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U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

South Texas Project
Unit 2
Docket No. STN 50-499
2RE08 Steam Generator Condition Monitoring Report

The subject report attached to this letter satisfies the reporting requirements of NEI 97-06, Rev. 1, Section 3.1.7 for a steam generator with greater than 1% of the inspected tubes exceeding the repair criteria. If there are any questions regarding this report, please contact Mr. Ron Baker at (361) 972-8961 or me at (361) 972-7181.

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jtc

Attachment: Westinghouse Report SG-01-07-002, "South Texas Project Unit 2 2RE08 Refueling Outage Condition Monitoring"

A001

STI: 31326000

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South Texas Project Unit 2
2RE08 Refueling Outage

Condition Monitoring

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South Texas Project 2RE08
Condition Monitoring Assessment

1.0 INTRODUCTION

NEI 97-06 (Reference 1) , requires that a condition monitoring assessment that evaluates structural and leakage integrity characteristics of SG eddy current indications be performed following each inspection. This evaluation provides an assessment of the South Texas Project Unit 2 steam generator tube structural and leakage integrity based on the 2001 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 consistent with RG 1.121.

This report documents the condition monitoring assessment of the NDE results from the South Texas Project 2RE08 refueling outage and inspection, performed in March 2001.

SG Design Information

The South Texas Project Unit 2 SGs are Westinghouse Model E2 SGs that utilize mill annealed Alloy 600 tubing, full depth hydraulically expanded tube to tubesheet joints, and stainless steel tube support plates with drilled tube holes and drilled flow holes.

Applicable Alternate Repair Criteria

One volt TSP ODSCC ARC, in accordance with Reference 2, were licensed for application at STP-2 in 1998. Application of a 3-volt ARC at hot leg TSPs C, F and J (the first three TSPs above the flow distribution baffle) in conjunction with expansion of 16 tubes at each of these TSPs to "lock" them was approved by the NRC on March 8, 2001 and the new Technical Specifications became effective at that time. The inspection planning for STP has been consistent with the requirements of References 1 and 2.

2RE07 Inspection Summary

Indications suggestive of the following degradation mechanisms were detected in the South Texas Project 2RE07 inspection:

- Axial ODSCC at TSP intersections
- Axial ODSCC at hot leg and cold leg freespan dings
- Freespan Volumetric indications
- AVB wear
- Wear at non-expanded preheater baffle intersections

The evaluation for axial ODSCC at TSP intersections is documented in Reference 3. Axial ODSCC was observed at freespan dings and was judged to be bounded in severity by previously reported ding indications, and may be attributed to the increased inspection capabilities employed at the 2RE06 inspection. The observed freespan volumetric indications were attributed to non-cracking mechanisms, most probably MBMs without historical record. A small number of tubes with AVB wear was observed. The maximum tube wear depth reported at non-expanded preheater baffles was 9% TW in SG C. A total of 187 tubes was repaired by plugging. Details of the 2RE07 inspection are contained in Reference 4.

Cycle 8 Operating Leakage

Prior to August 2000, the plant was operating with a constant operational leakage of about 1 GPD. Since early August 2000, STP Unit 2 has experienced an increase in operating leakage, initially observed in SG C, but over a period of time, also observed in the other three SGs. At the start of the 2RE08 outage, the total operational leakage from all four SGs was approximately 35 GPD. It was judged that the most probable cause of the leakage was from ODSCC at the TSPs; an active degradation mechanism at STP-2.

2.0 Summary and Conclusions

2.1 Inspection and Testing

2.1.1 Inspection Scope

The inspections performed during 2RE08 met the performance requirements of NEI 97-06, Rev. 1(Reference 1) and the EPRI PWR SG Inspection Guidelines, Rev 5 (Reference 10).

A pre-outage noise evaluation was performed that showed the limiting noise that could mask a structurally significant flaw in the U-bend was 0.44 volts and at the TTS, 0.36 V vertical maximum. Based on this, criteria for data quality were established for the inspection and retest were performed as necessary..

The inspection scope was expanded to include +Point testing of DSIs between 1.0 and 1.5 volts, and a sample of DSIs between 0.6 and 1 volt, at the hot leg of TSPs 2H, 3H and 4H, the locations where the 3V ARC are licensed. All of the Row 2 tubes in SG-D were inspected with +point as a result of finding an axial indication in a row 1 U-bend in this SG. The scope for +Point examination of "paired dings" was expanded due to observing circumferentially oriented ODSCC at a freespan ding.

Ultrasonic testing was performed on 4 tubes that exhibited the largest TSP ODSCC signals in SG-D to confirm the morphology of the indications. In addition, an indication above the lowest preheater baffle plate was examined by UT and it was determined that the indication was most likely due to prior impingement by a foreign object that was no longer at that location.

2.1.2 In Situ Testing

In situ leak and proof tests were performed on 12 tubes, consistent with industry guidance for selection and testing of candidate tubes. Only 2 of the 12 tubes were required to be tested based on the industry in-situ screening criteria (Reference 6). The 2 required in-situ tests addressed freespan ODSCC axial indications in R39C16-SG-A, and R10C64 in SG-C. Indications of previously unobserved degradation mechanisms, e.g., circumferential ODSCC at the TTS, axial ODSCC at the R1 U-bend apex, and circumferential and axial ODSCC in a paired ding, were tested. Six of the highest voltage TSP ODSCC indications were tested to confirm structural integrity for axial tearing and were tested with end cap loading to simulate axial cracks. A leak test was also performed for any tube that was proof tested, and for the large DSIs, leakage identified during a secondary side pressure test was confirmed.

All of the in situ test successfully demonstrated SLB burst capability of the indications. Leakage was observed from only the high voltage DSI indications tested. The leak rate data are consistent with the industry database supporting the TSP ODSCC ARC for correlation of leakage to bobbin voltage.

2.2 Condition Monitoring

Based on the results of the 2RE08 inspection, the STP-2 SGs currently meet all structural and leakage requirements for condition monitoring consistent with Reg. Guide 1.121 and the performance criteria of NEI 97-06, Rev. 1. Specific conclusions for each degradation mechanism observed during the inspection are provided in the following sections.

2.2.1 ODSCC at TSP

Based on the methods contained in GL 95-05, the limiting SLB leak rate calculated using the actual measured EOC-8 bobbin voltage distributions (5.7 gpm at room temperature for SG-D) is well below the allowable limit of 15.4 gpm. With credit taken for limited displacement of the lower 3 TSPs under the bounding deflection loading discussed in WCAP-15163, Rev. 1, Addendum 1 (Reference 14) during a SLB event, tube burst probabilities for all SGs based on the as found EOC-8 conditions are well below the NRC reporting guideline of 10^{-2}.

2.2.2 TTS Circumferential Cracking

The three largest indications, based on depth and PDA, were in situ leak and pressure tested without evidence of leakage and without burst at $3\Delta P_{NO}$. Since the other indications are bounded by the indications that were in situ tested, the requirements for condition monitoring are satisfied.

2.2.3 Freespan Cracking

A total of twenty-five (25) freespan axial cracks were found during this inspection. The most severe had a predicted ligament tearing pressure on order of 2000 psi. The indication was tested in situ and no leakage was found at a pressure of 2800 psi. In addition, the indication was proof tested to a pressure in excess of 4100 psi with not burst or tearing being evident. The second most severe indication was also tested with similar results. However, that indication had an estimated ligament tearing pressure in excess of 4300 psi which exceeds the maximum burst pressure criterion. Based on analysis and in situ testing results, all of the axial freespan indications were concluded to satisfy condition monitoring requirements.

2.2.4 U-bend ODSCC

A single OSCC indication was found at approximately the apex of a row 1 tube during the +Point inspection program for the low row U-bends. The indication is low voltage (0.3 V), that was also identified by the high frequency (HF) +Point probe, even though it is an OD indication. The flaw S/N ratio was 1.2 from the mid-range (MR) +Point, and between 0.5 and 0.8 for the HF +Point probe.

Based on sizing techniques developed for ODSCC (Reference 19), the flaw was sized at 0.14" long with average depth of 49% (71% maximum depth) using the 600kHz HF +Point data. For this size crack, a burst pressure of greater than 8000 psi would be expected. No leakage was found during the in-situ test of this flaw. Therefore, the U-bend axial ODSCC indication meets the structural and leakage requirements for Condition Monitoring.

There was one instance in which a tube was preventively plugged due to an incomplete test. The U-bend portion of the tube at R1C57 in SG 2D would pass the Plus Point probe, but not the motor unit. The U-bend portion of this tube was not tested in 2RE07, and in 2RE06, it appears to have been tested from the other leg. A single occurrence of this is not considered indicative of an hourglassing problem, especially when it is considered that the STP tube support plates are constructed from stainless steel. The tube may have always been tight, and might again have passed the probe had it been tested from the other leg.

2.2.5 Volumetric

Twenty-one tubes were reported with volumetric type indications. For the purpose of condition monitoring, volumetric indications are considered to include manufacturing burnish marks (MBM) and non-quantifiable indications (NQI). Twelve of the 21 indications reported were MBMs. MBMs are defined as acceptable as-built conditions that do not challenge structural integrity.

Four indications of TSP wear were reported. These are addressed in the following section.

Four of the remaining 5 indications were reported as NQI by bobbin, and were characterized by +point examination as single volumetric indications (SVI). The remaining indication was reported from the +point examination of expanded preheater TSP intersection as SVI. None of the SVI indications was in situ tested because the in situ selection criteria did not require it. The SVI reported from +point, but not from bobbin, was UT tested and found to have depth no greater than 8% TW. History review indicated that the four NQI reported by bobbin were also reported at 2RE07 and were essentially unchanged at 2RE08. All SVI indications were repaired by plugging.

All of the SVI indications were small indications with very low voltages. The indication that was sized by UT exhibited a 0.13 voltage (+Point). The largest +Point voltage of the SVIs was 0.2 volts. Based on a voltage ratio and the UT confirmed depth, the depth of the largest indication is estimated at approximately 12%. The NDE sizing uncertainty for the detection technique is 14.1%. Thus, the potential depth of the largest indication is approximately 26.1%. Compared to the uniform thinning structural limit of 62%, the volumetric indications do not challenge structural integrity.

2.2.6 AVB and TSP Wear

Seventy indications of AVB wear were reported, 55 of them previously reported indications. The maximum indication reported was 32%, less than the Technical Specification plugging limit of 40%. The applicable NDE sizing for AVB wear is 16.9% at the 95% confidence limit, based on the qualification database for the qualified technique. The structural limit for AVB wear is 77%TW. Since the maximum potential indication of AVB wear, 48.9%, is less than the structural limit, and no leakage will occur at this depth of wear, the requirements for Condition Monitoring are satisfied.

Four indications of wear at the preheater baffle plates (RWS) were reported. The maximum depth of these indications was 5% TW. The applicable NDE sizing for TSP wear is 14.1% at the 95% confidence limit based on the qualification database for the qualified technique. The structural limit for assumed uniform thinning of a tube is 62%. Since the maximum potential depth of wear at a TSP intersection is 19.1%, the requirements for condition monitoring are satisfied for this degradation mechanism.

3.0 STP 2RE08 Inspection Scope

During the South Texas Project 2RE07 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. No tubes were identified to contain eddy current indications that could potentially challenge the Reg. Guide 1.121 tube integrity recommendations. It was expected that all operational assessment structural and leakage integrity requirements would be satisfied at EOC-8 for the degradation mechanisms observed at EOC-7. Based on the observed indications at 2RE07, the South Texas Project Unit 2 SGs were expected to meet all structural and leakage integrity requirements at 2RE08.

The following degradation mechanisms were confirmed to be present in the 2RE07 results:

- Axial ODSCC at TSP intersections
- Axial ODSCC at hot leg and cold leg freespan dings
- Freespan volumetric indications
- AVB wear
- Wear at non-expanded preheater baffle intersections

3.1 South Texas 2RE08 Signal Noise Evaluation

In response to the Sept 29,2000 "SGMP Information Letter Concerning Lessons Learned from a Review of Recent Steam Generator Related Issues", prior to the 2RE08 outage, noise levels in the small radius U-bends and top of tubesheet region were evaluated (Appendix A) to determine the impact upon significant flaw detection capability. For the small radius U-bends, it was determined that the noise levels between all SGs were similar, and SG A only was used. Particularly for the Model E2, the Row 1 bend radius is 3.25", which is the largest Row 1 bend radius of Westinghouse SGs with mill annealed tubing. The Model E2 Row 1 bend radius is approximately equal to the Row 2 bend radius of a Model D3/4 SG. For the top of tubesheet region, tubes from both SG A and SG B were used. The tubes near the T-slot were used since this is the region of the Model E2 SG that OD deposits and sludge deposition are most likely to occur. The FDB cutout exists above the T-slot, and cross flow velocities are likely lowest in this region. Vertical maximum noise levels for the sampling of South Texas 2 tubes were compared against the limiting flaw amplitude values provided by SG-01-01-001 (Reference 8). For the U-bend region, a vertical maximum +Pt amplitude of 0.44 volts is selected, while for the top of tubesheet region, a vertical maximum +Pt amplitude of 0.36 volts is selected. This amplitude represents a 60% maximum depth flaw, at a lower 90% probability, 50% confidence level. The pre-outage vertical maximum noise values (evaluated at an upper 90% probability, 50% confidence) were well below these respective limits, thus indicating that the noise levels in the South Texas Unit 2 tubes were not of a level that could mask a flaw such that when growth were applied over the next cycle, structural or leakage integrity would be challenged. Tubes used for the pre-outage evaluation were also monitored during the outage to determine if a change in OD deposit condition had occurred.

Evaluation of the noise levels during the outage indicates that the same approximate values were obtained for the tubes using in the pre-outage evaluation. For the U-bends, the pre-outage average and standard deviation values were 0.24 volts and 0.08 volts, respectively for the apex region. During the outage, the values for the same tubes were 0.30 and 0.06 volts. Vertical maximum levels were monitored during the outage, and if excessive vertical maximum noise components were observed, the tubes were retested. Retesting was shown to be an effective method of reducing noise levels, since at South Texas 2, the largest contribution to noise levels was found to be attributed to probe usage. Once the probes were changed, the noise levels were substantially reduced for these tubes.

At the top of tubesheet, the noise levels were monitored at the approximate mid-point of the transition as well as ½" above the transition. The transition mid-point values give an indication of the geometry effects introduced by the expansion transition, while the values ½" above the top of tubesheet give a measure of the OD deposit noise contribution. The 2RE08 values were found to be slightly reduced compared to the pre-outage study. For the top of tubesheet region pre-outage study, tubes plugged in 2RE07 were used. For the 2RE08 study, immediately adjacent tubes were used. Additionally, adjacent to the in situ pressure tested tubes with circumferential cracks were evaluated. The noise levels in these tubes were found to be well within the range of noise values seen for the entire sampling population.

3.2 Planned Scope

On the basis of the conclusions drawn from the 2RE07 inspection results, and in recognition of the discretion provided by the anticipated licensing of 3-Volt ARC criteria for TSP ODSCC, the following scope for the 2RE08 inspection was detailed in the Degradation Assessment.

- 100% full length bobbin (except Rows 1 and 2 U-bends)
- 100% +Pt inspection of DSIs and MRIs >3 volts at 2H, 3H, and 4H, 100% +Pt inspection of DSIs > 1 volt at the FDB and all remaining TSP intersections
- +Point exam of TSP mix residual signals (MRI) > 1.5 volts at TSPs other than 2H, 3H, 4H
- 34% hot leg TTS +Pt including 100% critical area inspection in the FDB cutout region and 20% random sample of non-critical area tubes plus expanded tube candidates (3 volt ARC support)
- 100% Row 1, 20% Row 2 small radius U-bend +Pt inspection using mid-range +Pt probe
- 100% +Pt inspection of dents >5 volts
- 100% +Pt inspection of freespan dings > 5 volts

- 20% hot leg freespan ding (>1 volt) +Pt exam between TTS and 02H (PWSCC related) in all SGs
- 20% +Pt inspection of hot leg and cold leg paired dings between the top two TSPs in all SGs
- 20% expanded preheater baffle +Pt inspection
- Special interest RPC inspection including MBMs without historical reference, freespan dings ≤ 5 volts exhibiting rotation greater than the calling criteria (DNI), and any other freespan bobbin indications without historical reference. Also included in the special interest RPC inspection will be hot leg tubes with PLP calls by bobbin, and a 20% magnetically-biased +Pt inspection of freespan PVN signals >1 volt.

3.3 Scope Expansions

Additions and changes to this scope based on the results of the 2RE08 inspection findings include the following:

- +Point exam for all DSIs from 1.0 volts to 1.5 volts at 2H, 3H, 4H TSPs and a sample of DSIs from 0.6 volts to 1.0 volt to support preventive plugging based on leakage probability predictions. (DSIs >1.5V and ≤ 3V at the three support plates above the flow distribution baffle were not examined since the confirmation rate was regarded near unity and the decision was made to preventively plug these tubes.)
- 100% of Row 2 tubes in SGD were examined with mid-range +Point coils upon finding an axial indication in R1C2 at the tube apex. Additional testing with high frequency +Point coils was conducted on selected tubes (8), including R1C2 in SG 2D.
- The scope for +Point exam of "paired ding" conditions was expanded because of the observation of ODSCC at freespan dings (DNI) and bobbin indications (NQI). In particular, in SG D at R6C10 above the 16C TSP elevation, a paired ding configuration exhibited a circumferential indication (16C+3.5") and an axial indication (16C+2.5"); both indications were judged to be ODSCC.

The inspection program as completed is given in Table 3.2-1.

3.4 Ultrasonic Testing

In conjunction with in situ testing, four tubes were selected for ultrasonic testing (UT); these were the 4 locations corresponding to the largest TSP ODSCC DSI calls in SGD. All 4 locations exhibited multiple, closely spaced, axial crack indications; all had been reported as from +point examination as single axial indications (SAI). The UT examination confirmed the morphology to be dominantly OD axial cracking with some circumferential involvement consistent with the extent defined in reference 2. The results for these tubes are pertinent to the TSP ODSCC ARC; the data collected and the interpretation of the results are contained in TSP CMOA.

R48C93-22C+0.63' in SGC was subjected to UT examination to document (Reference 9) the nature of the degradation reported above the lowermost preheater baffle (22C). UT confirmed the freespan volumetric EC indication (SVI) found in the CL Expanded Baffle +Point program to exhibit shallow wear (maximum depth - 8%) from 0.26" to 0.45" above the top edge of the baffle plate. The circumferential extent of the degradation observed was limited to a 21° arc. No axial or circumferential crack indications were detected. . UT examination shows no cracking and a small wear scar of 8% depth above the expansion transition.

This indication was interpreted as wear resulting from impingement by a foreign object. This interpretation is consistent with the location of the indication on the tube, about 0.63" above the preheater baffle, and the location of the tube in the bundle, i.e., on the corner of the lower preheater baffle. EC did not identify a potential loose part (PLP) at this location or any other preheater location in this steam generator, thus indicating that a foreign object was no longer at this location. The low wear depth of ~8% by UT examination provides reasonable assurance that the nature of this part, if it has migrated, is not likely to result in unacceptable wear on any other tubes as this location is one of the highest flow locations in the steam generator..

Table 3.2-1
2RE08 Inspection Plan (as completed)

FINAL INSPECTION STATUS (Analysis Completed/Program) Date: 3/23/2001				
HL Bobbin	593/593	594/594	586/586	591/591
CL Bobbin	4655/4655	4632/4632	4615/4615	4633/4633
HL TTS +Point	4640/4640	4614/4614	4599/4599	4615/4615
HL TSP 2, 3, 4 +Pt >3V	22/22	20/20	30/30	37/37
HL FDB, TSP all others from 5H thru CL; +Pt 1V	1/1	4/4	6/6	2/2
HL Ding +Pt Program (>5V) 100%	17/17	25/25	27/28	89/89
CL Ding +Pt Program (>5V) 100%	6/6	12/12	6/6	73/73
HL Special Interest RPC: (MBM, PLP, PVN, ≤5V dings exceeding criteria)	268/268	367/367	388/388	371/371
CL Special Interest RPC: (MBM, PLP, PVN, ≤5V dings exceeding criteria)	38/38	56/56	48/48	66/66
U-bend Mid-range +Pt : 100% Row 1, 20% Row 2 100% Row 2 (Scope expansion) High frequency coil (Addition)	 143/143 N/A N/A	 143/143 N/A N/A	 143/143 N/A N/A	 143/143 96/96 8/8
CL Expanded Baffle RPC Program, 20%	64/64	64/64	320/320	64/64
HL Freespan Ding >1V 20%; +Pt:TTS-2H	17/17	21/21	25/25	22/22
HL U-Bend Ding Program	18/18	5/5	9/9	3/3
CL U-Bend Ding Program	5/5	7/7	7/7	10/10
HL Ding +Pt Program -paired dings	3/3	10/10	10/10	12/12
100% Ding Pairs Both Legs (Scope Expansion)	N/A	N/A	N/A	391/391
CL Ding +Pt Program -paired dings 20% CL Ding Pairs +Pt Program (Scope Expansion)	7/7 6/6	4/4 24/24	N/A 21/21	8/8 N/A

4.0 South Texas Project 2RE08 Inspection

The inspection was conducted in conformance with the EPRI guidelines for SG examination (Ref.) and as projected in the 2RE08 Degradation Assessment. Utility and Westinghouse engineering personnel reviewed the data files created each day to identify unusual conditions, new damage mechanisms and tubes that might be candidates for more extensive study, such as in situ testing and UT.

4.1 Inspection Results

Table 4.1-1 summarizes the results of the inspection for conditions that are relevant to tube integrity. The numbers of indications reported are cumulative of dual or multiple inspections of some tubes; thus the numbers reflect the variety of calls reported, and elimination of duplicates and multiple indications is required to reduce the table data to affected tubes. This is accomplished in Table 4.1-3, the plugging summary, for which tubes were assigned to ultimate reasons for plugging on the basis of Tech. Spec., ARC, engineering, and administrative considerations.

Viewed from the perspective of the distribution of indications attributed to tube degradation mechanisms, Table 4.1-2 eliminates the duplications inherent in Table 4.1-1. Indications are assigned to degradation mechanisms using the pertinent NDE information such as profiles and phase angle correlation together with orientation and location of confirmed indications. Eleven distinct degradation mechanisms are tentatively identified. The freespan SVI indications are included in the freespan axial ODSCC total; this is consistent with the conservative treatment of these indications as IGA. Indications or circumstances that cause administrative tube plugging, such as those for PVN signals or incomplete tests, are not considered as reflective of degradation mechanisms.

The total of tubes plugged for reasons related to TSP ODSCC include those expanded to lock the lower TSPs as required for the 3 volt ARC, as well as tubes that were preventively plugged to reduce the potential for leakage in Cycle 9. Adding these to the tubes with DSIs that did not satisfy the ARC, there were 812 tubes plugged for TSP ODSCC. Forty-one (41) tubes that were identified as possible leakers during secondary side pressure test had no reported degradation indications in the tubing in excess of repair limits to correlate to the observed leakage (more than half exhibited DSIs below the applicable repair limit).

Phase angle correlation suggests that two of the ding-related axial indications are ID in origin. Only one of the circumferential indications at the top of the tubesheet (expansion transition) appears to have ID origin, and the freespan axial and the volumetric indications as well as the single Row 1 U-bend indication all appear to have OD origin. Five tubes were plugged because of PVN signals found at or below the top of the tubesheet, and 1 tube was plugged because complete inspection of the U-bend could not be accomplished.

Table 4.1-1
Inspection Results Summary

South Texas Unit 2 Spring 2001 Inspection - 2RE08 Date processed: 3/22/01					
Indication	**Description**	**Steam Generator**			
		A	**B**	**C**	**D**
DNI	Dent ODSCC	3	3	11	9
DSI	TSP ODSCC - total count	702	1338	1021	812
	TSP ODSCC - (Max V.)	8.05	9.72	8.96	11.09
	TSP ODSCC - Number > 1V	150	149	132	138
	Number >1V and not located at 2H to 4H	1	6	6	2
	2H, 3H, 4H > 1.5V	78	62	63	64
Preventive	2H, 3H, 4H > 0.6 ≤ 1.5V	201	325	321	269
DTI	Tubesheet expansion flaw	0	0	0	0
MRI	Mix residual > 1.5V	96	99	53	78
NQI	Freespan ODSCC	15	14	14	5
PCT	Preheater baffle, AVB, Loose part wear	289	438	455	380
PLP	Possible loose part	0	0	14	0
PVN	Permeability variations > 1V	130	81	103	72
RWS	Preheater baffle wear signal	1	2	1	2
SCI, MCI	Circumferential cracks	3	2	2	3
SAI, MAI	Axial indications	268	414	436	351
	Freespan cracks	7	1	13	5
VOL	Volumetric indications - not pluggable (MBM, preheater wear)	2	5	3	6
SVI	Freespan Volumetric Indications	2	0	3	0

Table 4.1-2
Tube Degradation Mechanisms based on 2RE08 Inspection Results
South Texas Unit 2 Spring 2001 Inspection - 2RE08

			Date processed: 3/27/01			
#	**Degradation Mechanism**	**Indication**	**A**	**B**	**C**	**D**
1	TSP ODSCC - total count	DSI	611	1229	972	768
	TSP ODSCC - Number > 1V		106	108	117	118
	#>1V and not at 2H to 4H		1	6	6	2
	2H, 3H, 4H > 3V		22	19	28	33
2	Freespan Axial ODSCC (confirmed by +Pt)	SAI/SVI	6	0	3	1
3	Row 1 U-bend ODSCC	SAI	0	0	0	1
4	Preheater Baffle Wear (confirmed by RPC)	RWS	1	1	1	1
5	AVB wear	PCT	15	18	12	25
6	Circumferential EZODSCC	SCI, MCI	2	2	2	2
7	Circumferential EZPWSCC	SCI	1	0	0	0
8	Ding-related Circumferential EZODSCC (detected by +Pt)	DNI	0	0	0	1
9	Ding-related Axial ODSCC (confirmed by +Pt)	SAI	2	1	12	3
10	Ding-related Axial PWSCC (confirmed by +Pt)	SAI	1	0	1	0
11	Loose Parts Wear (direct RPC detection adjacent to expanded baffle)	SVI	0	0	1	0

Table 4.1-3
2RE08 Tube Plugging Summary

Indication	Description	Steam Generator			
		A	B	C	D
SCI, MCI	Tubes plugged for Circumferential cracks	3	2	2	3
SVI	Tubes plugged for Volumetric indications	2	0	3	0
PCT	Tubes with ≥ 40% TWD by Bobbin	0	0	0	0
SAI, MAI	Tubes with Freespan or U-bend Cracking	7	1	11	4
PVN	Tube with PVN in Active Zone	1	0	4	0
LOCK	Tubes Locked for 3V ARC	22	18	18	18
ARC	Tubes to be plugged for DSIs				
	Original (3 V) ARC-2H, 3H, 4H >3V, and confirmed >1V at other TSPs	23	20	32	31
	Modified (3 V) ARC - 2H, 3H, 4H >1.5V	30	24	27	24
PREV	Tubes for Preventive Plugging (DSIs > 0.6V ≤ 1.5V , confirmed by +Pt, ordered by leakage probability)	138	125	122*	139
LEAKER	Leaking Tubes without Pluggable Indications	21	4	11	5
INC	Tubes plugged for incomplete inspection	0	0	0	1
	PLUG TOTAL	246	194	230*	224

*: Preventive plugging in SGC limited to 9.9% cumulative, using prioritized leakage probability for confirmed DSIs below 1.5 volts at TSPs 2H, 3H, and 4H.

5.0 Insitu Testing

5.1 Summary of Tubes Tested

Insitu testing was performed on 12 tubes as summarized on Table 5.1. Only 2 of the 12 tubes tested met the selection criteria for insitu testing (References 6 and 7). The remaining 10 tubes were conservatively tested for the following reasons:

- to evaluate the source of operational leakage suspected to be due to TSP ODSCC
- to evaluate degradation mechanisms not previously observed at South Texas 2 (TTS circumferential ODSCC, U-bend Axial ODSCC)
- to evaluate the unusual condition of a paired ding with an axial crack at one of the dings and a circumferential crack at the other of the paired dings.

All of the insitu tests were performed to the proof test pressure of 4150 psig. The test pressure was determined from a factor of 3 applied to the normal operating Δp (1250 psi) for STP, corrected for the temperature difference between the normal operating conditions (620°F) and the room temperature test conditions, plus a pressure gauge uncertainty of 25 psi. The test pressure for circumferential indications was 4315 psig to provide the proper end-cap loads. The test conditions were consistent with the most recent industry guidance on pressurization rate and hold times (Reference7).

The in situ test of tube R1C2 was a full length tube test; the remainder of the insitu tests were local tests of the specific indications.

5.2 Insitu Test Results

Table 5.2 summarizes the results of the insitu test performed.

All of the flaws tested passed the $3\Delta P_{NO}$ proof test pressure without burst. As anticipated prior to the tests, only the TSP ODSCC flaws exhibited leakage. None of the other indications tested exhibited leakage at any time during the tests. Figure 5-1 shows the leak vs. pressure curves for the indications that exhibited leakage during the tests.

Appendix E, Section 4 of Reference 6 discusses the interpretation of in situ leak test data when the flaw is restricted by a surrounding structure such as the TSP. It is concluded that the leak rates developed under these circumstances are not representative of the database that supports the ODSCC ARC. Nevertheless, these tests confirmed that the tubes indicated as leaking by the secondary side pressurization test were indeed the tubes with higher voltage ODSCC indications at the TSPs.

During the leak tests, no leakage was observed at ΔP_{NO} for four of the six tubes that exhibited leakage at higher ΔP. It is believed that the prior secondary-side pressurization of the SGs caused the relatively loosely packed crevices to compact into the crack and obstruct leakage until sufficient pressurization was achieved to purge the crack. "Loosely packed" in this context is a relative term which has as its basis of comparison the crevice packing of SGs with carbon steel TSPs, the design of all other domestic SGs for which the TSP ODSCC ARC have been licensed. For SGs with carbon steel support plates, the crevice not only becomes packed with deposits transported by the coolant, but the deposits become compacted by the corrosion products from the TSP itself. Thus the crevices are tightly packed, evidence for which is provided by the absence of leakage in all domestic in situ tests of intersection with ODSCC at TSP intersections in SGs with carbon steel support plates. The stainless steel support plates at STP-2 become packed with coolant-transported deposits, but compaction of these deposits by TSP corrosion does not occur.

The room temperature leak test results were corrected to reference operating temperature conditions[1] of 616°F based on the methods described in Appendix B of Reference 11. Table 5.3 summarizes the measured and temperature adjusted leak rates for the flaws that leaked during in situ testing.

Figure 5.2 compares the temperature adjusted leak rates with the leak rate/bobbin-voltage correlation from Reference 12. The data from STP-2 are typical of the prior industry leak rate data. Four of the six data points fall below the median leak rate of all of the industry data, while the other two points are slightly above the median leak rate . The largest STP-2 leak rate falls on the average leak rate correlation of the industry data.

For the ΔP_{SLB} leak rates, the crevice is not considered to provide significant restriction to flow; thus the temperature adjusted leak rates are directly comparable to the industry leak rate database. As noted above, the crevice deposits are believed to be loosely packed; thus a large, high-pressure leak rate could readily dislodge or fracture the deposits. Evidence of this is provided by the in situ test of tube R15C89 in SG-B, for which leakage was recorded at 1400 psid during increasing pressurization and decreasing pressurization (see Table 5.2). The leakage reported after the tube had been pressurized to ΔP_{SLB} was significantly higher than the leakage reported at the same pressure differential during increasing pressurization. From this it can be concluded that the higher pressurization dislodged the deposits and opened up the crevice, effectively making the leak test representative of a free-span leak test.

Prior analysis has shown that a crevice of 1-2 mils is sufficient to result in negligible crevice resistance to leakage flow. Since the TSPs are stainless steel, and no TSP corrosion products are available to tightly pack the crevice, and since the crevice is filled at normal operating conditions, the differential thermal contraction between the tube and the TSP will open the crevice. The difference in the coefficients of thermal expansion of the Alloy 600 tubes and the type 405 SS TSPs, and the larger temperature change in the tube results in opening the crevice about 1 mil. Thus, at room temperature, the

[1] The reference temperature condition for the industry database is 616°F. Adjustment of the leak rates to STP-2 operating temperature (620°F) would result in slightly lower at-temperature leak rates.

crevice between the tube and the TSP is open sufficiently for the leak test to be representative of a free-span leak test.

Table 5.1 Insitu Testing Summary

SG	Tube	Location	Indication		Test Required?	Comment
			Bobbin	Plus Point		
A	R39/C16	TSC+1.02	DNI (5.7 V)	SAI (1.94 V)	Yes	Avg L and Depth > Screening Criteria
B	R28C81	TSH-0.02	NA	SCI (0.21 V)	No	Previously Unobserved Degradation Mechanism
	R15C89	02H+0.09	DSI (9.72 V)	SAI (6.12 V)	No	Leak Test Prior to Proof Test
	R20C48	03H-0.17	DSI (6.93V)	MAI 5.15 V)	No	Leak Test Prior to Proof Test
C	R4C97	TSH-0.11	NA	SCI (0.59 V)	No	Previously Unobserved Degradation Mechanism
	R10C64	20C+11.07	DNI (0.59 V)	SAI (0.90 V)	Yes	Avg L and Depth > Screening Criteria
D	R24C47	03H-0.03	DSI (11.09 V)	SAI (4.98 V)	No	Leak Test Prior to Proof Test – Highest voltage DSI
	R10C109	02H+0.0	DSI (10.37 V)	SAI (4.85 V)	No	Leak Test Prior to Proof Test
	R24C68	04H+0.0	DSI (7.9 V)	SAI (4.98 V)	No	Leak Test Prior to Proof Test
	R25C72	02H+0.0	DSI (7.45 V)	SAI (4.65 V)	No	Leak Test Prior to Proof Test
	R6C10	16C+2.52	DNI (0.66 V)	SAI (0.10 V)	No	Unusual Condition; Paired Ding with separated axial and circ. cracks
		16C+3.5	NA	SCI (0.82 V)	No	
	R1C2	10H+7.23 (U-Bend)	Not Tested	SAI (0.17 V)	No	Previously Unobserved Degradation Mechanism Full Length Test

Table 5.2 Insitu Test Results

SG	R	C	Location		+Point		Bobbin		Test	Pressure	Leak Rate
			Ref.	± inch	Ind.	Volts	Ind.	Volts		psig	gpm
*A	39	16	TSC	1.02	SAI	1.94	DNI	5.70	Leak	1400	0
									Leak	2000	0
									Leak	2500	0
									Leak	2841	0
									Proof	3300	Passed
									Proof	3800	Passed
									Proof	4150	Passed
B	20	48	03H		MAI	5.15	DSI	6.93	Leak	1400	0
									Leak	2000	0.00006
									Leak	2500	0.052
									Leak	2841	0.07
									Proof	3300	Passed
									Proof	3800	Passed
									Proof	4150	Passed
B	28	81	TSH	-0.02	SCI	0.22	N/A		Leak	1441	0
									Leak	2000	0
									Leak	2575	0
									Leak	2925	0
									Proof	3400	Passed
									Proof	3900	Passed
									Proof	4315 (1)	Passed
B	15	89	02H		SAI	6.12	DSI	9.72	Leak	1400	0.00008
									Leak	1800	0.02
									Leak	2000	0.052
									Leak	2500	0.4
									Leak	2841	1.2
									Leak	1400	0.44
									Proof	3300	Passed
									Proof	3800	Passed
									Proof	4150	Passed
C	10	64	20C	9.35	SAI	0.90	DNI	0.59	Leak	1400	0
									Leak	2000	0
									Leak	2500	0
									Leak	2841	0
									Proof	3300	Passed
									Proof	3800	Passed
									Proof	4150	Passed
C	4	97	TSH	-0.11	SCI	0.59	N/A		Leak	1431	0
									Leak	2041	0
									Leak	2519	0
									Leak	2845	0
									Proof	3400	Passed
									Proof	3900	Passed
									Proof	4305 (1)	Passed

Table 5.2 (continued) Insitu Test Results

SG	R	C	Location		+Point		Bobbin		Test	Pressure	Leak Rate
			Ref.	± inch	Ind.	Volts	Ind.	Volts		psig	gpm
D	1	2	10H	7.23	SAI	0.17		No test	Leak	1400	0
									Leak	2000	0
									Leak	2500	0
									Leak	2841	0
									Proof	3324	Passed
									Proof	3800	Passed
									Proof	4154	Passed
D	6	10	16C	3.50	SCI	0.82	N/A	0.66	Leak	1441	0
				2.52	SAI	0.10	DNI		Leak	2000	0
									Leak	2575	0
									Leak	2925	0
									Proof	3400	Passed
									Proof	3900	Passed
									Proof	4315 (1)	Passed
D	24	47	03H		SAI	7.98	DSI	11.09	Leak	1440	0.0002
									Leak	2046	0.08466
									Leak	2530	0.24024
									Leak	2700	0.40074
									Leak	2849	0.53798
									Proof	3379	Passed
									Proof	3843	Passed
									Proof	4209	Passed
D	24	68	04H		SAI	4.98	DSI	7.90	Leak	1421	0
									Leak	2021	0
									Leak	2540	0.046
									Leak	2627	0.053
									Leak	2760	0.078
									Leak	2840	0.113
									Proof	3369	Passed
									Proof	3858	Passed
									Proof	4180	Passed
D	25	72	02H		SAI	4.65	DSI	7.45	Leak	1440	0
									Leak	2017	0.0142
									Leak	2540	0.04751
									Leak	2820	0.09375
									Proof	3359	Passed
									Proof	3862	Passed
									Proof	4178	Passed
D	10	109	02H		SAI	4.85	DSI	10.37	Leak	1421	0
									Leak	2051	0.02675
									Leak	2530	0.09071
									Leak	2824	0.26484
									Proof	3369	Passed
									Proof	3890	Passed
									Proof	4190	Passed

(1) Proof test pressure increased to provide proper end-cap load for circumferential indications.

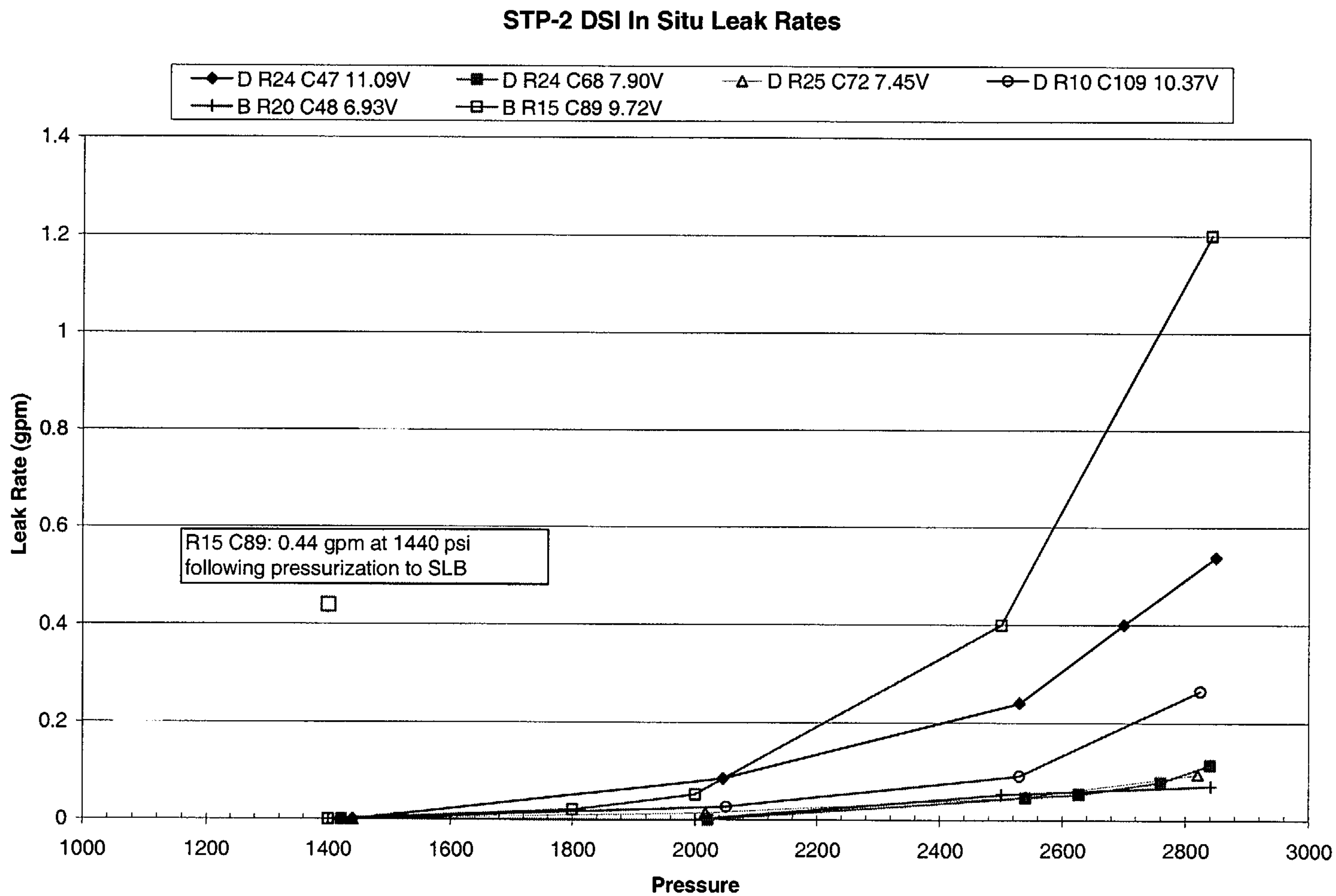
(2) Axial end caps loading was applied for the SGs B and D large DSI tests to simulate axial tearing loads for those proof tests

Table 5.3

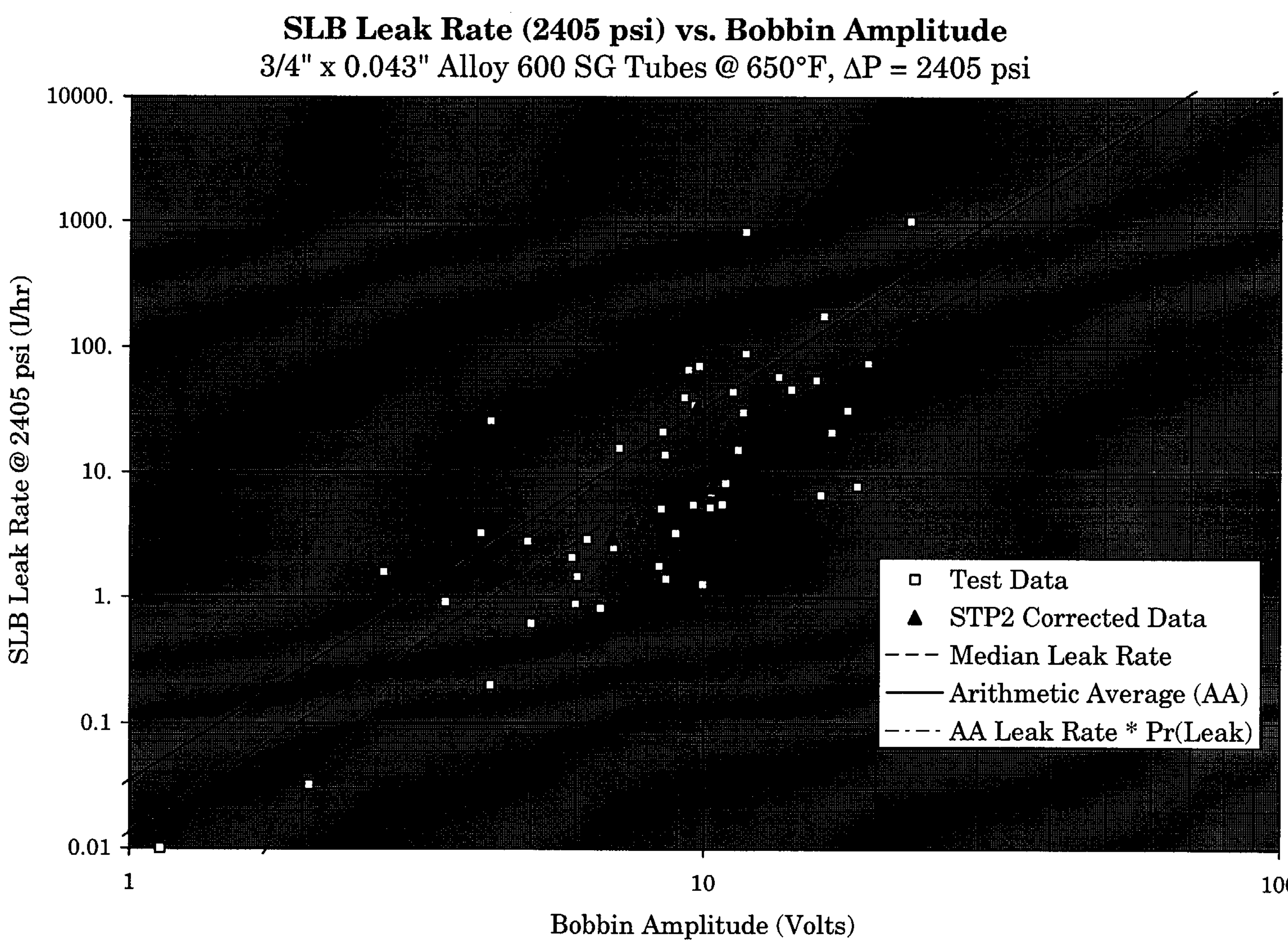
Temperature Corrected Insitu Leak Rates

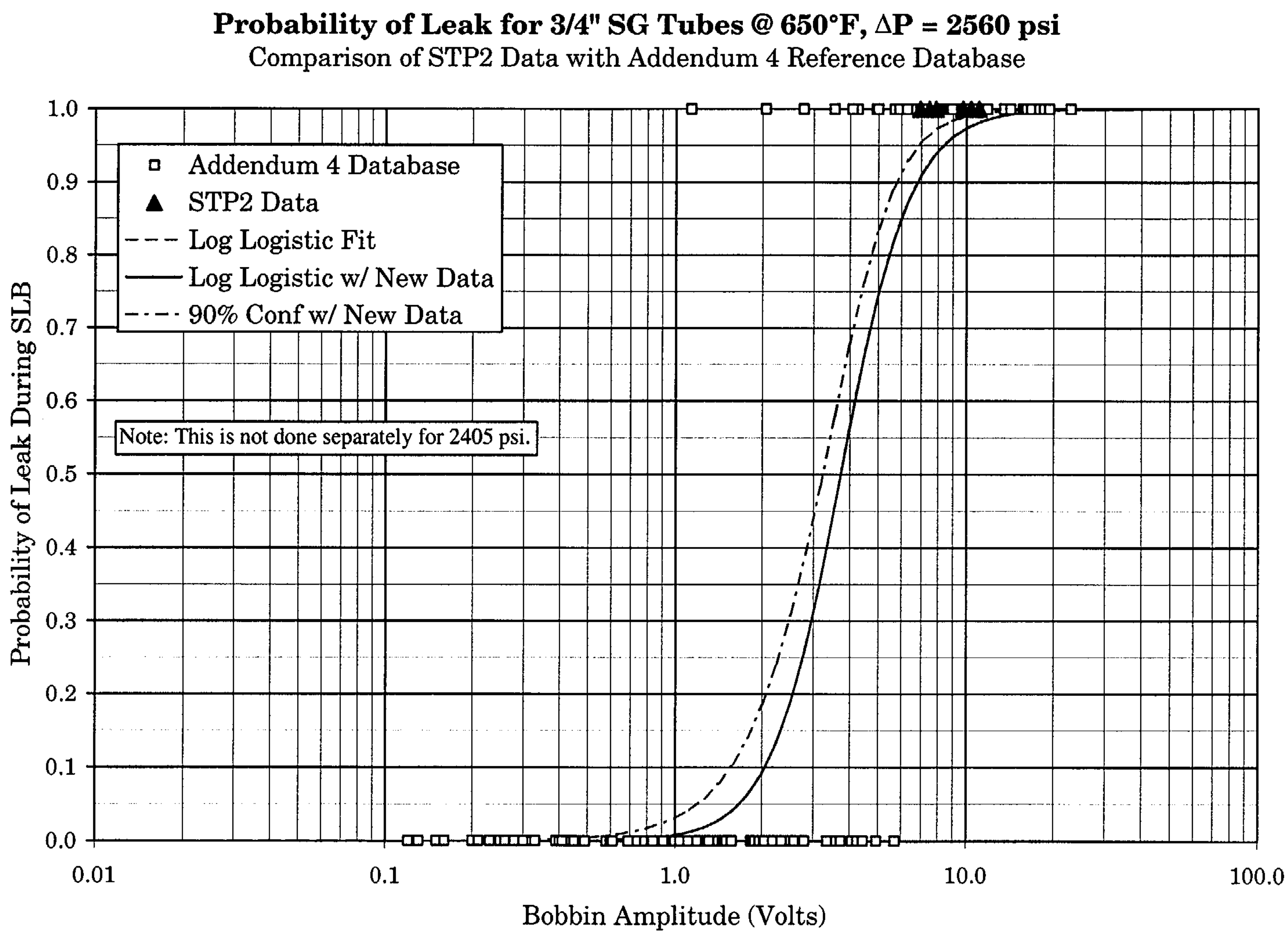
SG	Tube	Insitu Test		616°F Leak Rate (L/hr) @ 2405 psid	Tube Flow Stress @ RT (ksi)
		Pressure (psid)	RT Leak Rate (gpm)		
B	R15C89	2841	1.2	32.6	76.0
B	R20C48	2841	0.07	3.0	79.0
D	R24C47	2849	0.54	21.4	79.5
D	R24C68	2840	0.11	3.8	70.5
D	R25C72	2820	0.09	4.1	80.5
D	R10C109	2824	0.26	7.6	84

Figure 5.1



Note: Tests at <200 psi/sec pressurization rate and 2 minute minimum hold times.


SLB Leak Rate (2405 psi) vs. Bobbin Amplitude
3/4" x 0.043" Alloy 600 SG Tubes @ 650°F, ΔP = 2405 psi
10000.
1000.
100.
10.
1.
0.1
0.01
SLB Leak Rate @ 2405 psi (l/hr)
1
10
100
Bobbin Amplitude (Volts)
Test Data
STP2 Corrected Data
Median Leak Rate
Arithmetic Average (AA)
AA Leak Rate * Pr(Leak)


Probability of Leak for 3/4" SG Tubes @ 650°F, ΔP = 2560 psi
Comparison of STP2 Data with Addendum 4 Reference Database
Addendum 4 Database
STP2 Data
Log Logistic Fit
Log Logistic w/ New Data
90% Conf w/ New Data
Note: This is not done separately for 2405 psi.
Probability of Leak During SLB
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.01
0.1
1.0
10.0
100.0
Bobbin Amplitude (Volts)

6.0 Condition Monitoring Assessment

6.1 ODSCC Indications at Tube Support Plates

A summary of the eddy current data for TSP indications in all four steam generators is shown on Table 6-1, which tabulates the number of bobbin indications at TSPs (total and larger indication population), the number of those indications that were RPC inspected, the number of RPC confirmed indications, and the number of indications removed from service due to tube repairs. Although a 3 volt repair limit has been approved for the hot leg indications at the lower 3 TSPs (2, 3 and 4), all indications over 1.5 volts were conservatively repaired. Indications at other TSP locations exceeding 1 volt and confirmed by RPC were also repaired as their repair limit is 1 volt.

6.1.2 Voltage Growth Rates

Bobbin voltage signals from the last outage (EOC-7) were reevaluated along with the data from the current inspection to obtain more reliable growth data for the just completed Cycle 8. Table 6-2 shows the average composite voltage growth rate for all four South Texas Unit-2 SGs during Cycle 8 as well as the growth data for the prior 3 cycles. The average composite voltage growth rate during Cycle 8 is 81.9%/EFPY, which is about 80% higher than the last cycle growth (45.4%/EFPY). The increase in Cycle 8 average growth rate reflects growth rate increase for smaller indications (BOC indications below 0.75 volts, about 82%/EFPY) since larger indications (above 0.75 volts) had a more modest increase (about 25%/EFPY) and are a very small faction of the total population.

Large growth was also found during the Cycle 6 operation of Braidwood Unit-1 and second half of Cycle 7 in Byron Unit-1. Figure 6-1 compares the growth distributions for these two cycles with the latest growth data for South Texas Unit-2. Cumulative probability distribution functions for the all SG composite voltage growth are shown. The growth data are presented on an EFPY basis to account for the differences in the operating periods. The data in Figure 6-1 show that the South Texas Unit-2 Cycle 8 growth distribution is comparable to the Braidwood Unit-1 Cycle 6 growth data. The largest voltage growth observed in the Braidwood-1 Cycle 6 was 8.1 volts/EFPY and the largest voltage growth during the South Texas Unit-2 Cycle 8 was 8.6 volts/EFPY.

The voltage growth data for the above Braidwood-1 and Byron-1 cycles exhibited a dependency on the BOC voltage. The Cycle 7 growth data for South Texas Unit-2 also appeared to show a dependency on BOC voltage. To determine if the latest growth data for South Texas Unit-2 was also dependent on the BOC voltage, Cycle 8 growth values were plotted against their BOC-8 voltage, and the resulting plot is shown in Figure 6-2. The data in Figure 6-2 do not show a dependency on the BOC voltage as the relative frequencies for large growth values among indications under 0.5 volts are comparable to those for indications over 0.5 volts. For example, the frequency of growth over 5 volts for indications under 0.5 volts is about 1.9% (56 out 2912) compared to about 4.4% (29 out of 659) for indications above 0.5 volts. Therefore, EOC-9 leak rate and burst probability projection analysis assumed growth to be independent of the BOC voltage.

6.1.3 Leak and Tube Burst Analysis Methods and Database

Monte Carlo analysis methods are used to calculate SLB leak rates and tube burst probabilities based on the actual voltage distributions and projections for the next cycle. NDE uncertainties applied for the Cycle 8 voltage distributions in the Monte Carlo analyses for leak rate and burst probability are the same as those described in the last 90-day report (Reference 3). Leak and burst database presented in Addendum-3 to the database report, Reference 12, was applied for both analyses based on the actual EOC-8 voltages (condition monitoring analysis) and projections to EOC-9 conditions (operational assessment). This database includes 1998 pulled tube leak and burst test data from South Texas Unit-2.

Since credit can be taken for operability of pressurizer power-operated relief valve during design-basis events at South Texas Unit-2, the applicable steam line break pressure differential is 2405 psi. The following leak rate correlation is developed in Reference 6-2 for 3/4" tubes at 2405 psi differential pressure based the updated database.

$$\text{Leak Rate } (l/hr) = 10^{\left(-1.8708 + 2.9767 \times \log_{10}(volts)\right)}$$

The above leak rate correlation was used to perform both condition monitoring and operational assessment analyses.

6.1.4 SLB Leak Rate and Burst Probability at EOC-8

The results of the EOC-8 condition monitoring analyses for leak rates and tube burst probabilities at SLB conditions are summarized in Table 6-3. The corresponding results from the EOC-8 projection analyses presented in the last 90-day report, Reference 6-1, are also shown.

Bounding equivalent static and dynamic analysis results presented in Reference 14 show that the lower tube support plates, specifically TSPs 2, 3 and 4, undergo only a limited displacement during a postulated SLB event; consequently, ODSCC indications at those TSP locations would be restrained from bursting even if their free span burst pressure is exceeded. Therefore, SLB leak rates for indications at the lower 3 TSPs were calculated using the IRB leakage methodology discussed in Reference 14. Leak rates and burst probabilities for the indications at the remaining TSPs were calculated using the standard GL 95-05 methodology (Reference 15). It is evident from the results shown in Table 14 that the SLB leak rates for all four SGs based on the IRB methodology are well within the allowable limit of 15.4 gpm. Indications at the lower 3 TSPs are assigned a burst probability of $1x10^{-5}$ as they are restrained from bursting. Steam generator tube burst probabilities based on indications population at the remaining TSPs are well within the NRC guideline of 10^{-2} for all 4 SGs.

The leak rates calculated using the actual measured EOC-8 voltages are higher than the projections presented in the last 90-day report because the actual growth rates during Cycle 8 were higher than those assumed for the projections. The growth distribution applied for the EOC-8 projection was obtained by examining the growth data for the prior two cycles and selecting the limiting distribution, consistent with the GL 95-05 guidelines. Steam generator C was projected to be the limiting SG at EOC-8, but the condition monitoring analysis predicts a higher SLB leak rate for SG-D. However, if the two largest indications in SG-D are removed, both SGs C and D would yield comparable leak rates and burst probabilities. Large few indications in the population distribution tail may occur randomly in any SG, and they may not be predicted by a Monte Carlo analysis.

Table 6-3 also shows the condition monitoring results based on the conventional GL 95-05 methodology, which ignores the effect of TSPs restricting indications from bursting. Again, EOC-8 leak rates for all SGs are well below their allowable limit of 15.4 gpm, but the burst probabilities are higher than the NRC reporting guideline of 10^{-2}. However, 92% of the indications found in the EOC-8 inspections were present at elevations 2H, 3H and 4H and, as noted above, the support plates at those locations undergo only a limited displacement and consequently restrict indications from bursting. Therefore, tube probabilities calculated using the conventional GL 95-05 methodology are not relevant.

In summary, the limiting SLB leak rate calculated using the actual measured EOC-8 bobbin voltage distributions (5.7 gpm at room temperature for SG-D) is well below the allowable limit of 15.4 gpm. With credit taken for limited displacement of the lower 3 TSPs during a SLB event, tube burst probabilities for all SGs based on the as found EOC-8 conditions are well below the NRC reporting guideline of 10^{-2}.

Table 6.1-1

South Texas Unit-2 March 2001

Summary of ODSCC at Support Plates Inspection and Repair Data

	SG-A	SG-B	SG-C	SG-D
Number of Indications				
Total	611	1229	972	768
> 1 volt	106	108	117	118
> 3 volts	22	19	28	33
> 5 volts	10	10	10	15
RPC Inspected	218	321	327	306
RPC Confirmed	217	313	322	300
Repaired	288	279	281	276
Returned to Service	323	950	691	492

Table 6.1-2
South Texas Unit-2 March 2001

Bobbin Voltage Range	Number of Indications	Average Voltage BOC	Average Voltage Growth		Average Percentage Growth	
			Entire Cycle	Per EFPY	Entire Cycle	Per EFPY
	Cycle 8 (1999 - 2001) - 458 EFPD					
Entire Voltage Range	3580	0.37	0.378	0.301	102.7%	81.9%
V_{BOC} < .75 Volts	3488	0.36	0.372	0.297	104.8%	83.6%
≥ .75 Volts	92	0.85	0.552	0.440	65.3%	52.1%
	Cycle 7 (1998 - 1999) - 342.5 EFPD					
Entire Voltage Range	2262	0.41	0.174	0.185	42.6%	45.4%
V_{BOC} < .75 Volts	2141	0.38	0.164	0.175	43.0%	45.9%
≥ .75 Volts	121	0.89	0.348	0.371	39.2%	41.8%
	Cycle 6 (1997 - 1998) - 564.9 EFPD					
Entire Voltage Range	1484	0.31	0.13	0.08	42%	27%
V_{BOC} < .75 Volts	1437	0.29	0.13	0.08	44%	29%
≥ .75 Volts	47	0.93	0.16	0.10	17%	11%
	Cycle 5 (1995 - 1997) - 450 EFPD					
Entire Voltage Range	703	0.31	0.12	0.10	39%	31%
V_{BOC} < .75 Volts	696	0.31	0.12	0.10	39%	32%
≥ .75 Volts	7	0.91	0.20	0.16	22%	18%

Average Voltage Growth Statistics – Composite of All Steam Generators

Table 6.1-3
South Texas Unit 2 2001 EOC-8 Outage
Summary of Calculations of Tube Leak Rate and Burst Probability

SG	Indication	POD	Number of Indications(1)	Max. Volts	Burst Probability 1 Tube	Burst Probability 1 or More Tubes	SLB Leak Rate (gpm)(2)
EOC - 8 PROJECTIONS(3)							
A	All Indications in the SG	0.6	509	5.8	2.4×10^{-3}	2.4×10^{-3}	0.20
B			1294	6.0	4.5×10^{-3}	4.5×10^{-3}	0.37
C			927	6.2	6.3×10^{-3}	6.4×10^{-3}	0.48
D			792	5.9	2.7×10^{-3}	2.7×10^{-3}	0.25
EOC - 8 ACTUALS Limited TSP Displacement							
A	At TSPs 2H to 4H	1	577	8.1	Negligible(4)	Negligible (4)	1.9
	At Other TSPs		34	1.5	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	1.0×10^{-4}
	Total		611	-	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	1.9
B	At TSPs 2H to 4H		1143	9.7	Negligible (4)	Negligible (4)	2.0
	At Other TSPs		86	5.3	1.0×10^{-3}	1.0×10^{-3}	0.09
	Total		1229	-	1.0×10^{-3}	1.0×10^{-3}	2.1
C	At TSPs 2H to 4H		884	8.2	Negligible (4)	Negligible (4)	2.7
	At Other TSPs		88	1.3	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	4.1×10^{-4}
	Total		962	-	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	2.7
D	At TSPs 2H to 4H		704	11.1	Negligible (4)	Negligible (4)	5.7
	At Other TSPs		64	2.4	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	2.8×10^{-3}
	Total		768	-	$< 4.0\times10^{-6}$	$< 4.0\times10^{-6}$	5.7
EOC - 8 ACTUALS GL 95-05 Methodology							
A	All Indications in the SG	1	611	8.1	2.6×10^{-2}	2.7×10^{-2}	1.4
B			1229	9.7	2.8×10^{-2}	2.9×10^{-2}	1.4
C			972	8.2	3.4×10^{-2}	3.5×10^{-2}	1.7
D			768	11.1	6.2×10^{-2}	6.5×10^{-2}	2.9

Notes: (1) Adjusted for POD.
(2). Equivalent volumetric rate at room temperature.
(3) Based on a Projected Cycle 8 length of 461 EFPD (vs 458 EFPD actual).
(4) Much less than 10^{-5} (Reference 16).

Figure 6-1
South Texas Unit-2 March 2001
Comparison of Cycle 8 Growth Rates with Braidwood-1 and Byron-1 Data
Composite of All Steam Generators

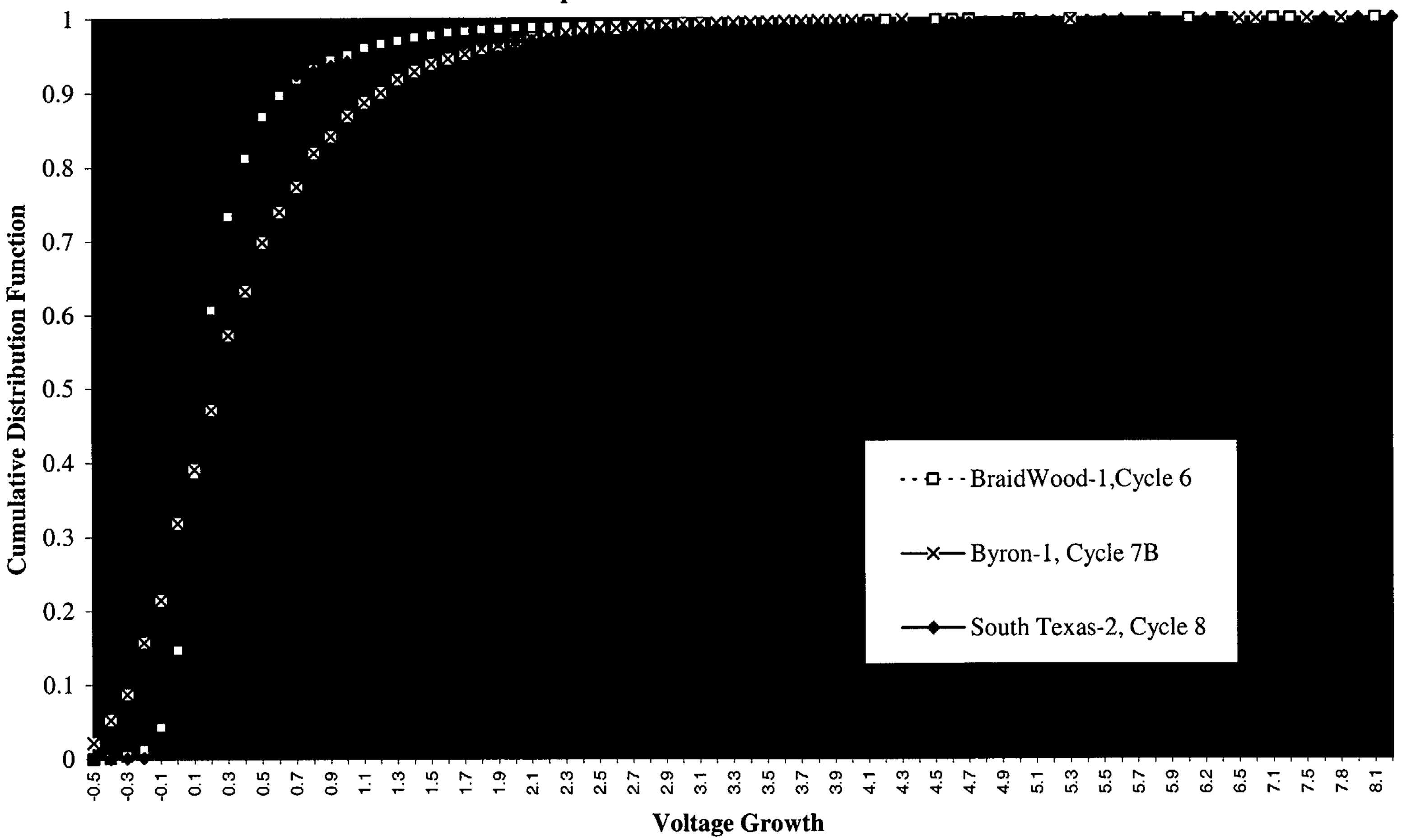
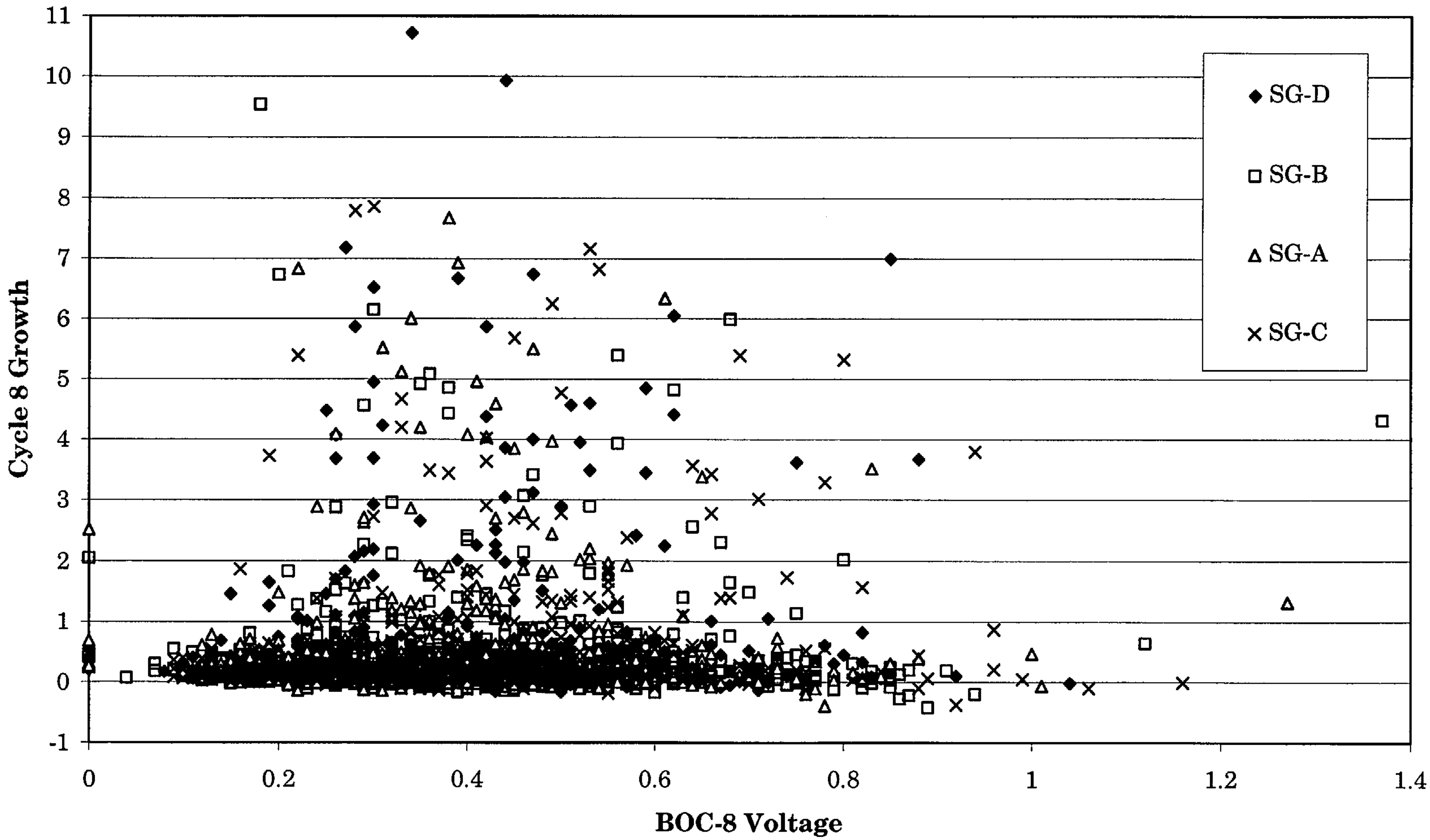


Figure 6-2
South Texas Unit-2
Growth During Cycle 8 as a Function of BOC Voltage



6.2 Circumferential Cracking

The purpose of this section of the report is to deal with the structural integrity of the circumferential indications found during the inspection. A total of ten (10) circumferential indications were detected, with nine (9) of those being at the top of the hot-leg tubesheet and one (1) at a paired-ding feature located about 3.5" above the 16C tube support plate. All of these indications were plugged. A summary table extracted from the plugging list is provided in Table 6.2-1. Examination of the table data indicate that most of the indications are too small to reliably size, hence the subsequent reported depths and areas should not be considered to be very accurate. This is not a shortcoming because the indications are small. The locations of the cracking relative to the row and column numbers in the SGs are illustrated on Figure 6.2-1.

RPC profiles were generated for all of the circumferential indications in order to estimate the depth of the indications as a function of the length along the indications. A summary of the profile information is provided in Table 6.2-2. None of the indications were considered to have structurally significant percent degraded areas (PDAs). The maximum value observed was on the order of 25 to 29% after adding a degradation allowance to account for the potential for undetected crack depth at the ends of the crack (taken as 30% over the reported length of the indication). Figure 6-10 of the EPRI circumferential cracking document, Reference 13, shows that the burst strength of a circumferentially cracked tube with a PDA of 75% is half of that of a non-degraded tube. For the STP SG tubes these values would be on the order of 5,000 and 10,000 psi respectively. The expected burst pressure for at tube with an observed PDA of 30% would be on the order of 75% of that of a non-degraded tube or about 7,500 psi.

For small indications with large reported depths, the maximum depth information is likely to be inaccurate. The reason for this is that the maximum depths are usually reported to occur near the ends of the crack where the transition from cracked material to uncracked material causes a change in the phase angle leading to a prediction of significant depth. (This was observed during the development of the sizing methods for cracks at dented intersections.) A crack with a reported angular extent of 40° has an arc length of about 1/4". For this reason, the depths are strongly suspected of being significantly overestimated. This suspicion was essentially confirmed by the results of in situ leak and proof testing.

Three of the most severe indications, based on depth and PDA considerations, B-R28C81, C-R04C97, and D-R06C10, were leak and pressure tested in situ with no evident leakage or failure of the tubes. The leak tests were conducted to maximum differential pressures in the range of 2845 to 2925 psi. The proof tests were conducted to pressure differences ranging from 4305 to 4315 psi. The details of the testing are provided in the section 5 of this report.

Table 6.2-1: Summary of Circumferential Indications from the Plugging List								
Index No	**SG**	**Row**	**Col**	**Loc**	**Inch1**	**Ind**	**Volts**	**Extent**
7	A	45	80	TSH	-0.16	SCI	0.13	21
8	A	4	84	TSH	-0.15	SCI	0.18	17
11	A	20	110	TSH	0.00	SCI	0.48	26
13	B	35	31	TSH	-0.07	SCI	0.19	35
15	B	28	81	TSH	-0.02	SCI	0.21	96
19	C	3	59	TSH	-0.16	MCI	0.11	29
30	C	4	97	TSH	-0.11	SCI	0.59	93
33	D	6	10	16C	3.50	SCI	0.30	168
34	D	4	71	TSH	-0.14	SCI	0.32	61
37	D	27	108	TSH	0.30	SCI	0.39	40

Table 6.2-2: Summary of Evaluation Information for the Circumferential Indications Found this Outage									
Tube	Elevation	Max Volts	Axial Offset	ID / OD	Profile Length	Reported Length	Profile PDA	Adjusted PDA	Maximum Depth
A-R04C084	TSH	0.18	-0.15	OD	17.0°	64.0°	0.8%	5.2%	33.0%
A-R20C110	TSH	0.48	-0.01	ID*	26.4°	26.4°	3.8%	3.8%	97.0%
A-R45C080	TSH	0.13	-0.15	OD	21.4°	39.0°	0.3%	2.2%	12.0%
B-R28C081	TSH	0.21	-0.06	OD	96.3°	123.0°	17.1%	19.7%	97.0%
B-R35C031	TSH	0.19	-0.09	OD	34.7°	66.0°	3.0%	6.1%	55.0%
C-R03C059	TSH	0.11	-0.16	OD	29.3°	89.0°	1.6%	7.1%	39.0%
C-R04C097	TSH	0.58	-0.12	OD	93.2°	189.0°	13.4%	22.0%	91.0%
D-R04C071	TSH	0.32	-0.16	OD	60.7°	140.0°	3.2%	10.4%	34.0%
D-R06C010	16C	0.93	3.56	OD	167.5°	186.0°	27.5%	29.5%	100.0%
D-R27C108	TSH	0.39	0.30	OD	39.5°	93.0°	8.4%	13.5%	99.0%

* Preliminary assessment; further review continuing.

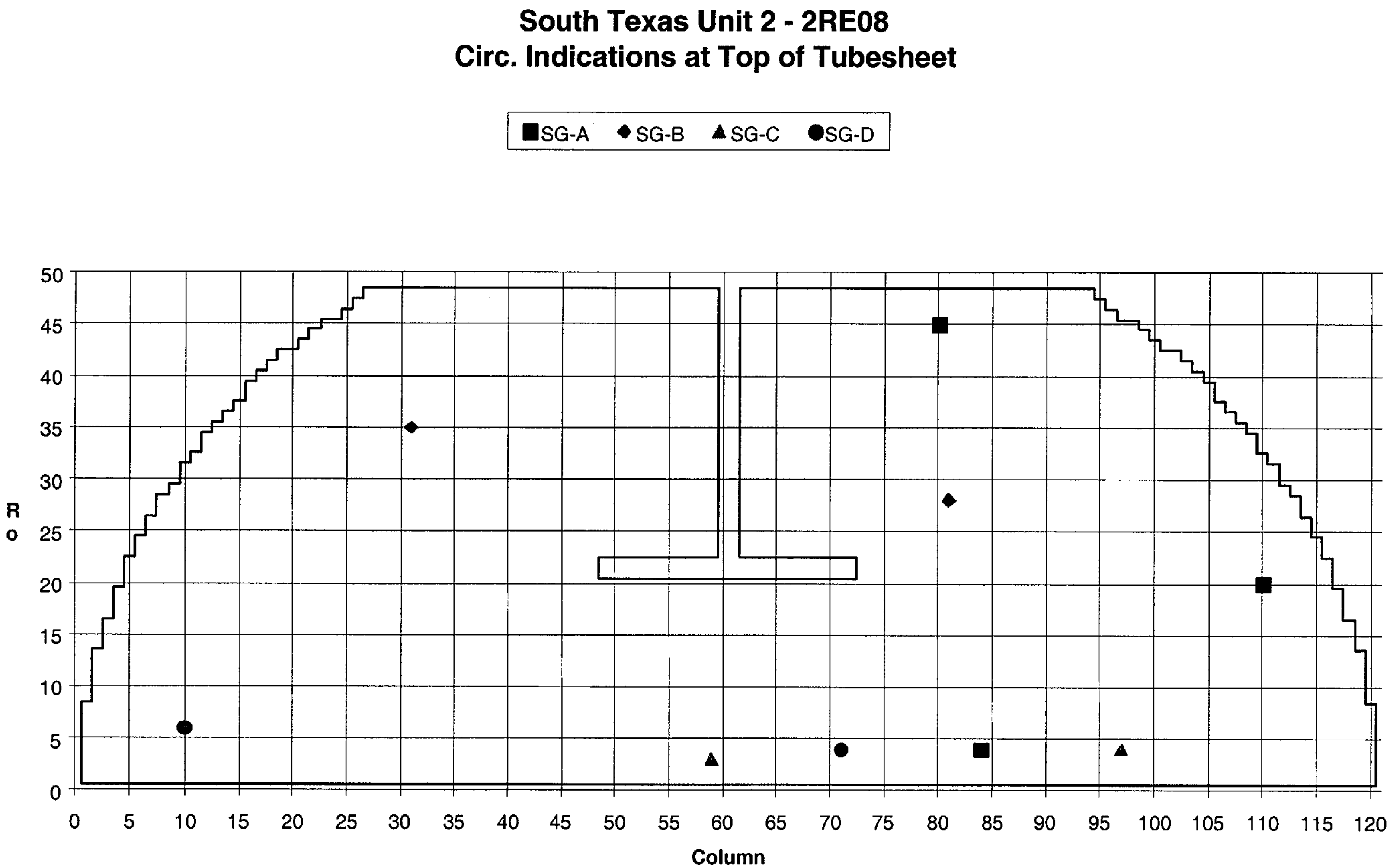


Figure 6.2-1: Location of Circumferential Indications

6.3 Freespan Cracking

A total of twenty-five (25) freespan axial cracks were found in the STP Unit 2 SG tubes. Of these, all twenty-five (25) were concluded to be of OD origin. Also, one (1) of the OD origin indications was a U-bend indication and is also discussed separately in this report. Per Table 4.1-1, the indications were distributed as 7, 1, 13, and 5 (including the U-bend indication) in SGs A, B, C, and D respectively. The cracks are described in the following sections. Two of the indications were considered to be significant because the estimated ligament tearing pressures were less than or on the order of 4000 psi. In general, the lengths of the cracks were on the order of 0.25" or less. One indication had a reported length of about one-half inch. In summary, the condition monitoring requirements were demonstrated by analysis or in situ testing to be met for all tubes with reported OD axial cracking.

6.3.1 ODSCC

A summary of the freespan OD axial cracks found in the STP Unit 2 SGs is presented in Table 6.3-1. A total of twenty-five (25) were reported for profiling and strength evaluation. A mean expected burst pressure for each of the indications was calculated using a Westinghouse burst pressure model based on finding the weakest link in a complex crack profile. A description of the model and the methodology for the calculation is provided in Reference 17. Because of recent concerns regarding the database used for the development of industry burst models (the potential for the results to be affected by the rate of pressurization of the test specimens) the ligament tearing pressure for each of the specimens was also calculated, Reference 18. The coefficients of the ligament tearing model were modified slightly to correspond to results obtained from an ANL reanalysis of the PNL data in February of 2000. It is noted that both models utilize the same methodology for finding the weakest structural section of the crack profile.
Some of the profiles were modified for the burst and ligament tearing calculations in accord with accepted practice if the measured depths were determined to be artificially exaggerated at the ends of the flaw by the NDE process itself. It is not unusual for this to occur. However, in most cases the adjustment of the profile was not necessary because the indications are so small that the margins relative to the structural integrity criterion are large. The results of the analyses demonstrate that all of the cracks would be expected to exhibit burst and ligament tearing pressures greater than the $3 \cdot \bullet P_{NOp}$ structural limit for South Texas. Since all of the affected tubes were plugged, structural integrity at the end of the next operating period would be expected to be similar to that found at this inspection.

There were two freespan, axial cracks detected in the STP Unit 2 SG tubes that had eddy current signal phase angles that could have been interpreted as indicative of ID flaws. However, this indication is a result of the interference of the dent signal with the flaw signal when the +Point probe is being used and the flaws are consider to be OD in origin. These are also listed in Table 6.3-1 as SG A, R39C16 and SG C, R10C64. Both were found at dinged tube locations. The crack in the tube at R10C64 in SG C had a predicted ligament tearing pressure significantly less than the $3\cdot\bullet P_{NOp}$ structural criterion. This is because the profile maximum depth was reported to be 97%. The tube was leak rate and proof pressure tested in situ. No leakage occurred at a differential pressure corresponding to SLB conditions, and no burst or tearing of the tube at $3\cdot\bullet P_{NOp}$ conditions (note that the applied pressures are adjusted to account for the test being performed at room temperature). The tube at location R39C16 in SG A was also leak and proof tested with no remarkable results, i.e., the tube did not leak and burst or tearing was not observed.

6.3.2 PWSCC

No axial flaws were found which were concluded to have originated on the ID of the tube.

Table 6.3-1: Summary of Freespan Axial Cracks

SG	Row	Col.	Bobbin Call	Burst Model (psi)	Tearing Model (psi)	Maximum Depth	Notes	Leak Rate at 2840 psi	Proof Pressure (psi)
A	26	114	NQI	6065	4857	98			
A	35	35	NQI	7132	7394	79			
A	35	69	None	8034	8189	72	>5V		
A	36	52	NQI	5741	5027	100			
A	36	104	NQI	8633	8257	83			
A	39	16	DNI	5141	4368	100	>5V 2)	Zero	4150
A	42	24	DNI	6829	7055	79			
B	17	81	DNI	9327	9160	58			
C	3	35	DNI	10451	9224	19			
C	7	47	DNI	10215	10103	61			
C	7	72	DNI	9923	9722	65			
C	10	64	DNI	4347	1973	97		Zero	4150
C	16	79	DNI	10507	9199	16			
C	18	94	None	11280	10337	39	>5V 3)		
C	18	94	None	8140	7558	71	>5V 3)		
C	18	94	None	8461	8323	74	>5V 3)		
C	32	93	DNI	9512	9027	58			
C	39	16	DNI	13427	11448	6			
C	39	74	DNI	7826	7922	73			
C	48	92	DNI	11727	10039	8			
C	48	94	DNI	10152	9357	53			
D	1	2	No Test	7612	7708	89			
D	1	83	DNI	12490	10820	12			
D	6	10	DNI	12277	11411	43			
D	13	119	DNI	10289	10018	51			
D	35	82	NQI	8566	8884	84			

Notes:

1) Actual elevated temperature properties were used for all but R1 C2, which used a flow stress of 80 ksi.
2) R39 C16 SG A has no discernable change in bobbin signals from 2RE06 to 2RE08, additionally, the more the analysts looked at it, the more they felt it was not flawed. The ding amplitude was approximately 30 volts. The channel 5 phase was consistently about 163° for all 3 inspections. If assumed flawed, and the flaw produced the channel 5 rotation, there has been no growth since 2RE06.
3) R18 C94 SG C has no discernable change in bobbin signals from 2RE06 to 2RE08, even though the ding amplitude is only about 6 volts. If this tube is truly flawed at the depths predicted by +Pt, then there should have been some measure of channel 5 rotation. However, there was no rotation at all in channel 5.
4) Axial ODSCC in DNIs was adjusted using the guidelines previously developed.
5) Axial ODSCC in NQIs was adjusted at the tail if the volts were low and depth was high.
6) NQI adjustment averaged the depth between the 0% depth end point and third point.

6.4 U-bend ODSCC

One indication in SG D Tube R1C2 was found in the U-bend near the apex at about 9.1 inch from the top hot leg TSP 10. The indication is an axial ODSCC indication about 0.15" long, and was detected in the reference inspection with the mid-range +Point probe. Even though the indication is a low voltage (< 0.3 volt) OD signal, the indication can be clearly seen in a supplemental inspection performed with the high frequency +Point probe, which is more sensitive to ID degradation. The initial inspection consisted of a 100% mid-range +Point inspection of Row 1 tubes and a 20% inspection of Row 2 tubes. When the indication was found in SG D, the inspection was expanded to include 100% of the Row 2 U-bend tubes in SG D. No other indications were found in the initial or expanded inspections. For one tube (SG D, R1C57), the probe did not completely traverse the U-bend resulting in an incomplete test and the indication was preventively plugged.

The flaw signal to noise ratio for R1C2 was about 1.2 at 400 kHz, about 0.8 at 600 kHz and about 0.5 at 800 kHz. The evaluation of the R1C2 indication with a maximum amplitude < 0.3 volt shows that small signals can be detected in the U-bend, and detection was found for a signal to noise ratio near unity. For this indication, the high frequency results do not reduce the noise levels compared to the 400 kHz data. However, noise levels in R1C2 for the mid-range probe at 400 kHz were not horizontal and the indication could be better sized with the high frequency probe. The best data for sizing is the 600 kHz data from the high frequency probe based on signal to noise and horizontal noise at this frequency. Applying the axial ODSCC sizing techniques for indications at TSP intersections developed in Reference 19 to the 600 kHz data, the R1C2 length is 0.14", maximum depth is 71% and average depth is 49%. The 800 kHz data yields shallower depths but is judged to be less reliable due to the poorer signal to noise ratio, and the 400 kHz data cannot be sized with any confidence since the non-horizontal noise adds to the flaw phase angle to yield over estimates of depth.

Based on the short length and modest depths for R1C2, the burst pressure would be expected to exceed 8000 psi and no leakage would be expected at SLB conditions. This conclusion was confirmed by the results of the in situ test. Since the indication is in the U-bend, the indication was tested as a whole tube in situ test. No leakage was found in the leakage test to 2841 psi at room temperature (about 2600 psi adjusted to hot conditions), which more than bounds the South Texas-2 2405 psi SLB condition. The indication was then pressure tested to 4154 psi, which bounds the $3\Delta P_{NO}$ burst margin requirement. The in situ test confirmed that the burst margin is satisfied, and the test also was completed with no leakage even at the peak pressure of 4154 psi. The no-leakage result at 4154 psi confirms that the depths are not very deep where depths greater than about 95% would be required for throughwall ligament tearing of the short crack length at this pressure.

It is concluded that the in situ test results demonstrate that burst margin and leakage requirements are satisfied and condition monitoring requirements are met. The detection of the low voltage (< 0.3 maximum +Point volt) indication supports adequate detection in the U-bend with the mid-range probe.

6.5 Volumetric Indications

Twenty-one tubes were reported (see Table 6.5-1) as exhibiting volumetric indications as determined by +Point characterization of locations identified by bobbin probe inspection in all but one instance. Only the SVI on C48/93-22C+0.63" was reported directly from +Point since the indication was adjacent to an expanded intersection; this tube was examined as part of the +Point program for expanded preheater intersections.

MBM

MBM indications accounted for 12 of the 21 tubes in the volumetric category. According to the Degradation Assessment, detection of unclassified, freespan signals is accomplished by bobbin probe inspection. Reviewing the prior history data for the tube identifies new bobbin signals that are not potentially MBMs. Current unclassified signals identified in the baseline (or early ISI) that have not changed are called MBMs and are not RPC inspected or repaired. Those freespan indications that cannot be called MBMs on the basis of bobbin history lookup will be +Point inspected. Those +Point signals whose characterizations conform to shallow volumetric wall loss (usually < 20%) are designated VOL and are not required to be plugged. By definition, MBMs are referred to acceptable as-built conditions and do not represent in-service degradation. Therefore, in situ testing is not warranted and the condition monitoring requirements are satisfied.

NQI

Freespan bobbin indications reflective of potential flaw locations are designated NQI (non-quantifiable indication) unless +Point examination confirms the absence of detectable degradation; unconfirmed indications are designated as NQS (non-quantifiable signal). All NQIs must be +Point tested. If confirmation of degradation is confirmed and is characterized as volumetric in nature inconsistent with MBM characteristics, the +Point result is designated SVI; these indications are reflective of on-going tube degradation and are required to be plugged.

For tube integrity purposes such as the need to perform in situ testing of tubes with such indications, the industry guidelines for in situ testing (Ref. 6) of volumetric indications were followed. Based on RPC testing, the 3 indications with TWD values below the 77% uniform thinning structural limit (A45/69-72%, C48/93-66%, and C16/115-54%) satisfy condition monitoring requirements. The bobbin data characteristics of the 2 SVIs with TWD values greater than 77% (A28/106-90% by RPC/0.23 volts bobbin and C29/65-87% by RPC/0.24 volts bobbin) represent amplitudes far below the voltages expected for uniform thinning. A 10% uniform thinning ring of just 0.075" axial length is expected to produce a bobbin amplitude in excess of 5 volts. On the basis of the small amplitudes from both RPC and bobbin probes, these volumetric indications (SVIs) are demonstrated to satisfy conditioning monitoring requirements.

6.6 Tube Wear at AVBs and Tube Support Plates

Seventy indications of AVB wear were reported, 11 at AVB intersection that had not previously been reported (See Table 6.6-1). The maximum depth of wear reported at any indication was 32% TW; no tubes were plugged for AVB wear. The maximum wear depth among the new indications reported was 18% TW.

Reference 5 provides a structural limit for AVB wear of 77% TW. Similarly, Reference 5 provides the sizing uncertainty for AVB wear of 16.9% at the 95% one-sided confidence interval. (More recent data are available that show that the sizing uncertainty for AVB wear is significantly less than 16.9% at the 95% confidence limit).

Considering the maximum indication of wear at the AVB intersection left in service, 32% TW, adding the NDE sizing uncertainty at 95% confidence, 16.9%, the resulting wear depth of 48.9% TW is less than the structural limit for AVB wear, 77% TW. Therefore, the structural criteria for condition monitoring are satisfied for the AVB wear degradation mechanism.

Another category of indication characterized by +Point as volumetric wall loss is found at baffle plate locations; these may be detected at unexpanded preheater baffles by bobbin probe analysis and are reported as RWS indications. A bobbin retest with a TSP wear scar standard in place is conducted to provide an estimate of the % TWD (throughwall depth), using an Appendix H-qualified technique (ETSS96004.3).

The 4 indications of wear at support plate intersections (RWS) were all reported at preheater baffle plates (see Table 6.5-1), one in each SG. The maximum wear depth reported was 5%TW; therefore, in situ testing is not warranted. The NDE sizing uncertainties that apply for TSP wear are 14.1% at 95% confidence, when the support plate sizing data from ETSS 96004.3 are considered. Assuming uniform thinning of a tube, the structural limit for the tube is shown to be 62%TW. The potential degradation at the 95% CL, 19.1% (5% + 14.1%), is less than the structural limit, 62% TW, for assumed uniform thinning; thus, the requirements for condition monitoring are satisfied for the degradation mechanism of wear at the TSP intersections.

Table 6.5-1
Summary of Volumetric Indications

SG	CAL	ROW	COL	VOLTS	DEG	IND	% TWD	LOCN	INCH1	BEGT	ENDT	PDIA	PTYPE	Bobbin Result
A	77	11	37	0.71	110	VOL	NA	TSH	3.86	TSH	TSH	0.61	ZPSNM	MBM
A	129	28	106	0.2	48	SVI	NA	06H	15.17	06H	07H	0.61	ZPSNM	NQI
A	131	45	69	0.12	65	SVI	NA	05H	29.06	05H	06H	0.61	ZPSNM	NQI
A	110	47	86	1.53	136	VOL	0	21C	-0.48	21C	21C	0.61	ZPSNM	RWS
B	75	2	75	0.32	48	VOL	NA	TSH	2.5	TSH	TSH	0.61	ZPSNM	MBM
B	57	8	23	1.23	136	VOL	NA	TSH	0.35	TSH	TSH	0.61	ZPSNM	MBM
B	69	22	91	1.24	116	VOL	NA	TSH	1.44	TSH	TSH	0.61	ZPSNM	MBM
B	69	26	88	0.65	94	VOL	NA	TSH	3.6	TSH	TSH	0.61	ZPSNM	MBM
B	130	46	89	0.39	101	VOL	4	22C	0.25	22C	22C	0.61	ZPSNM	RWS
C	141	16	115	0.09	82	SVI	NA	04H	18.4	04H	05H	0.61	ZPSNM	NQI
C	79	23	94	0.68	122	VOL	NA	TSH	0.89	TSH	TSH	0.61	ZPSNM	MBM
C	157	29	65	0.16	50	SVI	NA	07H	16.22	07H	08H	0.61	ZPSNM	NQI
C	118	42	86	1.06	105	VOL	NA	21C	0.59	21C	21C	0.61	ZPSNM	MBM
C	134	47	29	2.19	142	VOL	0	21C	-0.25	21C	21C	0.61	ZPSNM	RWS
C	110	48	93	0.13	103	SVI	NA	22C	0.63	22C	22C	0.61	ZPSNM	NDD
D	17	15	55	0.99	106	VOL	NA	TSH	6.69	TSH	TSH	0.61	ZPSNM	MBM
D	17	19	59	0.63	87	VOL	NA	TSH	2.45	TSH	TSH	0.61	ZPSNM	MBM
D	15	31	54	0.43	94	VOL	NA	TSH	2.15	TSH	TSH	0.61	ZPSNM	MBM
D	120	41	102	1.29	61	VOL	NA	13C	21.11	13C	13C	0.61	ZPSNM	MBM
D	141	47	67	0.37	96	VOL	NA	02H	22.71	02H	03H	0.61	ZPSNM	MBM
D	118	47	82	1.17	143	VOL	4	19C	-0.32	19C	19C	0.61	ZPSNM	RWS

Table 6.6-1 Summary of AVB Wear Indications					
	SG-A	SG-B	SG-C	SG-D	Total
Total AVB Ind	15	18	12	25	70
Prior Indications	10	16	10	19	55
Max Wear Depth	19%	33%	25%	32%	xxxxxxxxxxx

References

1. NEI 97-06, Rev. 1; Steam Generator Program Guidelines; Nuclear Energy Institute, October 2000.

2. NRC GL-95-05, "Voltage-Based Repair Criteria for the Repair of Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking", USNRC Office of Nuclear Regulation, August 3, 1995.

3. SG-99-12-010, South Texas Unit 2 Cycle 8 Voltage-Based Repair Criteria Report; Westinghouse Electric Company; December 1999.

4. SG-99-11-001, Rev. 1; South Texas Project 2RE07 Outage Final Condition Monitoring Report and Operational Assessment; Westinghouse Electric Company; November 1999

5. SG-01-02-001, Rev. 1; South Texas Project Unit 2 Steam Generator Degradation Assessment 2RE08 Refueling Outage; Westinghouse Electric Company; February 2001. (Proprietary)

6. TR-107620-R1, Steam Generator In Situ Pressure Test Guidelines; EPRI, June 1999.

7. Letter, Lawrence F. Womack to SGMP Utility Steering Committees, "Steam Generator Management Program (SGMP) Information Letter Concerning Lessons Learned from a Review of Recent Steam Generator Related Issues", September 29, 2000.

8. SG-01-01-001;Site-Specific Eddy Current Noise Evaluation Methodology Relating to SG Tube Integrity; Westinghouse Electric Company (January 2001)

9. WD01002-DD-01-FR, Final Test Report for UTEC Examination Steam Generator Tubes at South Texas Project Unit 2, March 2001.

10. TR-107569; PWR Steam Generator Examination Guidelines: Revision 5; EPRI, September 1997.

11. NP-7480-L,V2-Rev1; Steam Generator Tubing Outside Diameter Stress Corrosion Cracking at Tube Support Plates-Database for Alternate Repair Limits, Volume 2: ¾ Inch Diameter Tubing; EPRI, August 1996.

12. NP-7480-L,Addendum 3; Steam Generator Tubing Outside Diameter Stress Corrosion Cracking at Tube Support Plates-Database for Alternate Repair Limits, EPRI, May 1999.

13. TR-107197-P1, "Depth-Based Structural Analysis Methods for Steam Generator Circumferential Indications," EPRI, Palo Alto, CA (November 1997).

14. WCAP 15163, Rev. 1, Addendum 1; South Texas Unit 2: 3V Alternate Repair Criteria Application of Bounding Analysis and Tube Expansions; Westinghouse Electric Company (January 2001).

15. WCAP-14277, "SLB Leak Rate and Tube Burst Probability Analysis Methods for ODSCC at TSP Intersections", Revision, Westinghouse Nuclear Services Division, December 1996.

16. WCAP-14273, "Technical Support for Alternate Plugging Criteria with Tube Expansion at Tube Support Plate Intersections for Braidwood-1 and Byron-1 Model D Steam Generators," Westinghouse Nuclear Service Division, February 1995.

17. WCAP-15129 (non-Proprietary), Revision 3, "Depth-Based SG Tube Repair Criteria for Axial PWSCC at Dented TSP Intersections," Westinghouse Electric Company (June, 2000).

18. NUREG/CR-6664, "Pressure and Leak-Rate Tests and Models for Predicting Failure of Flawed Steam Generator Tubes," U.S. Nuclear Regulatory Commission (August 2000).

19. LTR-SGDA-01-169, "Normal Operating Leakage Assessment for Preventive Plugging of ODSCC at TSPs South Texas Project Unit-2", June 18, 2001

Appendix A

U-Bend Detection of Low Voltage Indications

U-Bend Detection of Low Voltage Indications

Methodology

The South Texas Project Unit 2 steam generators have not had, until 2REO8, and reported U-bend indications. While comparison of noise levels between the qualification data set and the plant data may infer the detection of a postulated flaw, it is still only a statistical construct. A different means of evaluating the detectability of a postulated flaw is utilized in this document. The methodology to demonstrate the detectability of a postulated flaw involves the superposition of a controlled indication into the data stream for a tube. The tubes utilized for this technique are selected upon basic noise levels as described below. The postulated flaw is then superposed upon the plant noise levels in order to directly demonstrate its detectability. The position of the flaw can be controlled with respect to the location into which it can be inserted in terms of axial and azimuthal coordinates. By doing this in a systematic fashion, the effects of the differences in noise level on detection of the postulated flaw can be understood.

Construction of Postulated ID and OD Indications

The postulated indications to be inserted into the data stream can be, quite simply, derived from the eddy current standards. Particular ID and OD axial indications will be targeted for a voltage assignment and subsequent combination into the data from the U-bends. Based upon typical flaw amplitudes, voltages of 1.00 volt and 0.50 volt have been selected for ID and OD indications, respectively. The traditional technical specification plugging limit of 40% TW will be used to select which indications are to be targeted. For the purpose of this study the 40% ID and OD notches from the standard were selected. The amplitude of the target notch was set to the appropriate voltage and the selected data segment was removed for subsequent recombination with U-bend data.

STP-2 U-Bend Noise Ranges

A sampling of 62 U-bends from the 2REO8 was evaluated for overall noise levels. This was done using a simple approach in order to find the nominal and upper bound vertical amplitude for the U-bends. The vertical amplitude was selected because it is what is plotted on the C-scan plot which the analyst uses as a primary detection tool. The measurement of the vertical amplitude was done using a window that was large enough to encompass one scan line. This is consistent with what was done during the course of the inspection per the site analysis guidelines. Per the site guidelines, any vertical measurement greater than 0.75 volt was rejected. The data used were taken from mid-range probe data for steam generator D. This steam generator was selected because it had a reported OD axial indication in Row 1 Column 2. The results of the evaluation are tabulated below.

	Apex	Tangent
Minimum Noise (Vvm)	0.25	0.10
Maximum Noise (Vvm)	0.73	0.58
Nominal Noise (Vvm)	0.47	0.35

The noise at the tangent was similar in formation to that at the apex. The data through most of the U-bend was consistent in noise level and formation. Based upon that observation, it was decided that multiple data insertions could be made on a single U-bend in the region in and about the apex. The noise measurement for Row 1 Column 2 using the aforementioned methodology was 0.27 volt – well below the nominal level observed in the sampling.

Addition of Indications to Tubes

Two tubes from the sample group were selected for data combination; one with nominal noise levels and the other representing the maximum noise level observed in the sample. The data files for the tubes were copied multiple times for use in this study. The sample indications were inserted into the data multiple times. The insertions were done at approximately 30° intervals about the circumference. Three insertions were made into each data file. This is illustrated in Figure 1. This offset process was performed so that the indications would be inserted with the influence of all the noise variations seen about the circumference. The data were analyzed in order to determine the detectability of the target indication.

Results

Both target indications were detectable at all twelve circumferential locations in both the nominal and high noise environments. Figures 1 through 16 illustrate the detectability of the postulated indications under plant noise conditions. Based upon these data, it is shown that the postulated 40% ID and OD indications are detectable in the STP Unit 2 U-bend data.

Figure 1. 0.50 volt 40% OD indications from the standard inserted into data displaying nominal noise characteristics with 0°, 30° and 60° offsets relative to the original data. 60% OD indications are also present.

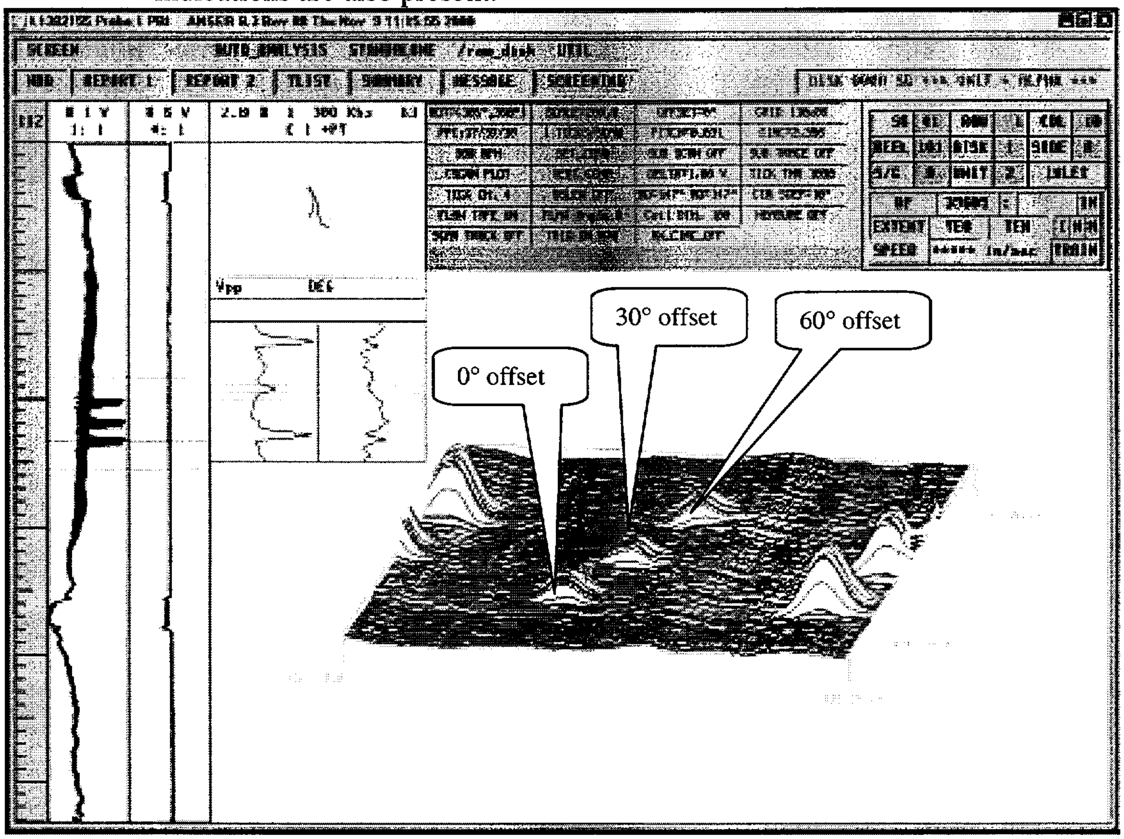


Figure 2. 0.50 volt 40% OD indications from the standard inserted into data displaying nominal noise characteristics with 90°, 120° and 150° offsets relative to the original data. 60% OD indications are also present.

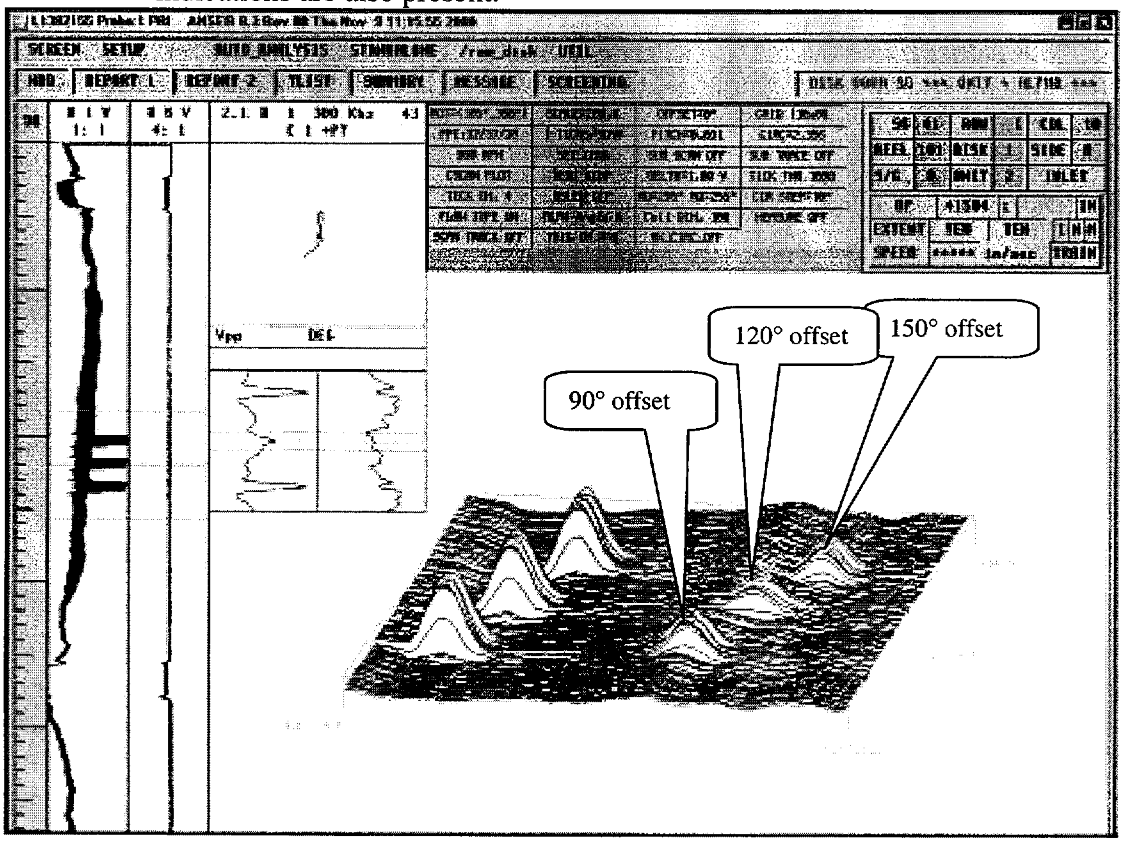


Figure 3. 0.50 volt 40% OD indications from the standard inserted into data displaying nominal noise characteristics with 180°, 210° and 240° offsets relative to the original data. 60% OD indications are also present.

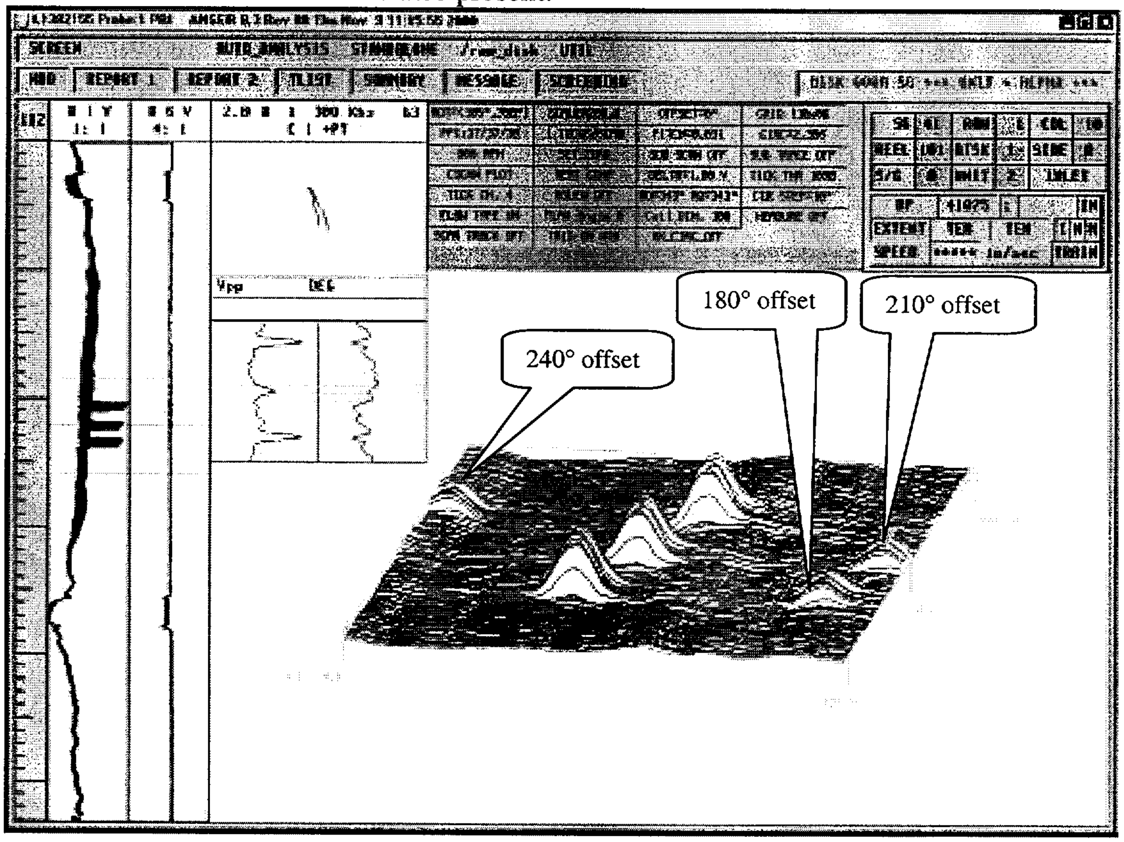


Figure 4. 0.50 volt 40% OD indications from the standard inserted into data displaying nominal noise characteristics with 270°, 300° and 330° offsets relative to the original data. 60% OD indications are also present.

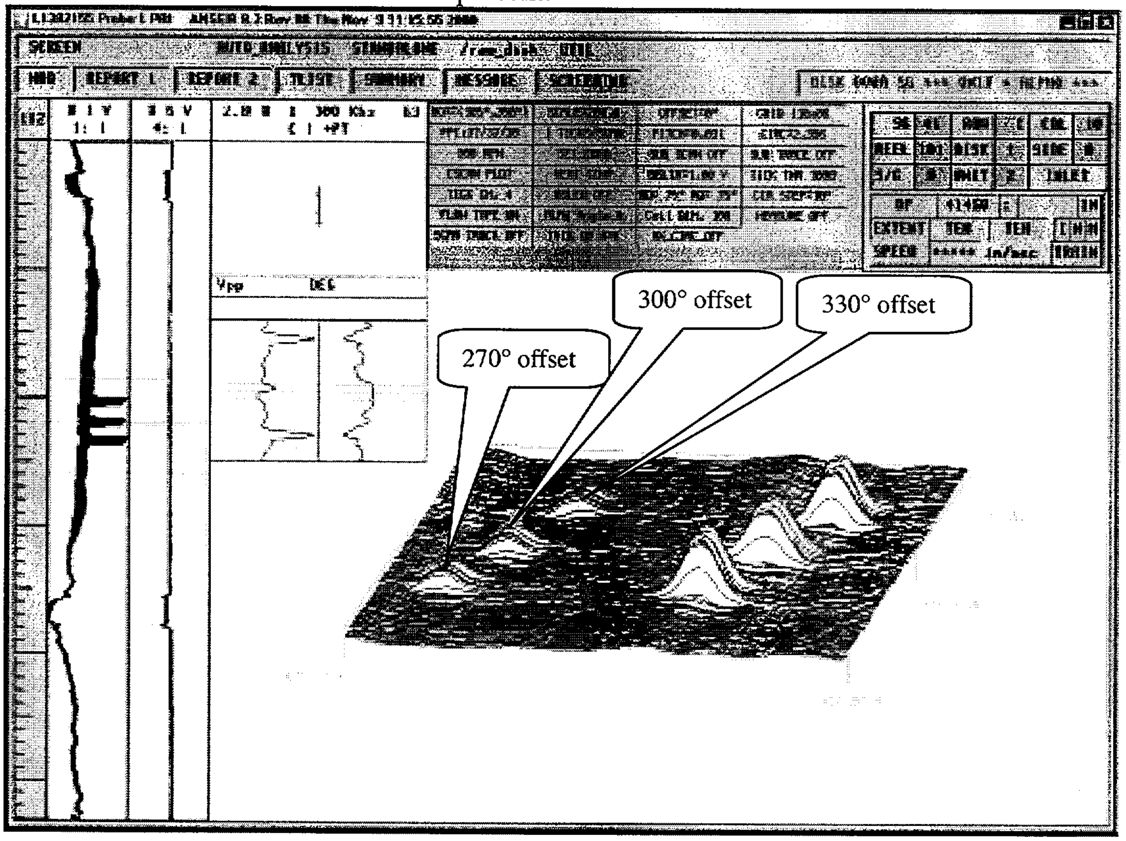


Figure 5. 0.50 volt 40% ID indications from the standard inserted into data displaying nominal noise characteristics with 0°, 30° and 60° offsets relative to the original data. 60% ID indications are also present.

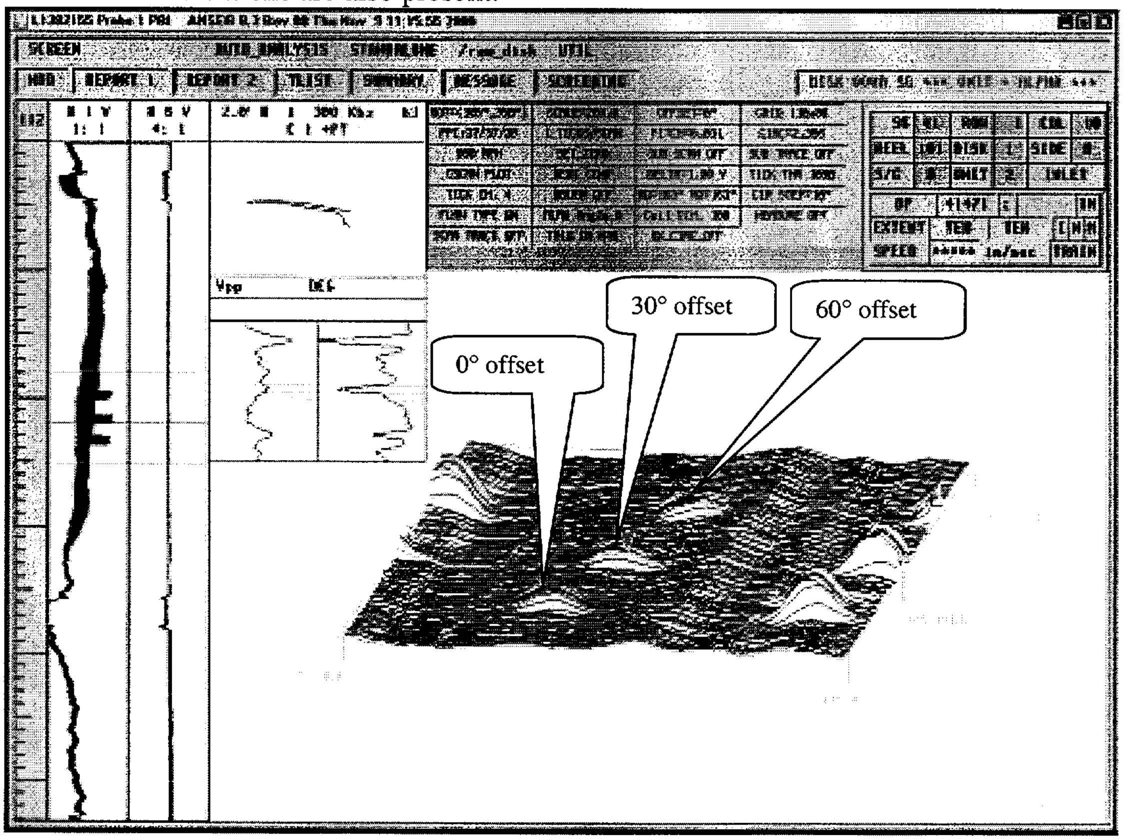


Figure 6. 0.50 volt 40% ID indications from the standard inserted into data displaying nominal noise characteristics with 90°, 120° and 150° offsets relative to the original data. 60% ID indications are also present.

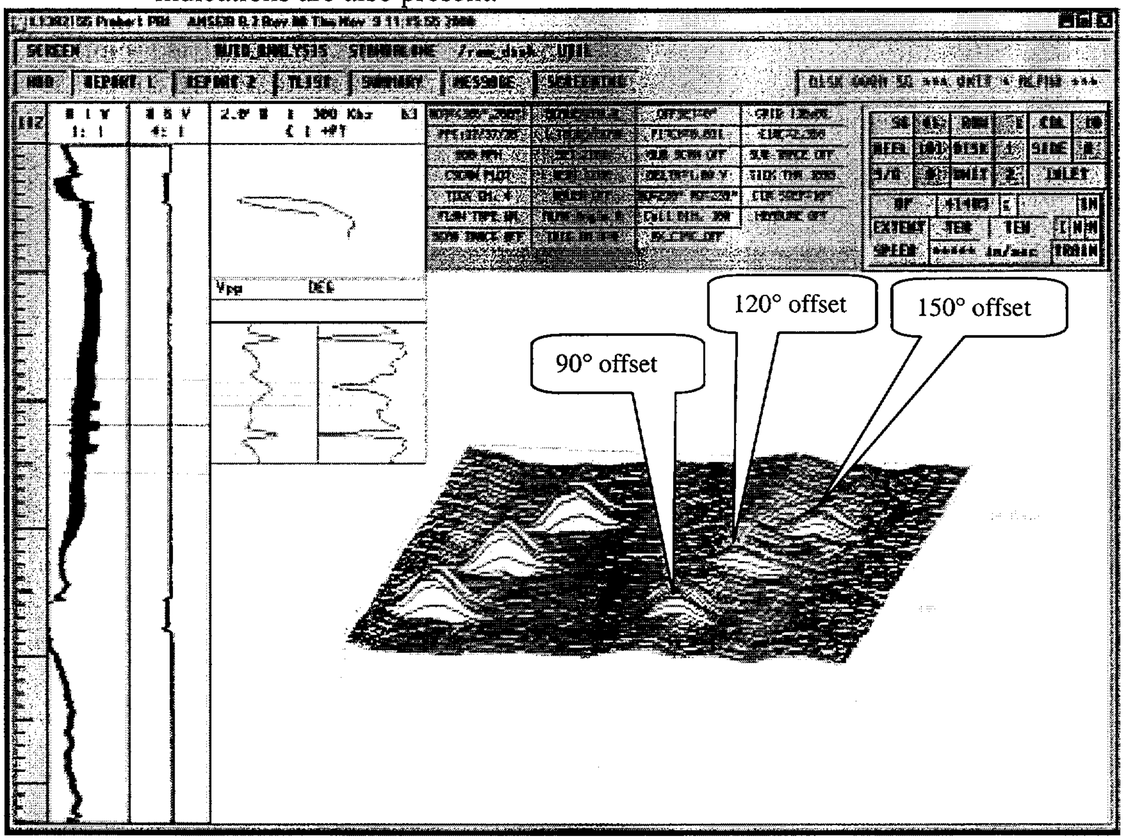


Figure 7. 0.50 volt 40% ID indications from the standard inserted into data displaying nominal noise characteristics with 180°, 210° and 240° offsets relative to the original data. 60% ID indications are also present.

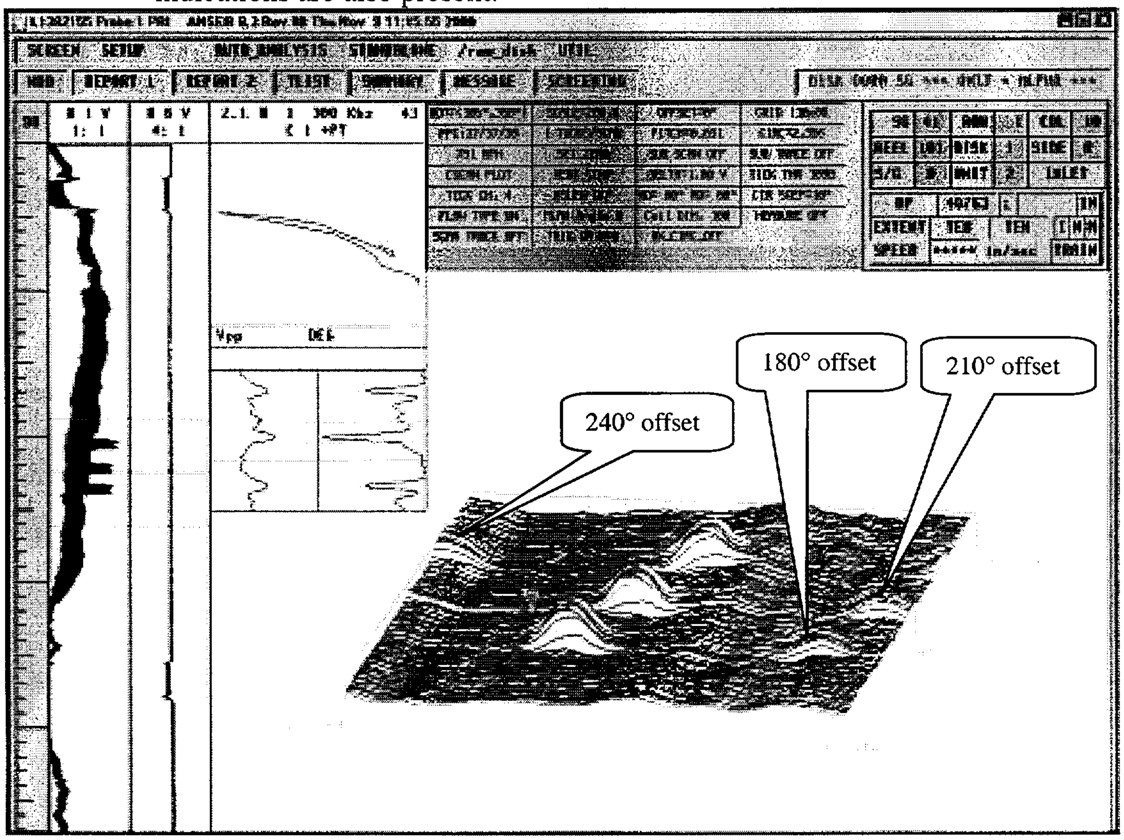


Figure 8. 0.50 volt 40% ID indications from the standard inserted into data displaying nominal noise characteristics with 270°, 300° and 330° offsets relative to the original data. 60% ID indications are also present.

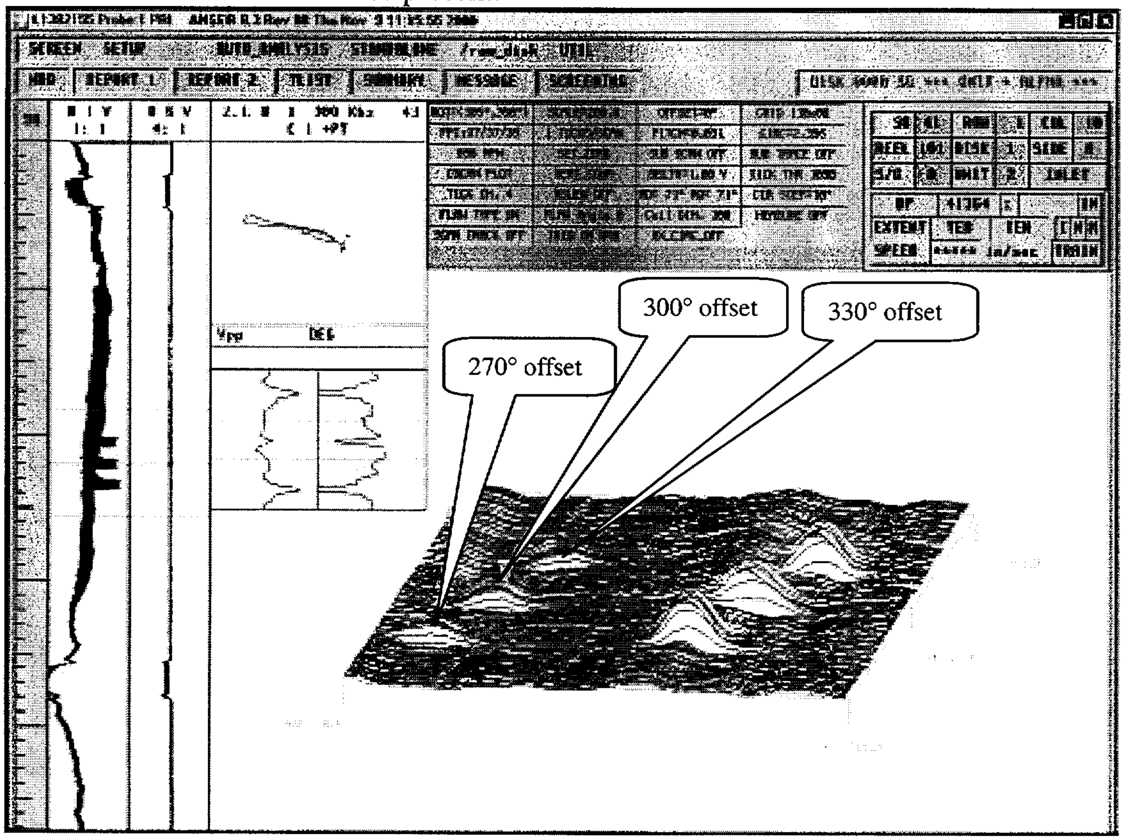


Figure 9. 0.50 volt 40% OD indications from the standard inserted into data displaying high noise characteristics with 0°, 30° and 60° offsets relative to the original data. 60% OD indications are also present.

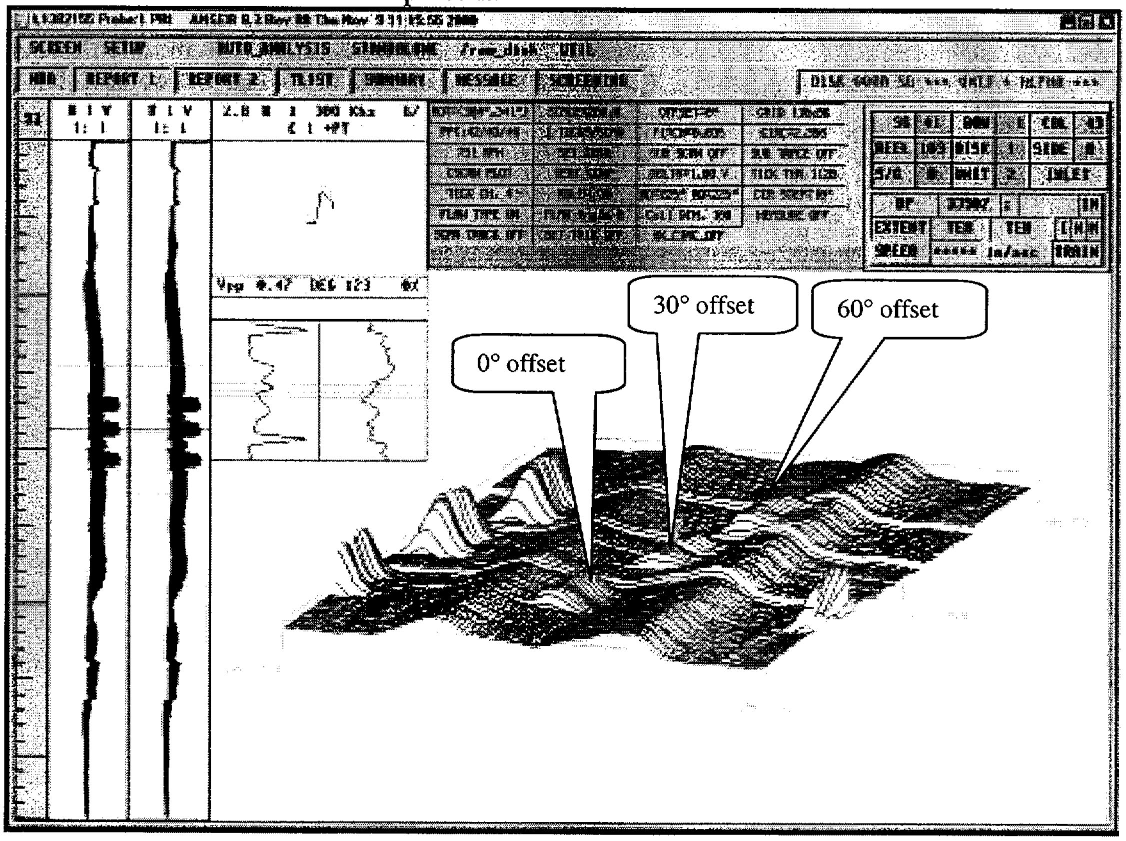


Figure 10. 0.50 volt 40% OD indications from the standard inserted into data displaying high noise characteristics with 90°, 120° and 150° offsets relative to the original data. 60% OD indications are also present.

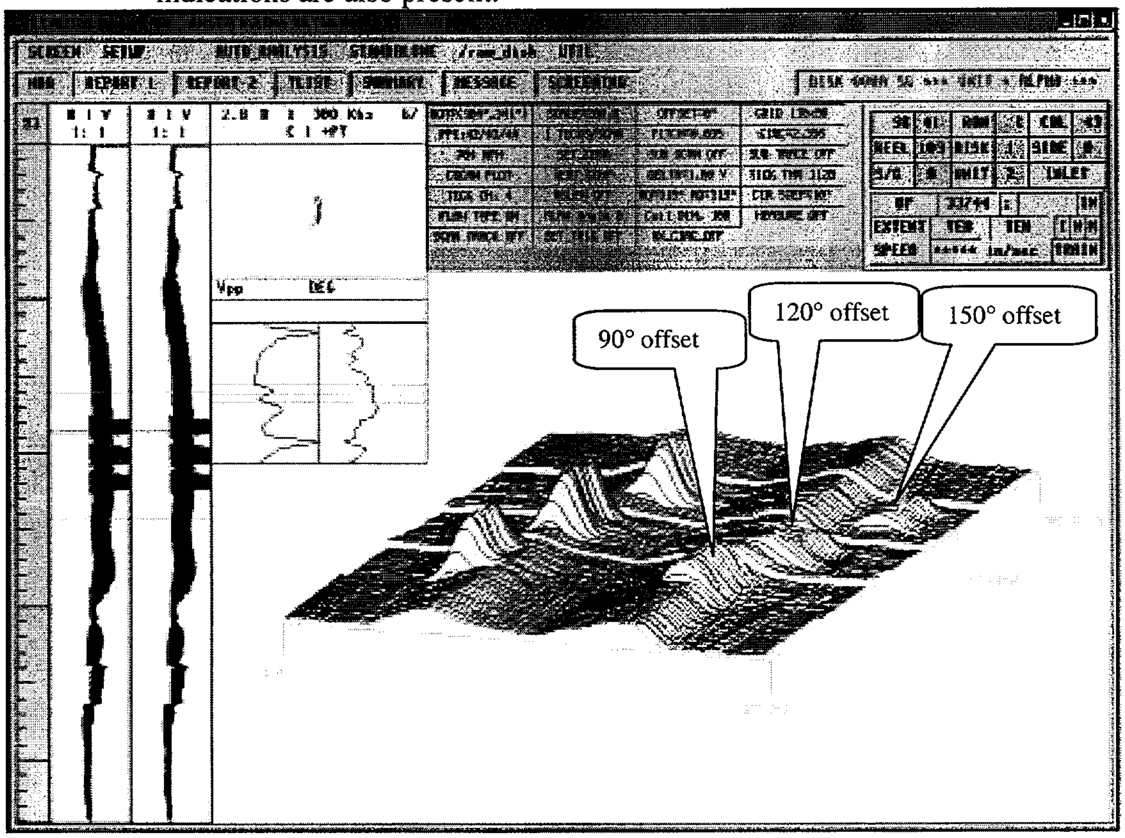


Figure 11. 0.50 volt 40% OD indications from the standard inserted into data displaying high noise characteristics with 180°, 210° and 240° offsets relative to the original data. 60% OD indications are also present.

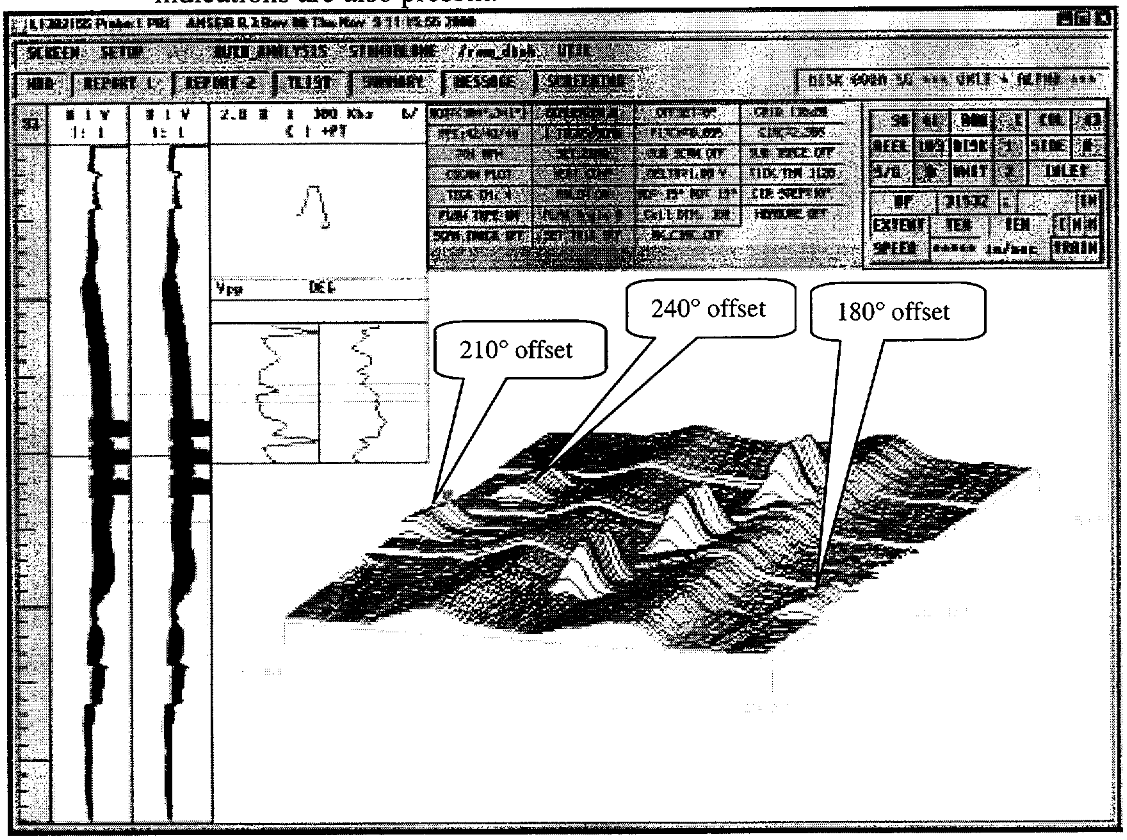


Figure 12. 0.50 volt 40% OD indications from the standard inserted into data displaying high noise characteristics with 270°, 300° and 330° offsets relative to the original data. 60% OD indications are also present.

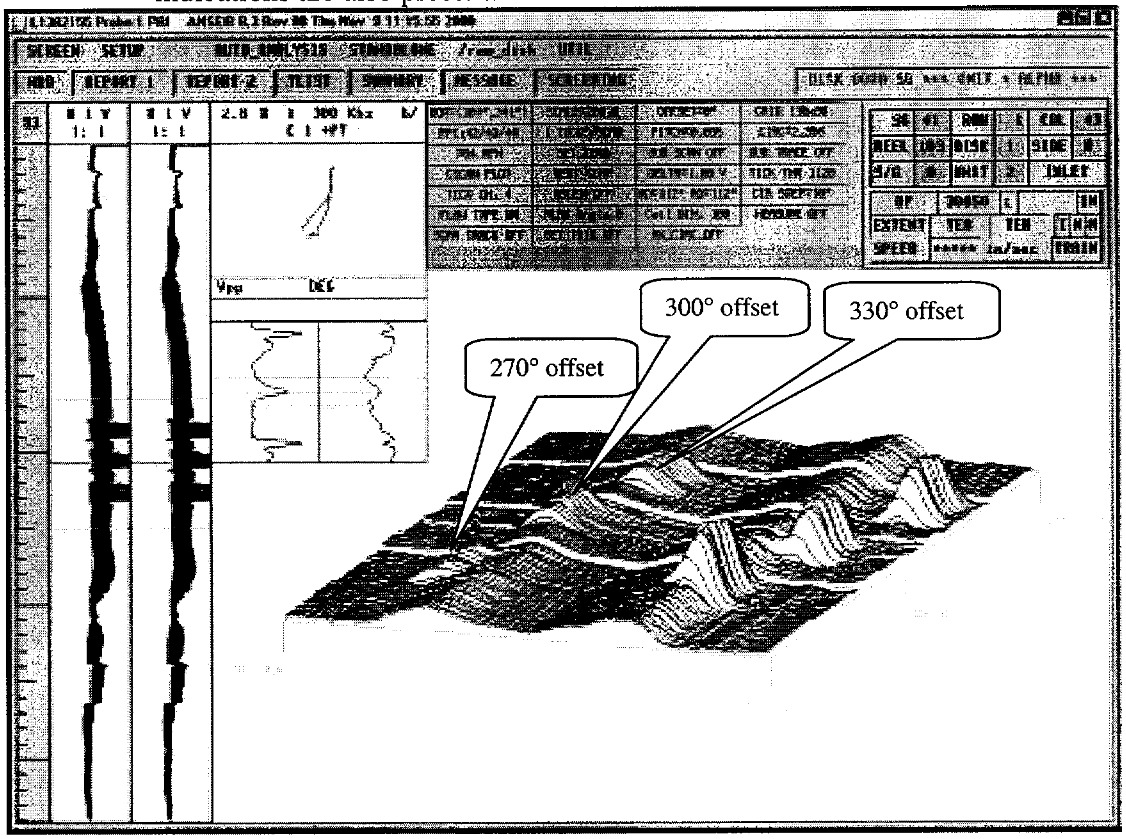


Figure 13. 0.50 volt 40% ID indications from the standard inserted into data displaying high noise characteristics with 0°, 30° and 60° offsets relative to the original data. 60% ID indications are also present.

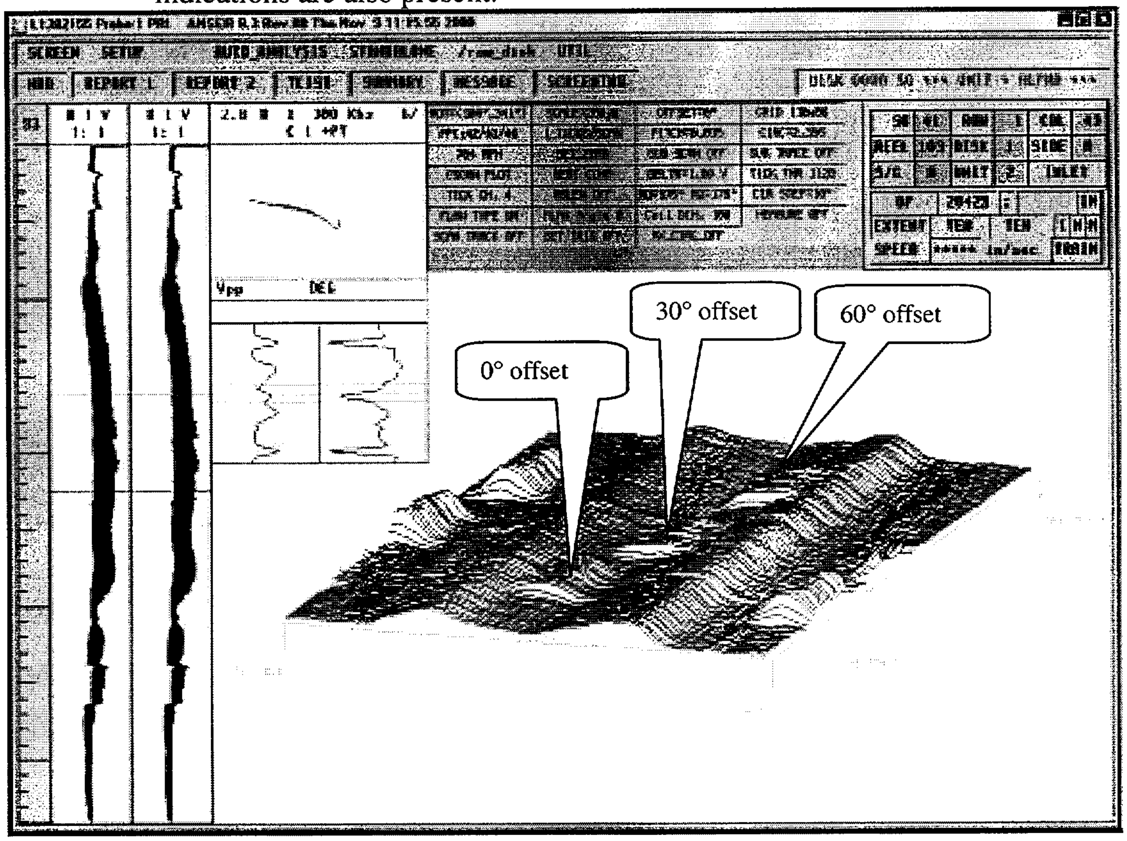


Figure 14. 0.50 volt 40% ID indications from the standard inserted into data displaying high noise characteristics with 90°, 120° and 150° offsets relative to the original data. 60% ID indications are also present.

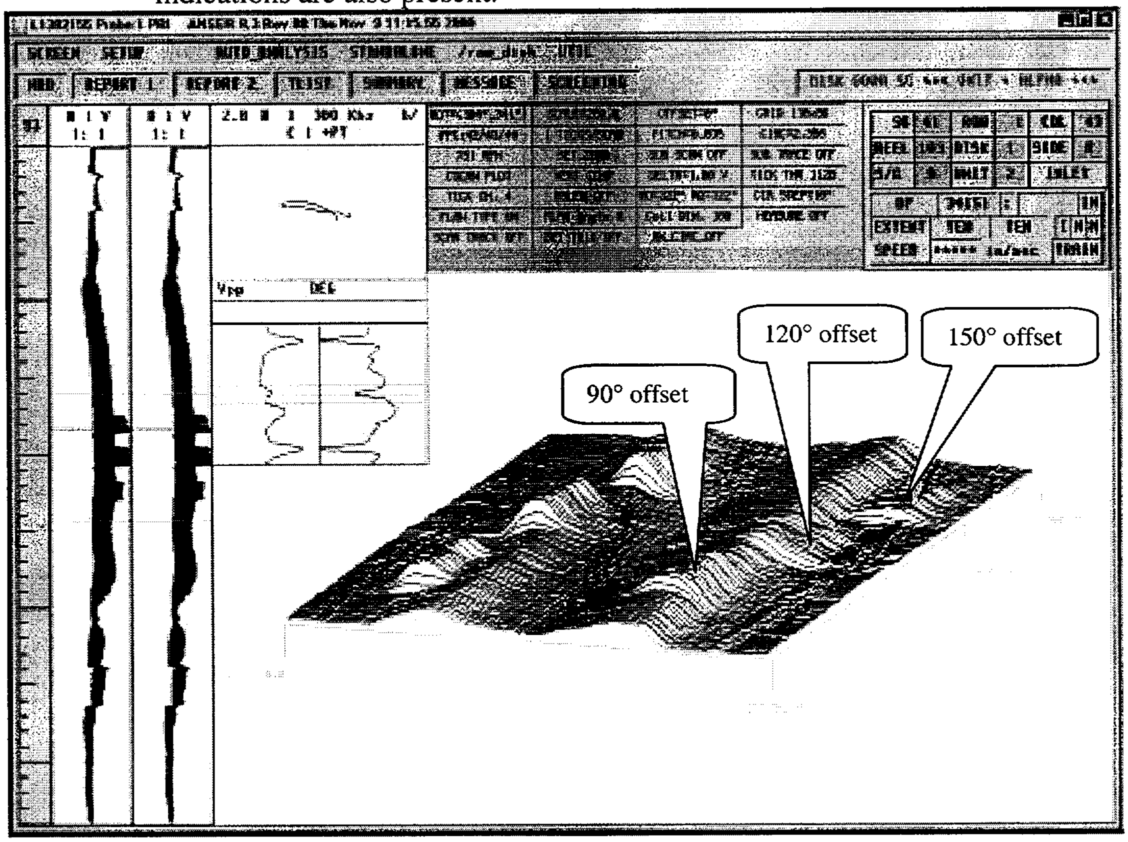


Figure 15. 0.50 volt 40% ID indications from the standard inserted into data displaying high noise characteristics with 180°, 210° and 240° offsets relative to the original data. 60% ID indications are also present.

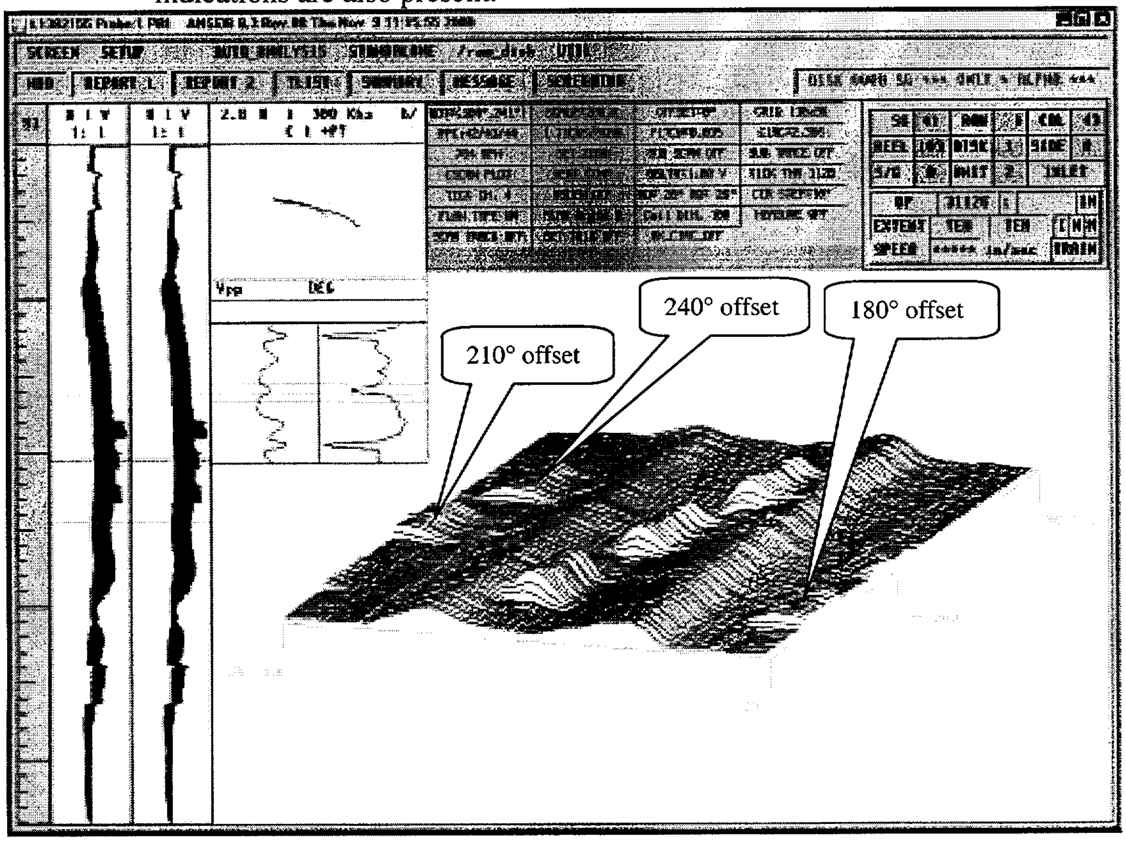


Figure 16. 0.50 volt 40% ID indications from the standard inserted into data displaying high noise characteristics with 270°, 300° and 330° offsets relative to the original data. 60% ID indications are also present.