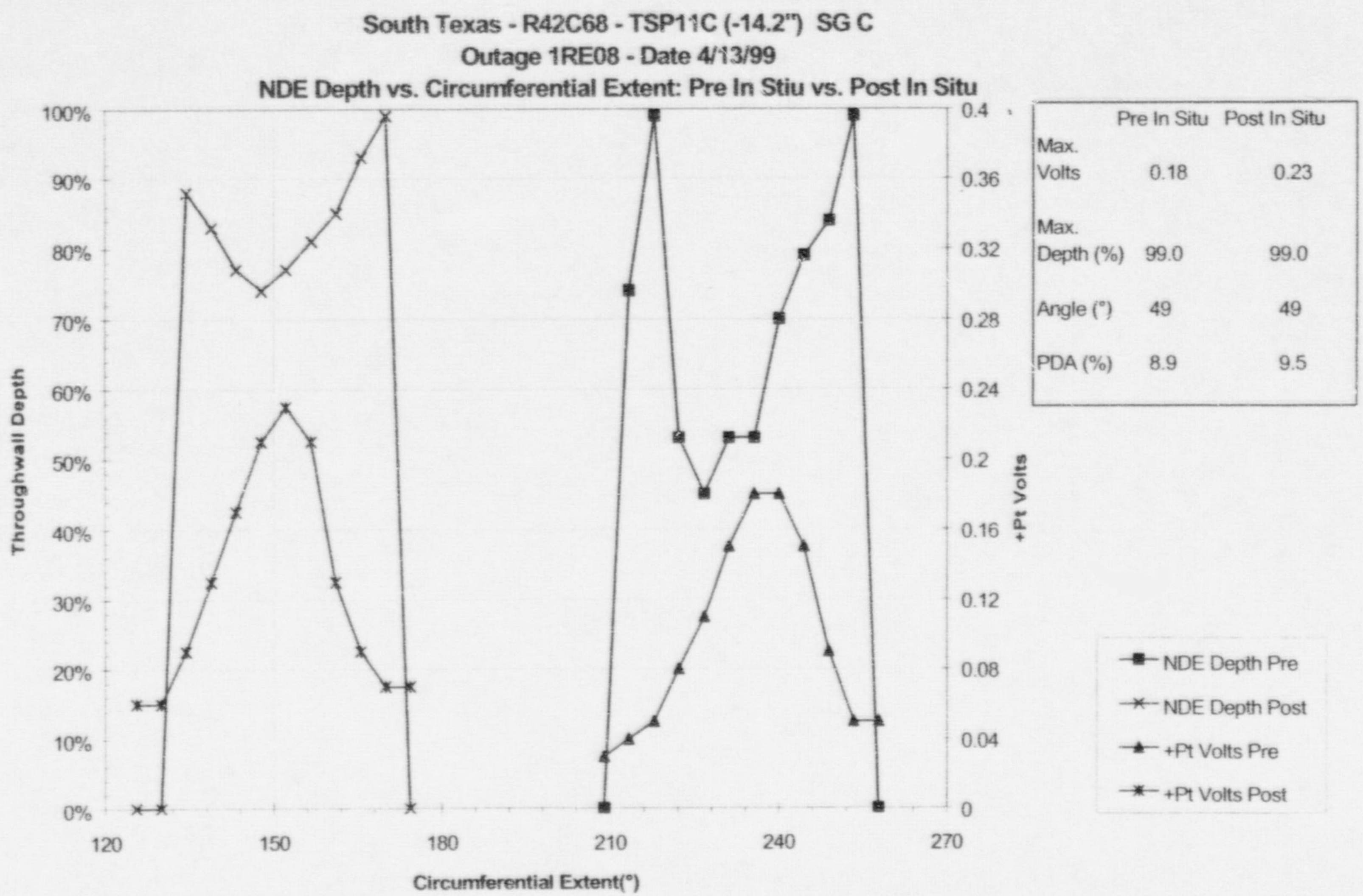

South Texas - R42C68 - TSP11C (-14.2") SG C
Outage 1RE08 - Date 4/13/99
NDE Depth vs. Circumferential Extent: Pre In Stiu vs. Post In Situ
Throughwall Depth
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
120
150
180
210
240
270
Circumferential Extent(°)
+Pt Volts
0.4
0.36
0.32
0.28
0.24
0.2
0.16
0.12
0.08
0.04
0
Pre In Situ
Post In Situ
Max. Volts 0.18 0.23
Max. Depth (%) 99.0 99.0
Angle (°) 49 49
PDA (%) 8.9 9.5
NDE Depth Pre
NDE Depth Post
+Pt Volts Pre
+Pt Volts Post

Figure 3

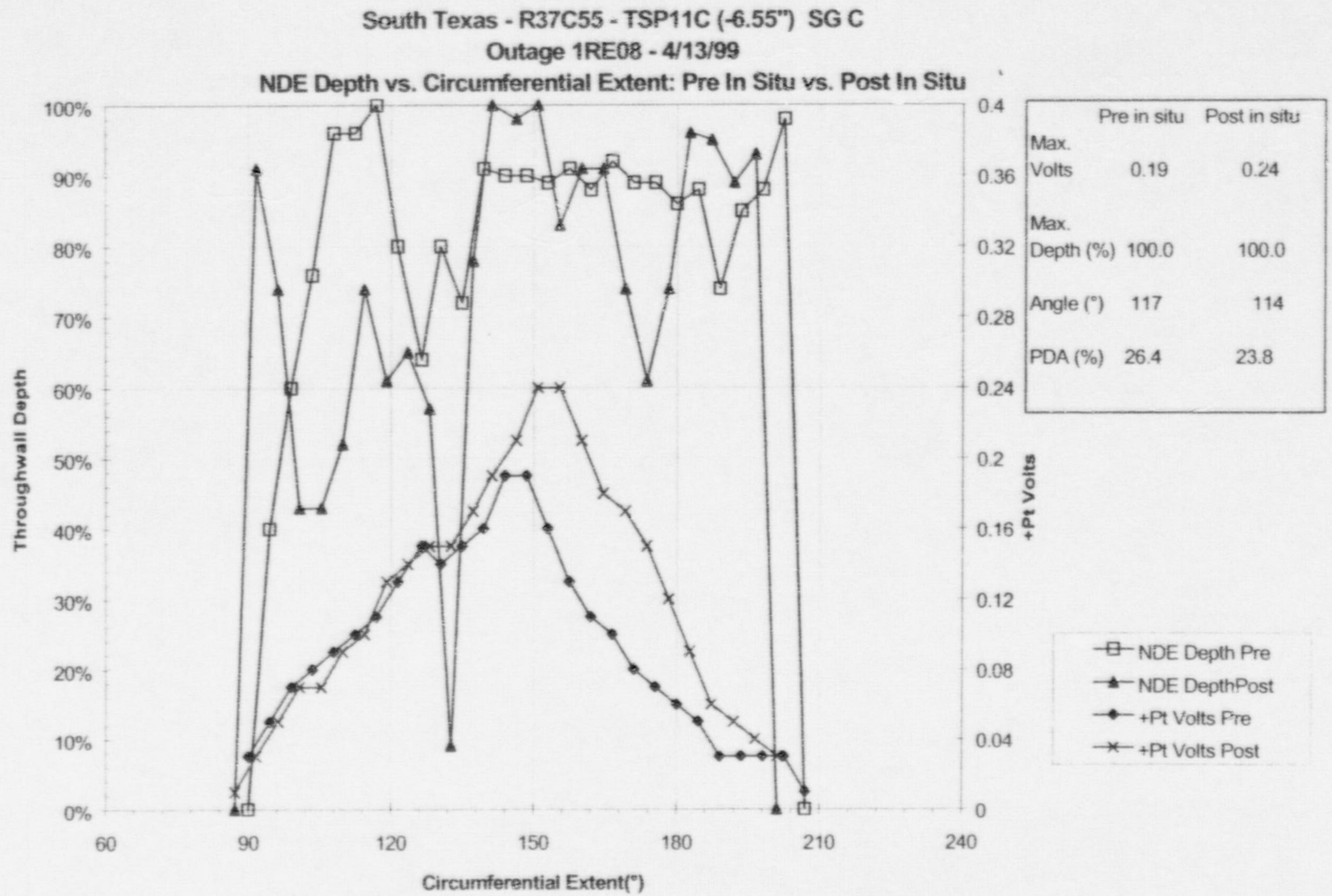
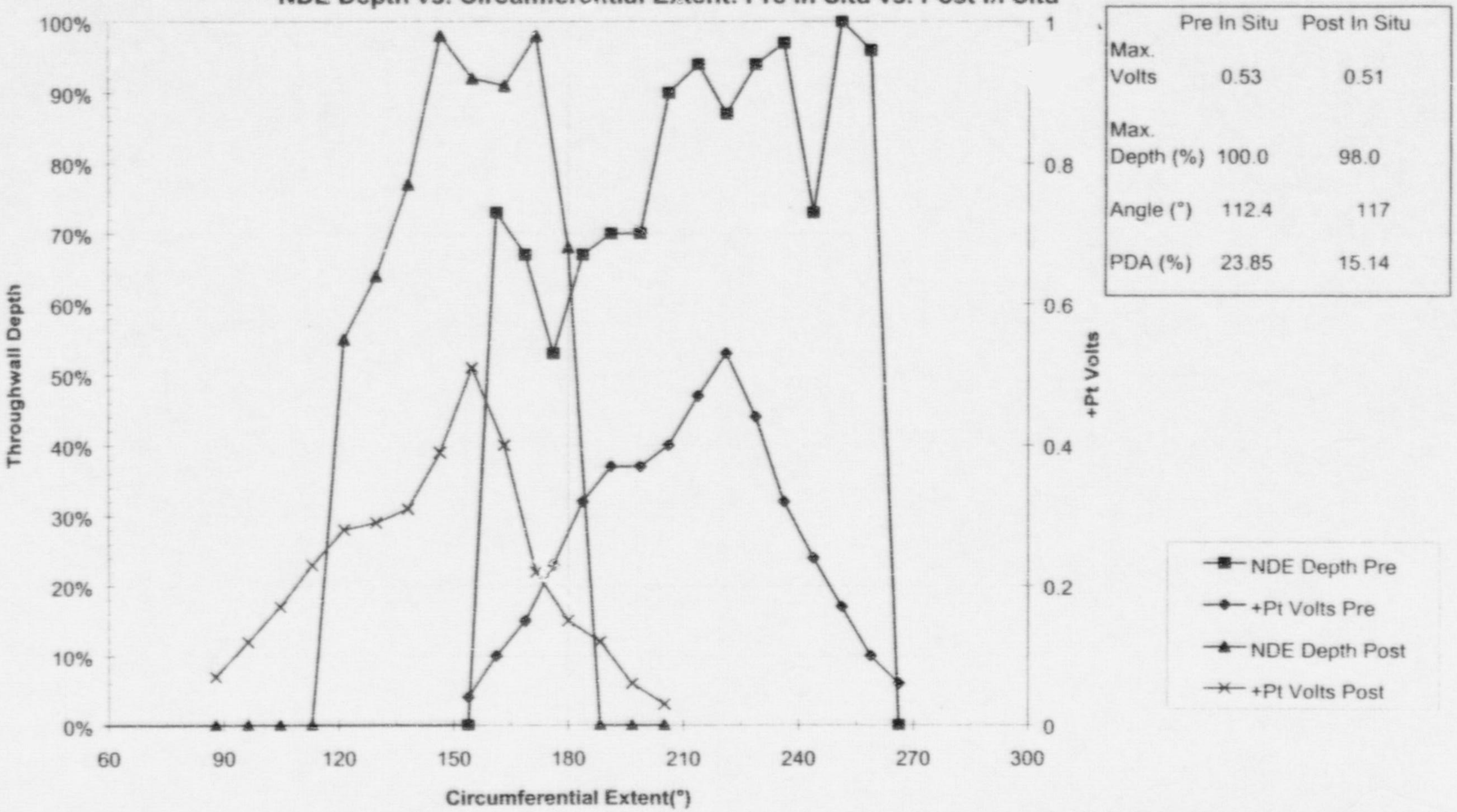

South Texas - R37C55 - TSP11C (-6.55") SG C
Outage 1RE08 - 4/13/99
NDE Depth vs. Circumferential Extent: Pre In Situ vs. Post In Situ
Throughwall Depth
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
60
90
120
150
180
210
240
Circumferential Extent(°)
+Pt Volts
0.4
0.36
0.32
0.28
0.24
0.2
0.16
0.12
0.08
0.04
0
Pre in situ
Post in situ
Max. Volts
0.19
0.24
Max. Depth (%)
100.0
100.0
Angle (°)
117
114
PDA (%)
26.4
23.8
NDE Depth Pre
NDE DepthPost
+Pt Volts Pre
+Pt Volts Post

Figure 4

South Texas - R43C42 - TSP11C (-2.32") SG D
Outage 1RE08 - 4/13/99
NDE Depth vs. Circumferential Extent: Pre In Situ vs. Post In Situ



	Pre In Situ	Post In Situ
Max. Volts	0.53	0.51
Max. Depth (%)	100.0	98.0
Angle (°)	112.4	117
PDA (%)	23.85	15.14

Figure 5

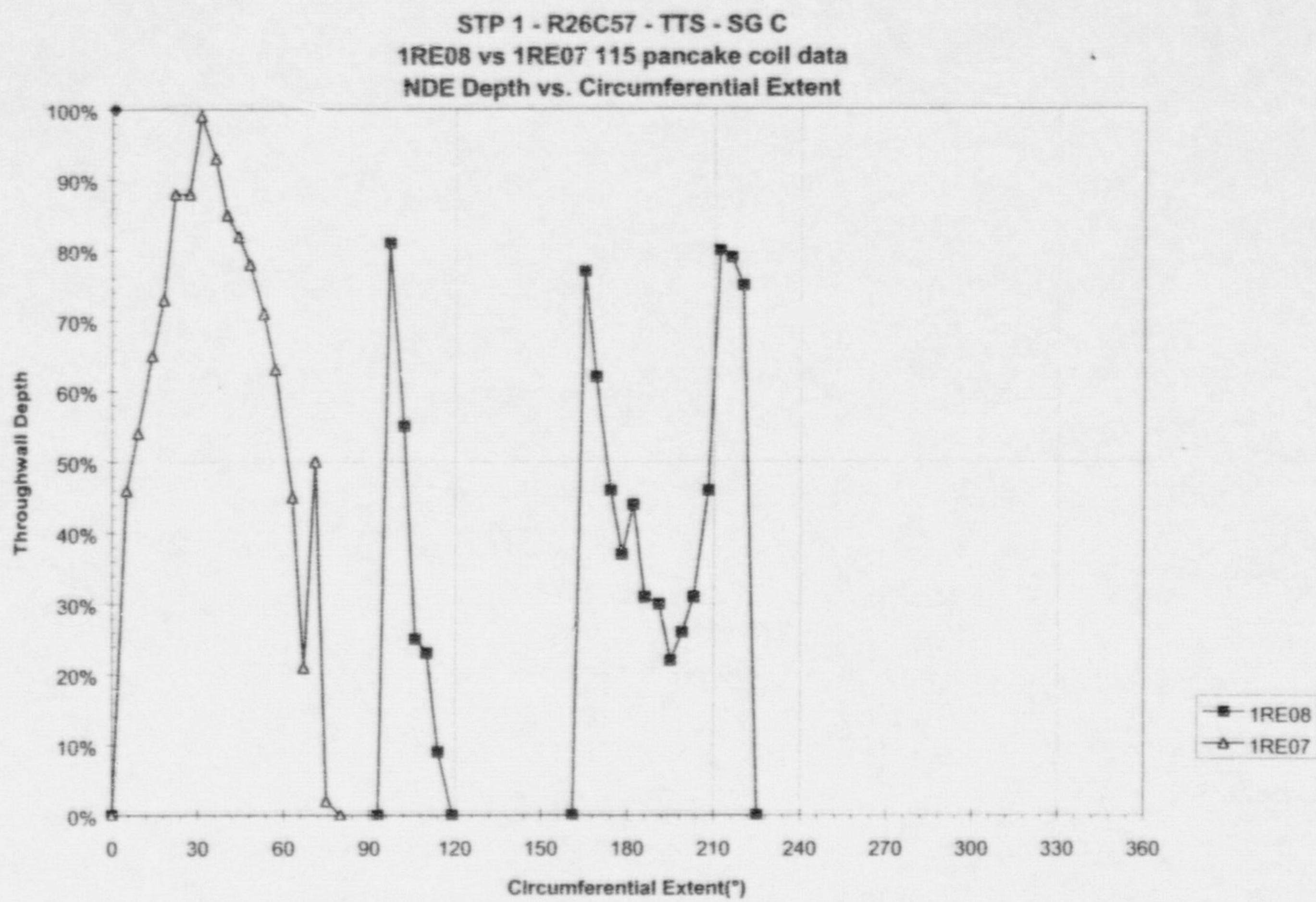

STP 1 - R26C57 - TTS - SG C
1RE08 vs 1RE07 115 pancake coil data
NDE Depth vs. Circumferential Extent
Throughwall Depth
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
30
60
90
120
150
180
210
240
270
300
330
360
Circumferential Extent(°)
1RE08
1RE07

Figure 6

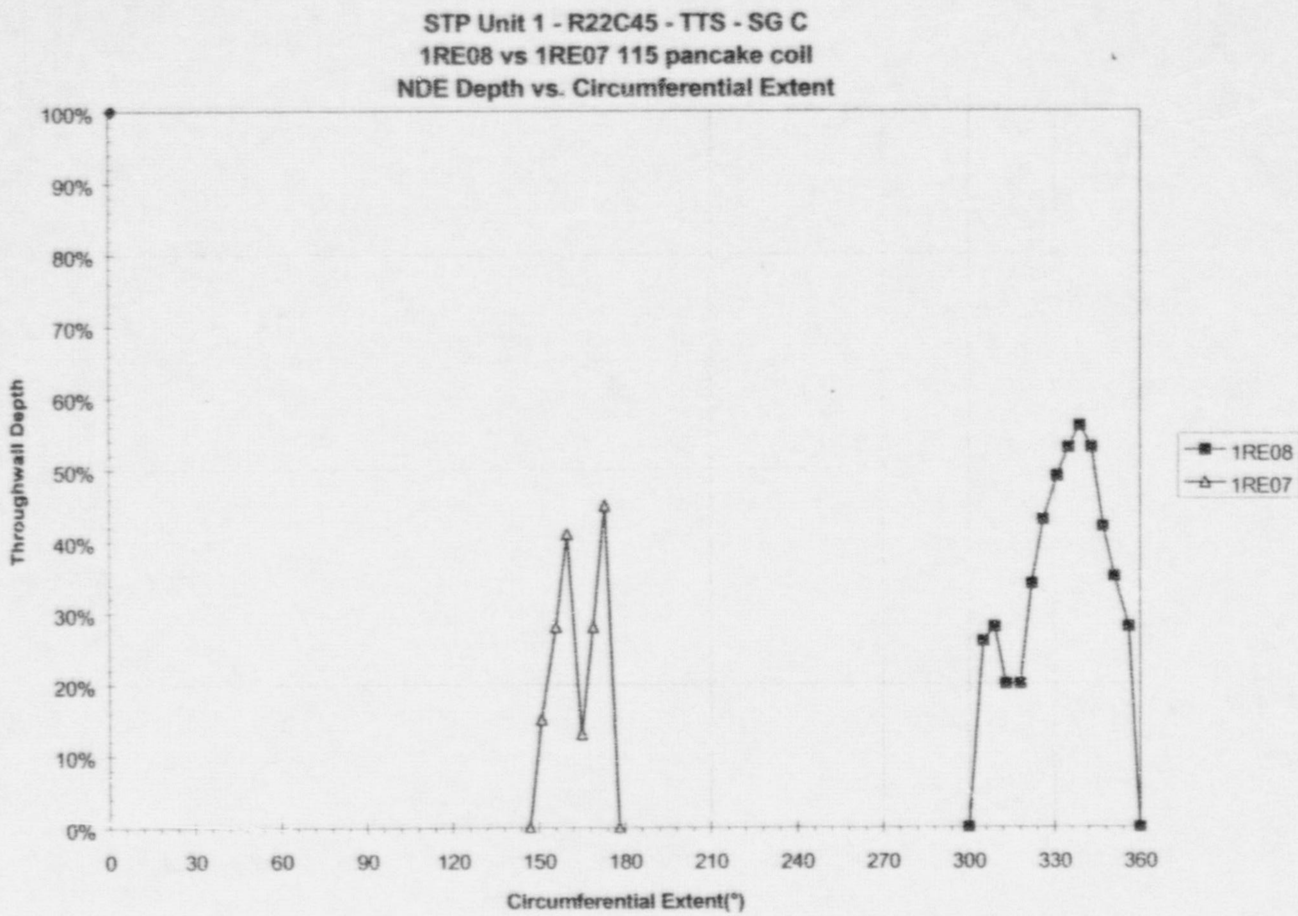

STP Unit 1 - R22C45 - TTS - SG C
1RE08 vs 1RE07 115 pancake coil
NDE Depth vs. Circumferential Extent
Throughwall Depth
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
30
60
90
120
150
180
210
240
270
300
330
360
Circumferential Extent(°)
1RE08
1RE07

Figure 7

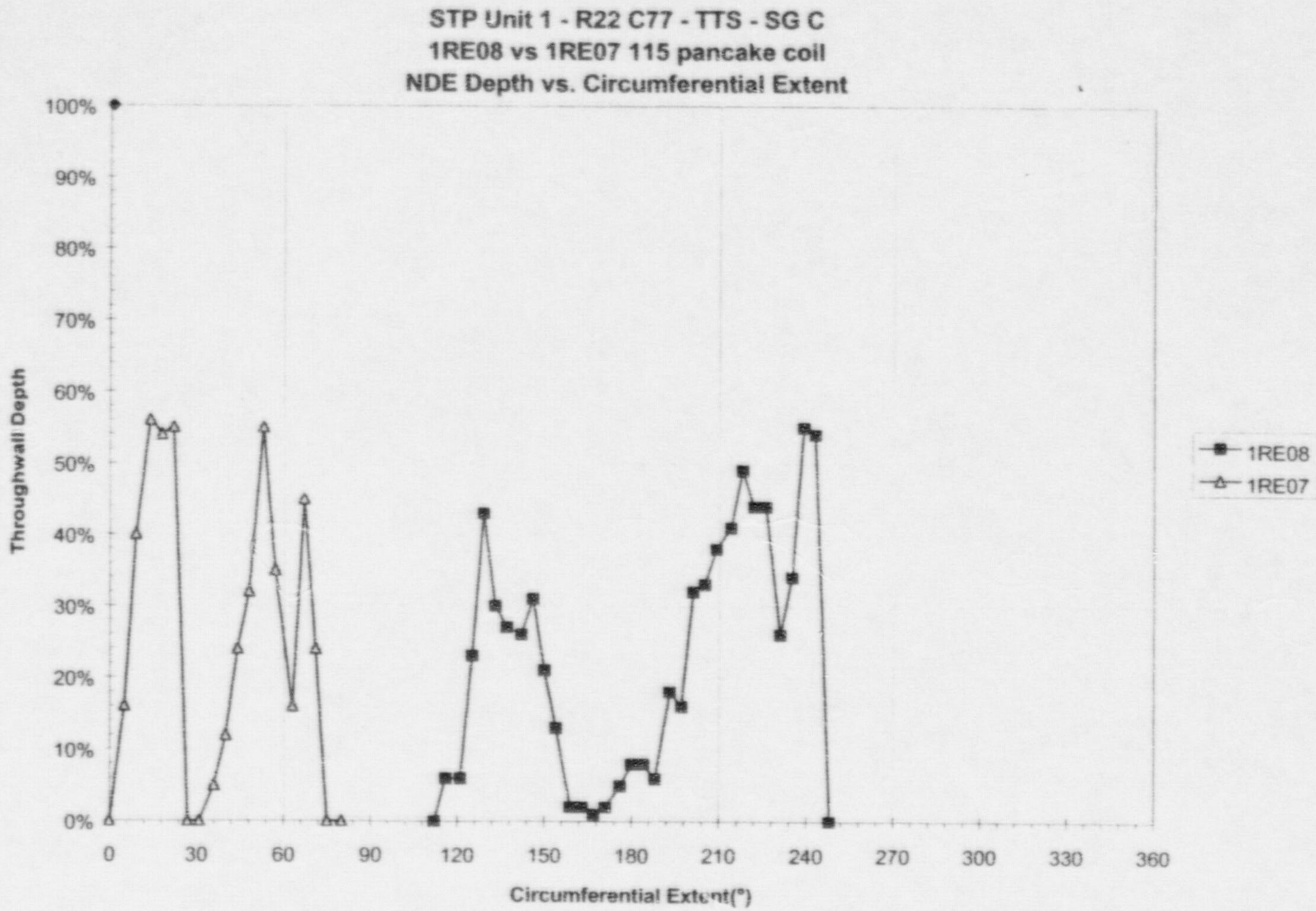

STP Unit 1 - R22 C77 - TTS - SG C
1RE08 vs 1RE07 115 pancake coil
NDE Depth vs. Circumferential Extent
Throughwall Depth
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
30
60
90
120
150
180
210
240
270
300
330
360
Circumferential Extent(°)
1RE08
1RE07

Figure 8

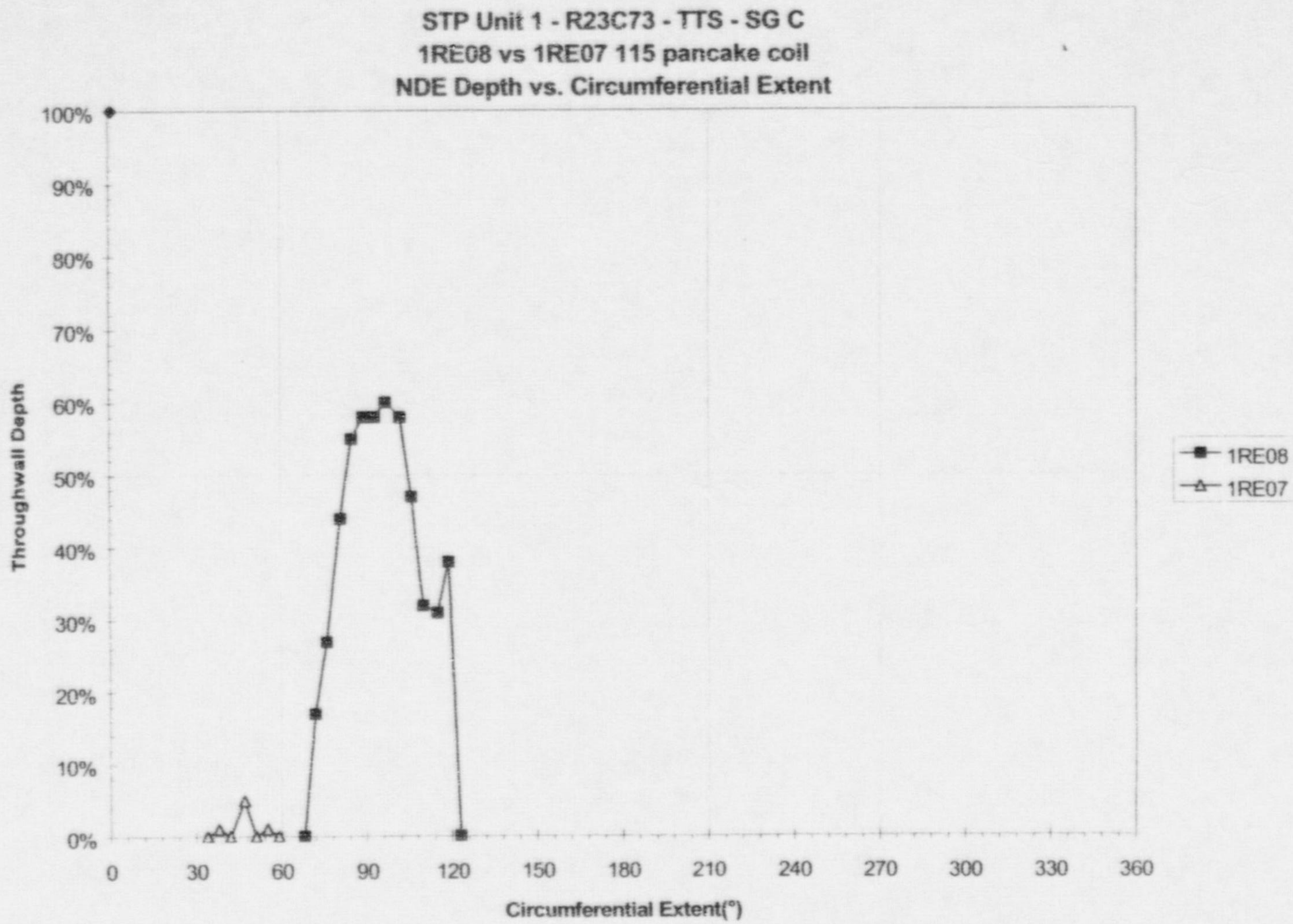
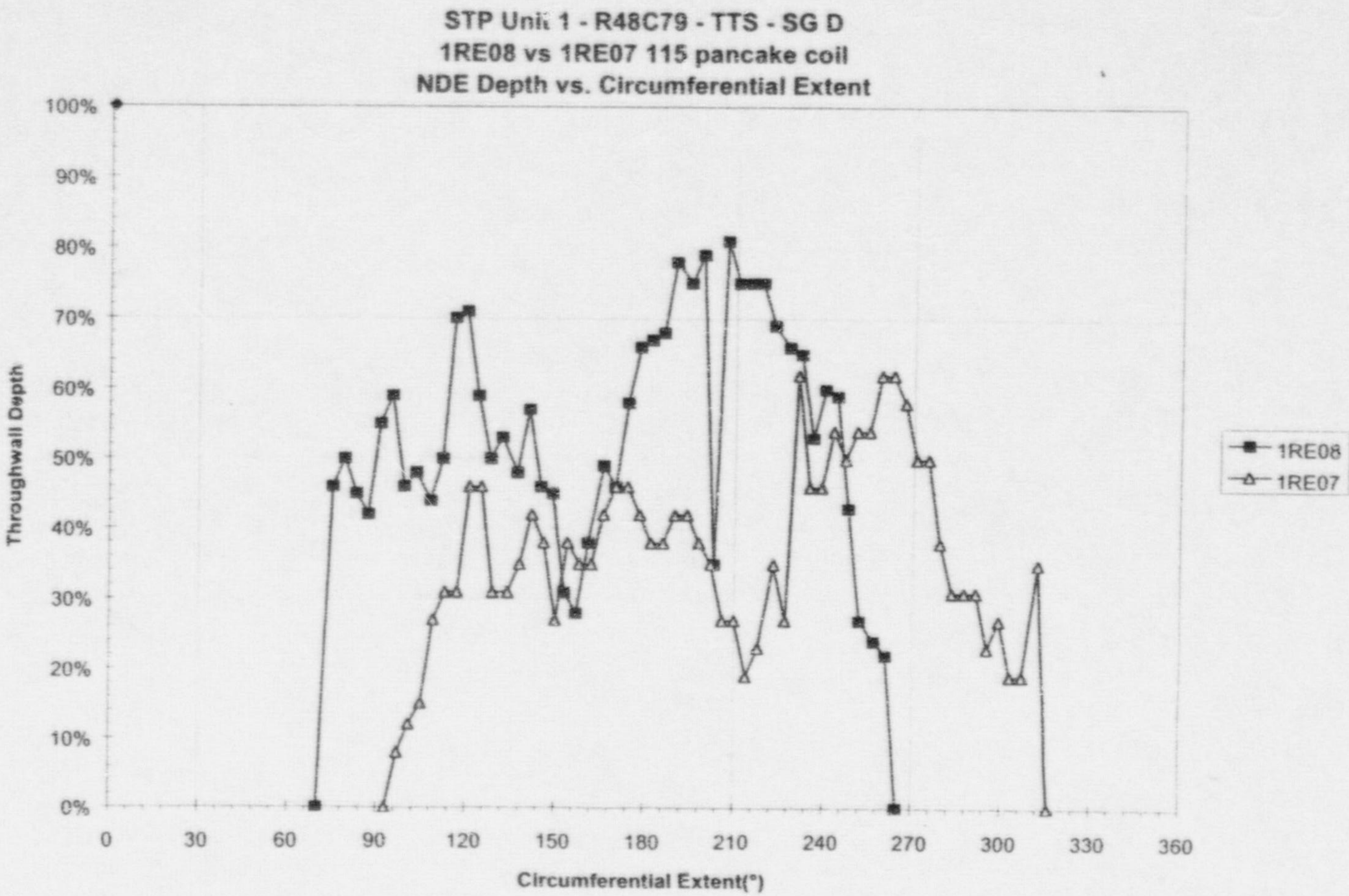

STP Unit 1 - R23C73 - TTS - SG C
1RE08 vs 1RE07 115 pancake coil
NDE Depth vs. Circumferential Extent
Throughwall Depth
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
30
60
90
120
150
180
210
240
270
300
330
360
Circumferential Extent(°)
1RE08
1RE07

Figure 9


STP Unit 1 - R48C79 - TTS - SG D
1RE08 vs 1RE07 115 pancake coil
NDE Depth vs. Circumferential Extent
Throughwall Depth
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
30
60
90
120
150
180
210
240
270
300
330
360
Circumferential Extent(°)
1RE08
1RE07