Enclosure 3

SG-SGDA-02-43-NP
Comanche Peak Steam Electric Station
1RF09 Outage Condition Monitoring Report and Preliminary Cycle 10 Operational Assessment

Westinghouse Non Proprietary Class 3

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Comanche Peak 1RF09 Condition Monitoring and Preliminary Cycle 10 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 Comanche Peak Unit 1 steam generator tube structural and leakage integrity based on the 2002 EOC-9 eddy current inspection results. Condition monitoring is "backward looking" and compares the observed EOC-9 steam generator tube eddy current indication parameters against structural and leakage integrity commensurate with the NEI 97-06 performance criteria. 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-10. This report documents the condition monitoring of the NDE results from the Comanche Peak 1RF09 Refueling Outage inspection, performed in October 2002. Additionally, this evaluation provides a preliminary assessment of SG tube integrity at EOC-10 that supports SG operability.

The Comanche Peak Unit 1 SGs are Westinghouse Model D4 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. A small number of tubes in each SG are expanded in the tubesheet using the WEXTEX explosive expansion process.

2.0 OVERALL CONCLUSIONS

Approximately 1 week prior to the planned shutdown for the 1RF09 outage, primary to secondary leakage was reported from SG 2. Over an approximate 2 day period, the leakage trending showed 6 spikes, with decaying leak rate following the spike. For the first 3 spikes of 5, 12, and 15 gpd, the leak rate decayed following the spike to less than 5 gpd. For the next 3 spikes of 25, 42, and 52 gpd, the leak rate began to decay but the duration between the spikes was reduced and the decay was not complete. The unit was taken off-line on September 28, 2002, prior to the primary to secondary leak rate reached the EPRI Primary to Secondary Leakage Guideline limit of 75 gpd. The leak rate trending curve is provided in Figure 1.

Upon shutdown, once the SG manways were removed, water was observed to be dripping from tube R41 C71, SG2, cold leg side, at 2 to 3 drops per minute with the SG water level approximately 5 feet above the top of the tube bundle. The 2001 bobbin data was reviewed for this tube. A 1.13 volt, 133^{o} phase angle signal in channel 1 (550 kHz differential), 0.68 volt, 94^{o} phase angle signal in channel 5 (130 kHz differential) was observed in the bobbin data. This signal was judged to be associated with the leakage source.

1RF09 bobbin data shows a 6.15 volt, 48^{o} phase angle signal in channel 1, 3.27 volt, 45^{o} phase angle signal in channel 5. The 1RF09 +Pt data showed a 6.5 volt, 92%TW, 0.91" long signal at the same elevation. At these signal amplitudes, it was concluded that this was the leakage source. Close scrutiny of the +Pt data suggests a possible ding presence at one tail of the indication. These flaw amplitudes will overpower any ding signal at the deeper portions of the flaw. In situ leak and proof testing of this tube was performed. A detailed discussion of the test results are provided in Section 4.5 and Section 4.6. In short, this tube did not provide for burst capability at 3 times normal operating pressure differential (3ΔP), and leaked at >1 gpm at <simulated steam line break (SLB) conditions, based on in situ testing results. Thus the NEI 97-06 burst and leakage performance criteria were not met. A stabilizer was installed in this tube following in situ pressure testing.

An extensive review of the 2001 bobbin reporting criteria was performed. The ding ODSCC inspection logic required that a ding signal be present in channel 1 for the signal to be evaluated as a potential ding flaw in channel 5. The bobbin reporting criterion for potential ding flaws is <155° phase in the 130 kHz differential process channel. Due to probe wobble, a ding signal was not reported at this location in 2001. As a ding signal was not identified, the signal was evaluated as a freespan differential signal. In order for the freespan differential signal to be considered as a reportable indication, a depth of >0%TW must be observed in either channel 5 or channel 3 (300 kHz). The channel 5 phase angle was within 1° of reporting. Since a >0% depth report was not present in either channel 3 or 5, this signal was not reported as a possible indication. The Comanche Peak 1RF08 eddy current analysis guidelines allowed the analyst to flag any complex signal that did not meet the reporting requirements but may be flawed, based on the analyst's judgment. Review of the 1999 bobbin data for R41 C71 suggests a distorted signal in channel 5, suggesting that corrosion initiated prior to the 1RF07 (1999) inspection.

The 2002 bobbin reporting criteria were revised to include signals like those observed in 1999 and 2001 for R41 C71. The 2002 bobbin reporting criteria was based solely on phase response of channel 5 between 20° and 160°. This change resulted in a large number of freespan differential signal (FSD) reports. This change identified as least one other ding flaw (as confirmed by +Pt) in SG 2. Several other ding flaws were reported and confirmed in the U-bend region of large radius tubes, however, the probe wobble conditions were more conducive to identification of a ding signal and evaluation as a potential ding flaw. These signals were reported as DNI by bobbin. In 2001, a DNI was reported in R49 C44, SG1, and subsequently confirmed as axial ODSCC by +Pt. The probe wobble conditions in this tube are such that the ding signal was readily discernable, and thus evaluated as a DNI. In the 2001 inspection, 20 DNI signals were reported by bobbin and +Pt tested, but only R49 C44 was confirmed. These signals existed in both the straight leg section and U-bend regions. In all cases, the bobbin coil could identify a ding signal, thus the 2001 inspection data did not suggest an issue with probe wobble and ding obscurity.

The initial 2002 FSD reporting criteria also resulted in the identification and confirmation of 2 tubes with freespan axial ODSCC in the straight leg section of tube without the presence of a ding. One tube (R11 C42 SG2) had axial ODSCC in the span between H3 and H5 (2nd and 3rd hot leg TSPs) and between H5 and H7. The second tube (R7 C17 SG3) had axial ODSCC on both the hot and cold leg sections, at about the same elevation as R11 C42. The indications appear to be axially aligned. R7 C17 was in situ pressure tested with no leakage or burst; R11 C42 was in situ leak tested and was removed from the SG for destructive examination. Laboratory burst pressure was 8177 psi. Subsequent reanalysis of the 2002 bobbin data identified 4 additional tubes with freespan axial ODSCC. The most significant of these, R7 C112, was in situ leak and proof tested in a full tube mode with no leakage or burst. R7 C112 also represented the limiting freespan axial ODSCC indication. The changes made to the bobbin reporting criteria will identify these types of indications much sooner in their growth evolution. Review of bobbin data for R7 C112 indicated that bobbin signals were present in the 1999 inspection.

The 1RF09 change to the bobbin reporting criteria will identify indications similar to the 1999 and 2001 signals for R41 C71, and thus help to ensure tube leakage and structural integrity from these types of indications. The 1RF09 change to the bobbin reporting criteria will identify indications similar to the 2 initially reported freespan indications without the presence of a ding. Based on in situ test results and calculated burst capabilities of these flaws, continued SG leakage and burst capability is expected.

A large increase in the number of reportable circumferential ODSCC indications were noted at the hot leg top of tubesheet locations. All indications were judged to meet the structural and leakage performance criteria. None were required to be in situ pressure tested, however, 8 conservative in situ tests for this mechanism were performed. No leakage or burst occurred.

The AVB and baffle plate wear mechanisms did not show excessive growth, and growth trends were consistent with Cycle 8. Two baffle plate wear indications required plugging due to measured wear scar depth of 41%TW (SG4), and 40%TW (SG2). No AVB wear signals exceeded 40%TW.

During the CPSES 1RF09 steam generator tube inspection, with the exception of R41 C71 SG2, 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. Based on the changes made to the bobbin reporting criteria and the observed signal characteristics for the top of tubesheet ODSCC mechanisms, which will be discussed in detail later, it is expected that all operational assessment structural and leakage integrity requirements will be satisfied at EOC-10 for the degradation mechanisms observed at EOC-9.

3.0 PRE-OUTAGE EVALUATION OF SG DEGRADATION STATUS

Pre-Outage Degradation Assessment

A pre-outage degradation assessment pursuant to EPRI TR-107621 R1 and EPRI TR-107569-V1R5 was performed for CPSES 1RF09. This degradation assessment identified the degradation modes which could occur at CPSES 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 CPSES Unit 1 SGs.

- Axial ODSCC at TSP intersections

- Circumferential and Axial ODSCC at the hot leg TTS expansion transition
- Axial ODSCC at Freespan dings

Degradation Structural Limits

The CPSES 1RF09 pre-outage degradation assessment (Reference 1) identified length and depth based structural limits for freespan axial and circumferentially oriented degradation. Lower bound length and depth based structural limits were developed for volumetric degradation modes (i.e., AVB wear, TSP wear) based on previously published industry data and correlations. The degradation assessment provides the structural limits and NDE uncertainties to support the condition monitoring and operational assessments of this report.

CPSES 1RF09 Initial Inspection Plan

The CPSES 1RF09 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 1RF09 initial inspection plan included;

1) 100% full length bobbin examination in Rows 3 and greater in all 4 SGs, 100% bobbin inspection in the hot and cold leg straight sections of Rows 1 and 2
2) 100% hot leg top of tubesheet (TTS) RPC examination in all 4 SGs
    - from +3 to –3" for hardroll expanded tubes
    - from +3 to hot leg tube end for WEXTEX expanded tubes
3) 100% Row 1 and 2 U-bend mid-range +Pt examination in all 4 SGs
4) Rotating probe examination of mixed residuals (> 1.5 volts as measured by bobbin) and hot leg 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 all dented TSP intersections at the H3 TSP ≥ 2 volts
7) 100% +Pt inspection of >5V hot leg dings from HTS to AV2 and >5V cold leg dings from CTS to C8, plus 20% +Pt inspection of freespan dings > 5 volts between AV2 and AV3 and C8 and C9
8) 20% +Pt freespan paired ding inspection between the top 2 TSPs
9) 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 CPSES 1RF08 outage in April 2001.

A C-3 condition was reported in SGs 2, 3, and 4 due to the detection of >45 circumferentially oriented ODSCC indications. The 1RF10 top of tubesheet +Pt inspection program will include 20% of the cold leg TTS expansion transitions in these SGs.

Based on the observed 1RF08 eddy current signals from the leaking tube, observation of axial ODSCC in a 6.2 volt ding within the critical area, and observation of axial ODSCC in small dings adjacent to >5V dings, the >5V ding +Pt program was expanded to include all >5V dings, at all locations. Additionally, 100% of the U-bend FSD signals and 20% of the ≥2 volt dents/dings between C11 and AV2 were inspected with +Pt. Another 20% sample of the dents/dings >0.75 volt and <5 volt within 0.75" of structures were also examined with +Pt.

3.1 1RF09 Identified Degradation Mechanisms

Indications suggestive of the following degradation mechanisms were detected in the CPSES 1RF08 inspection:

- Axial ODSCC at TSP intersections
- Axial ODSCC at the Hot Leg TTS expansion transition
- Circumferential ODSCC at the Hot Leg TTS expansion transition
- Axial PWSCC at the Hot Leg TTS expansion transition
- Axial ODSCC in the freespan not associated with dings
- Axial ODSCC at freespan dings <5V, and >5V
- Freespan Volumetric indications (not associated with operational degradation)
- AVB wear
- Wear at non-expanded preheater baffle intersections
- Wear due to loose parts or foreign objects

The 90-day report for axial ODSCC at TSP intersections will be documented in a separate ARC report, as part of analyses required per NRC Generic Letter 95-05. Tube support plate ODSCC indications for 1RF09 were nearly identical to 1RF08, both in total number of indications and observed bobbin amplitude. Only 1 indication had bobbin amplitude greater than 1 volt. This indication, in SG 4, was confirmed by +Pt and plugged.

Table 1 presents a summary of the number of repaired tubes in each SG and identifies the mechanism that necessitated the repair. A summary of all repaired tubes, including tubes plugged for degradation, tubes preventively plugged, and tubes permitted to remain in service by application of the voltage based alternate repair criteria per GL 95-05, and F*, is provided in Table 2.

Disposition Techniques for Identified Degradation Mechanisms

Depth measurement of AVB wear indications and non-expanded preheater baffle plate wear using the bobbin coil is acceptable 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 or equal to 1 volt by bobbin were RPC inspected for flaw confirmation, even though only those DSIs >1 volt are required to be +Pt inspected per GL 95-05. Indications identified in exclusion zones related to tube collapse potential near TSP wedges were RPC inspected, and if confirmed, were repaired regardless of voltage. No bobbin indications at TSP intersections were reported in exclusion zones. No mixed residual indications >1.5 volts by bobbin were detected, therefore, none were RPC inspected.

All crack-like indications in the expansion transition down to the F* distance were repaired upon detection since depth sizing techniques are not acceptable for continued operation justification. All hot leg top of tubesheet indications were located within the expansion transition region.

To reduce the potential for an axially oriented ODSCC indication to be obscured by baffle wear, all newly reported occurrences of preheater baffle wear by bobbin were RPC inspected. No ODSCC was detected. Through 1RF09, all previously reported baffle wear has been inspected with +Pt.

Indications previously called volumetric, have in the past been reviewed, and determined to be attributed to deposits, MBMs, dings and bulges, or tube material property changes which sometimes occur after power operation. SVI calls by RPC not associated with loose parts were traced to the baseline inspection bobbin data. These indications were conservatively repaired at 1RF09. All loose part wear signals were conservatively repaired.

Additionally, permeability variations were reported based on bobbin or RPC amplitude > 1 volt. Prior to the 1RF09 inspection, it was defined that permeability variations coincident with regions of the tube where active degradation mechanisms were present should be repaired if it was judged that the permeability could interfere with adequate flaw detection. This resulted in the conservative repair of 2 tubes in SG 3.

Any tube scheduled for a particular test (such as full length bobbin), that could not be tested due to a restriction in the tube or due to poor data quality, was conservatively repaired.

In addition to the mechanisms identified, the mechanisms that were *not* identified are also noteworthy. These include:

- SCC at dented TSP intersections
- Small radius U-bend PWSCC

"Dents" at Comanche Peak Unit 1 are believed to be related to manufacture, and not to corrosion of the carbon steel TSPs. Comanche Peak Unit 1 has not operated with secondary side chemistry regimes conducive to traditional denting morphologies. The lack of small radius U-bend PWSCC is related to the in situ heat treatment of the Row1 and 2 U-bends prior to operation. For similar plants that have performed U-bend heat treatment prior to operation, no degradation in the U-bends has been reported.

Table 1
Summary of 1RF09 Tube Repair Statistics Based on Observed Degradation
(Values do not reflect sleeve installation in SGs 2, 3, and 4)

Degradation Mode	HL sludge pile (>1" above TTS)	HL TTS Exp. Transition	Small Radius U-bend	Hot Leg TSP	Freespan (no ding)	Straight Leg (ding)	U-bend (ding)	Baffle Plate		Total
SG 1										
Axial ODSCC	0	0	0	0	0	6	4	0		10
Axial PWSCC	0	0	0	0	0	0	0	0		0
Circ. ODSCC	0	31	0	0	0	0	0	0		31
Wear	0	0	0	0	1 (1)	0	0	0		1
Volumetric	0	0	0	0	2 (2)	0	0	0		2
Sub Total	0	31	0	0	3	6	4	0		44
SG 2										
Axial ODSCC	0	2	0	0	2 (3)	2	2	0		8
Axial PWSCC	0	1	0	0	0	0	0	0		1
Circ. ODSCC	0	187	0	0	0	0	0	0		187
Wear	0	0	0	0	0	0	0	1		1
Volumetric	0	0	0	0	2 (2)	0	0	0		2
Sub Total	0	190 (3)	0	0	4	2	2	1		199 (4)
SG 3										
Axial ODSCC	0	2	0	0	4	0	0	0		6
Axial PWSCC	0	1	0	0	0	0	0	0		1
Circ. ODSCC	0	216	0	0	0	0	0	0		216
Wear	0	0	0	0	1 (1)	0	0	0		1
Volumetric	0	1 (1)	0	0	4	0	0	0		5
Sub Total	0	220	0	0	9	0	0	0		229 (5)
SG 4										
Axial ODSCC	0	3	0	1	0	0	1	0		5
Axial PWSCC	0	0	0	0	0	0	0	0		0
Circ. ODSCC	0	234	0	0	0	0	0	0		234
Wear	0	0	0	0	1 (1)	0	0	1		2
Volumetric	0	0	0	0	4 (2)	0	0	0		4
Sub Total	0	237	0	1	5	0	1	1		245
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
Overall Total	0	678	0	1	21	8	7	2		717 (4,5)

Notes for Table 1:
(1): Foreign object/loose part wear above a structure
(2): Baseline reviewed for these signals, indication existed in baseline data, therefore, not corrosion related.
(3): One tube with freespan ODSCC also had a circumferential ODSCC indication at the top of tubesheet
(4): One tube in SG 2 had a freespan axial ODSCC flaw and a circumferential ODSCC flaw at the top of tubesheet
(5): One tube in SG 3 had a freespan axial ODSCC flaw and a circumferential ODSCC flaw at the top of tubesheet

Table 2
Summary of Repaired Indications and Indications Justified for Continued Operation by Application of ARCs: CPSES 1RF09, October 2002
Values Apply to 1RF09 Inspection Only

SG	Tubes Repaired by Plugging	Tubes Repaired for Crack-like Defects	Tubes Repaired for Volumetric Signals Including Wear	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
1	48	41	3	4 (1)	28 (28 indications)	0	28
2	18	15	3	0	25 (25 indications)	0	25
3	22	15	5	2 (2)	21 (21 indications)	0	21
4	12 (3)	5	6	0	144 (159 indications)	0	144
Total	100	77	17	5	218 (233 indications)	0	218

(1) Includes one tube preventively repaired due to possible ding ODSCC
(2) Includes 2 tubes repaired due to PVN
(3) Includes 1 tube plugged by mistake.

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

Structural integrity of circumferential indications at the TTS is defined by EPRI TR-107197,"Depth Based Structural Integrity of Circumferential Indications". The controlling parameter with regard to structural integrity of circumferential indications is the percent degraded area, or PDA. The PDA represents the percentage of degraded cross sectional area of the tube.

The burst correlation for circumferential indications is documented in EPRI TR-107197, "Depth Based Structural Analysis Methods for SG Circumferential Indications". The burst curve was used to develop the 100%TW critical crack angle value of 294° (82% PDA) for CPSES Unit 1 at 3ΔP conditions using mean material property values.

Screening of indications for selection as in situ test candidates is performed at CPSES Unit 1 using a methodology which is consistent with EPRI Report TR-107620-R1, "Steam Generator In Situ Pressure Test Guidelines". The PDA screening limit is developed by reducing the 82% PDA for material properties at the lower tolerance limit (LTL) values and NDE uncertainty at the 95% probability level. The resultant PDA used for in situ screening purposes is 56%.

For in situ testing purposes, screening limits are applied to identify the most relevant subset of indications for testing. PDA values were determined for all circumferential ODSCC flaws reported at 1RF09. The methodology is described in Reference 5. In this methodology, the flaw maximum depth and flaw arc length are multiplied to obtain a gross estimate of PDA. This value is then reduced by a factor that relates maximum depth to PDA based on the flaw amplitude of pulled tubes with circumferential ODSCC in hardroll expansion transitions. The uncertainty evaluation for this method uses destructive examination data for pulled tubes and shows that the 95% confidence uncertainties are essentially equal to the uncertainties developed for profiling (Reference 2). Both of these methods represent a large improvement in the PDA sizing uncertainty compared to the data provided by EPRI TR-107197. To verify the similarity of the 2 processes (PDA quick screening vs profiling), a sample of 16 circ ODSCC flaws, including all in situ pressure tested circ ODSCC flaws had PDA developed from profiling. When plotted (profiling PDA vs quick screening PDA), a correlation with a slope of [ ]^{a,c,e} is obtained. This evaluation shows that the PDA quick screening method will produce similar PDA values as for profiling. Using the PDA to maximum depth ratio from Reference 5, the largest PDA value obtained at 1RF09 was 41.61%, which is well less than the PDA structural limit reduced for NDE uncertainty of 56% used for in situ screening.

For leak test screening, the first screen is maximum voltage ≥ 1.25 volts for PWSCC, 1.00 volts for ODSCC. As no indications exceeded the 1st screen, leak testing was not required. As a conservative measure, the three largest amplitude responses were in situ tested with no leakage or burst. Any tube with a maximum depth report greater than the maximum depth screening limit was reviewed to determine the arc length over which the maximum depth was reported. No additional indications were required to be in situ pressure tested as a result of this review. Pulled tube data shows that a 100%TW arc length of at least 30° is required for leakage at SLB conditions. The +Pt amplitude associated with this indication is 1.33 volts. As the largest reported amplitude at 1RF09 was 0.56 volts, this indication was judged to not represent a leakage potential. The reported maximum depth of this indication was less than the maximum depth screening limit. As noted above, the 3 largest 1RF09 flaw amplitudes were in situ pressure tested with no leakage or burst reported. There were a total of 8 tubes with circumferential ODSCC at the top of tubesheet that were in situ pressure tested with no leakage at 2970 psi and no burst at 4375 psi. The tubes were selected using the following criteria:

1. The three largest PDA values
2. The three largest flaw amplitudes
3. Additional tubes with large flawed arc extents that were judged to have less segmentation than others. A total of of 2 tubes were in this category.

Again, it should be noted that no in situ testing for circumferential ODSCC was required per the EPRI in situ testing guideline.

Table 6 presents a summary of the in situ testing performed at 1RF09 and past outages, and this table includes the pertinent flaw data.

A total of 668 circumferential ODSCC indications were identified at 1RF09. Based on phase angle analysis, all were judged to be representative of ODSCC. A total of 178 circumferential indications at the hot leg TTS were identified at 1RF08, and a total of 88 circumferential indications at the hot leg TTS were identified at 1RF07. While the number of TTS circumferential ODSCC indications has increased, previous growth evaluations have shown a trend of nearly all indications exhibiting a precursor signal in history review. The relative severity of these indications is judged to be small based on the low +Pt amplitudes and highly segmented morphology based on pulled tube examination.

In situ screening involves comparing the NDE reported value against the structural limit reduced for material property variation and NDE sizing capability. In the condition monitoring evaluation, the NDE reported parameter is adjusted for sizing capability and compared against the structural limit defined at the lower 90% probability, 50% confidence material property value. The mean correlation of NDE versus DE PDA for the PDA quick screening method is described by the equation provided below;

[ ]^{a,c,e}

With a standard error of regression of 10.77%. This equation and standard error of regression are used to estimate the "true" PDA at elevated probability and confidence levels. For the largest PDA reported for 1RF09 of 41.61%, the "true" PDA could be as large as 67%. This value is then compared to the structural limit PDA developed at the lower 90% probability, 50% confidence material property limit of 78% PDA. As the largest NDE adjusted PDA for all 1RF09 flaws is less than the condition monitoring limit, structural integrity performance criterion are satisfied for circumferential ODSCC indications at 1RF09. Figure 2 presents a cumulative distribution plot of PDA for all reported circumferential ODSCC indications at 1RF09. Also, the PDA quick screening method was applied to the Comanche Peak Unit 1 pulled tubes from the 1RF07 outage. The quick screening PDA values were determined to be 37% and 34.4%, for pulled tube PDA values (excluding ligaments) of 44% and 32.6%, respectively. PDA determined for these tubes using the methodology described in EPRI TR-107197 was approximately 20%, and 2%. Maximum +Pt amplitudes for these tubes were 0.24 volts and 0.14 volts, respectively. In summary, structural and leakage performance criteria are satisfied at EOC-09 conditions for circumferential ODSCC at the hot leg top of tubesheet expansion transition.

Maximum +Pt flaw amplitude is a reasonable qualitative assessment tool for determining the relative structural integrity characteristics of circumferential ODSCC indications. Figure 3 presents a summary of the maximum +Pt amplitude vs burst pressure and PDA for the hardroll ODSCC pulled tube database. The correlations developed satisfy the requirements of Reference 6, and therefore are considered valid for evaluating tube integrity. However, in this evaluation, the amplitude correlations are provided as a defense in depth in support of the PDA determination and in situ testing performed at 1RF09, as well as past inspections. The largest circumferential flaw amplitude reported at 1RF09 was 0.56 volts. Using the lower 90% probability, 50% confidence line relating +Pt amplitude to burst pressure, the estimated burst pressure of this indication is [ ]^{a,c,e}. Using the lower 90% probability, 50% confidence line relating +Pt amplitude to PDA, the estimated PDA of this indication is [ ]^{a,c,e}, which is in good agreement with the quick screening NDE adjusted PDA of [ ]^{a,c,e}. It should be noted that the morphology of the circumferential ODSCC mechanism at Comanche Peak Unit 1 has been established by tube pulls. This morphology has shown numerous (up to 70) non-degraded ligaments exist within the entire flaw network. The flaws are shown to exist within a relatively consistent elevation band. The tubes pulled for characterization of the circumferential ODSCC mechanism at Comanche Peak unit 1 were burst tested with the expansion transition in an unrestrained mode, that is, no tubesheet simulant was applied to the expansion transition region during burst testing. Burst pressures were >10,000 psi, consistent with the non-degraded tube burst pressure, and the burst occurred in the freespan region, several inches away from the expansion transition. Based on measured PDAs, these indications would have been expected to burst at approximately 7000 psi. The numerous non-degraded ligaments clearly added to the burst capability of these indications.

4.1.2 Expansion Transition Axial Flaw ODSCC Condition Monitoring Evaluation

Structural integrity of axial flaws is established based on reported NDE length and depth. The Westinghouse axial flaw burst prediction program, WEAKLINK, is used for estimation of burst capability of axial flaws.

With regard to freespan axial indications, the in situ screening procedure for burst is as follows. The first two screens are crack length ≥ 0.43" and maximum depth ≥ 70%. These values are reduced for eddy current uncertainty. Indications which 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 draft RG 1.121 recommendations. The freespan screening flaw length of 0.43" provides for burst integrity at draft RG 1.121 recommendations for a single flaw morphology of 100% TW depth, using LTL material properties. For flaws with 100%TW lengths greater than about 0.1", the +Pt coil is expected to overestimate the true flaw length. The unadjusted 100%TW flaw length that provides for burst capability at 3ΔP is 0.48", however, this value was conservatively reduced using length measurement uncertainty data for part throughwall flaws.

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.

At the CPSES 1RF09 inspection, 7 axial ODSCC indications at the expansion transition were reported. The largest +Pt amplitude was 0.42 volts. All indications were profiled. The longest reported axial ODSCC flaw length from profiling was 0.30", which is well less than the 100%TW critical flaw length, reduced for length measurement uncertainty. Therefore, structural integrity of these indications is provided. Maximum reported depth of these indications was well below the in situ screening limit, and therefore, leakage integrity is also established. The +Pt depth profiles for these indications suggests very shallow depths. As a conservative measure, the maximum depth versus +Pt amplitude correlation of Reference 4 was used to evaluate the flaw depths. The lower 90% probability, 50% confidence relation was used. The depths from amplitude suggest depths substantially deeper than reported by phase. The limiting indication with regard to burst capability is R24 C60 SG3. The voltage adjusted maximum depth is 58%TW, with a length of 0.30", and average depth of 41.3%. The voltage adjusted depth profile for this indication results in an average depth that is roughly twice the phase based average depth, thus the voltage adjusted profile was used. Burst capability using the lower 90% probability, 50% confidence material properties, per the EPRI tube integrity guideline, is 7750 psi. With NDE sizing uncertainty at the lower 90% probability, 50% confidence level are applied singularly to the length and depth, the predicted burst pressure is 6057 psi. The maximum depth of any indication based on +Pt amplitude is observed for R19 C74, SG3. The maximum depth from phase is 32%TW, while the maximum depth from amplitude is 64%. This flaw is only 0.13" in length, and has a burst capability greater than R24 C60. In summary, structural and leakage performance criteria are satisfied at EOC-09 conditions for axial ODSCC at the hot leg top of tubesheet expansion transition.

4.1.3 TSP ODSCC Condition Monitoring Evaluation

Only 1 indication exceeding 1.0 volt was reported by bobbin (R38 C41 at H3 in SG 4). This indication was confirmed by +Pt (0.15 volts, 123° phase angle) and repaired by plugging. The voltage based structural limit for TSP ODSCC indications is 4.57 volts for a SLB ΔP of 2560 psi (with safety factor applied). The largest bobbin DSI voltages and total DSI reports for each SG are provided below in Table 4.

This data shows that SG 4 appears to be the most susceptible SG with regard to ODSCC initiation. For all SGs, the average absolute voltage growth is -0.02 volts.

Mixed residual indications with a bobbin voltage > 1.5 volts are RPC inspected. No mixed residuals >1.5 volts were detected.

A complete evaluation per the GL 95-05 requirements will be provided in the ARC 90-day report. The 1RF09 TSP ODSCC bobbin amplitudes are essentially equal to the 1RF08 values. Past GL 95-05 analyses have indicated that the projected leak rate at end of next cycle conditions will be approximately 0.001 gpm, and conditional burst probability of several orders of magnitude less than the GL 95-05 burst limit. Using the Addendum 4 relation of burst pressure to bobbin amplitude, the lower 95% confidence burst pressure of a 1.06 volt indication is 5377 psi.

Table 4
1RF09 TSP ODSCC Degradation Summary

	SG 1	SG 2	SG 3	SG 4
Number Ind.	28	25	21	160
Number ≥ 1 volt	0	0	0	1
Max 1RF09 Voltage	0.45	0.74	0.84	1.06
Average Voltage Growth Cycle 9 (per Cycle)	-0.01 volts	-0.06 volts	0.01 volts	-0.02 volts
Average % Voltage Growth Cycle 9 (per EFPY)	1.7%	0.51%	11.3%	-1.95%

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.

- Axial ODSCC in the freespan
- Axial and circumferential ODSCC in freespan dings
- Axial PWSCC at the top of tubesheet expansion transition
- Axial PWSCC in small radius U-bends
- AVB wear
- Tube wear at non-expanded preheater baffles
- Tube wear due to foreign objects/loose parts

4.2.1.a Freespan ODSCC Condition Monitoring

The initial bobbin analysis program conducted at 1RF09 included auto data screening (ADS) as the primary analysis, with a manual secondary analysis. The ADS program included a 0.20 volt cutoff in channel 5 (130 kHz). Two tubes were reported with freespan ODSCC in the absence of an external stress riser at 1RF09 as a result of the initial bobbin analysis. The tubes are R11 C42 SG2, and R7 C17 SG3. Bobbin indications were reported as FSD signals, and subsequent +Pt examination concluded that axial ODSCC was present. The bobbin amplitudes in the 130 kHz channel are small (<0.3 volts). The associated maximum +Pt amplitudes are also small (0.21 and 0.26 volts). As can occur with small amplitude +Pt signals, the +Pt depth profile may overestimate the true depths. R7

C17 was in situ tested with no leakage or burst reported. Thus structural and leakage performance of R7 C17 has been established by in situ testing. R11 C42 was in situ tested to 2841 psi, which is the temperature adjusted SLB pressure differential, with no leakage reported. R11 C42 was removed from the SG for destructive examination. In the laboratory, the room temperature burst pressure was 8177 psi, and the burst pressure for a non-degraded tube section was 10,142 psi. Adjusting for operating temperature, the burst pressures are 7605 psi and 9432 psi.

Figure 5 presents the pre in situ +Pt depth profile for R11 C42. As seen from Figure 5, the voltage response is low, but the depth from response is uncharacteristically high. It is believed that this profile is a gross overestimate of truth. The post in situ depth profile shows *shallower* depths compared to the pre in situ profile. This phenomenon was also observed for R7 C17. Signal amplitude for these indications was only marginally increased following pressure testing. The observation of shallower depth responses from phase analysis suggests that the pre in situ depth profile is unreliable. To qualitatively assess the validity of the 300 kHz +Pt profile, the 150 kHz channel was also used for profiling. The 150 kHz responses resulted in flaw amplitudes slightly larger than obtained from the 300 kHz channel, which is expected, but the depth profile resulted in depths of nearly 100%TW over significant lengths. The 150 kHz depth profile shows no relation between depth and amplitude, whereas the 300 kHz profile shows some relation between depth and amplitude for the flaw lengths near the center of the profile. Based on the 150 kHz profile, and using the actual material properties of this tube, leakage should have been experienced at approximately 2000 psi. No leakage was reported at 2841 psi. This evaluation suggests that neither of the phase based depth profiles for R11 C42 is representative of the true depth profile. Additionally, the bobbin coil prime:quarter mix amplitudes for the confirmed flaws are bounded by 0.41 volts for R11 C42 and 0.33 volts for R7 C17. Based on a regression line using the TSP ODSCC pulled tube data for ¾" OD tubing, a mix channel response of 0.41 volts suggests a maximum depth of 48%TW. Therefore, the bobbin amplitudes are inconsistent with the reported depths from phase, and the +Pt amplitudes are inconsistent with the reported depths from phase. As stated above, the post in situ depths from phase are shallower than the pre in situ depths. The post in situ depths from phase begin to approach the depth profile for depths associated with the +Pt amplitude.

Instead, the lower 95% probability, 50% confidence relation between maximum depth and +Pt amplitude will be used to assess the burst capability of R11 C42. Figure 6 shows the depth by phase and depth by voltage responses as well as a selected profile used for burst pressure evaluation. As a conservative measure, the depth values from phase will be used for the section between 10.4 and 10.9". The depth from phase values above 10.9" are judged to be unreliable. The depth from volts values below 10.4" are conservative compared to the depth from phase response. Using the actual material property values for this tube adjusted for operating temperature, the burst pressure is determined to be 6590 psi. At room temperature conditions, the predicted burst pressure is 7086 psi, about 1000 psi less than the actual burst pressure. As the voltage versus depth relation was used at a lower 95% probability, 50% confidence level and the section between 10.4" and 10.9" are assumed to represent overestimates of truth, uncertainties in depth evaluation are included, and the condition monitoring is satisfied. The depth versus amplitude relation used slightly more conservative statistical adjustment compared to the EPRI tube integrity assessment guidelines.

The post in situ testing +Pt voltages show good agreement with the post in situ depth from phase analysis for R7 C17. Note that R7 C17 was proof tested to 4070 psi in a full tube mode with no leakage or burst. As a sensitivity, the post in situ +Pt voltages were used to estimate the true flaw depths for R11 C42 since it is unlikely that significant flaw tearing occurred during the in situ leak test. The lower 95% probability, 50% confidence relation between maximum depth and +Pt amplitude was used. Using this profile, the lower 95% probability, 50% confidence burst pressure is 8440 psi at room temperature, and provides good agreement with the laboratory burst pressure of 8177 psi. The operating temperature adjusted burst pressure using amplitude sizing for the entire flaw length is 7848 psi.

Burst pressure evaluation of R11 C42 have shown, by numerous methods and conservative adjustments to the +Pt depth profile, that burst capability remains greater than the Comanche Peak 1 3ΔP value of 3816 psi, for all evaluated cases.

The +Pt evaluation of R11 C42 showed that not all of the identified +Pt indications had corresponding bobbin calls. However, all +Pt indications >0.10 volts had corresponding bobbin signals, they just were not reported. This occurrence prompted TXU to perform a reanalysis of the bobbin data to specifically identify signals with low (<0.20 volts in 130 kHz) amplitude bobbin signals that may not have been reported in the initial analysis. This reanalysis identified 4 additional freespan indications, two of which were similar to R11 C42 and R7 C17 (the locations are R4 C51 SG3 and R7 C90 SG3), one that was substantially less significant compared to R11 C42 and R7 C17 (R11 C94 in SG2) and one that was more significant. This significant indication, R7 C112 SG3 at H8 + 8.56", had a maximum 130 kHz amplitude of 0.48 volts, 300 kHz amplitude of 0.72 volts, maximum +Pt amplitude of 0.81 volts, and total length of 2.81". While not a small amplitude signal, it was later determined that this indication was misclassified in the original bobbin analysis, and thus was not initially reported as a DFI. The original bobbin analysis used a 2 cycle lookback for comparing change against the current signal. All 3 of these indications were in situ leak and proof tested with no leakage or burst reported. The phase and amplitude based depth profiles of R7 C112 are provided in Figure 7. The misclassification of R7 C112 led to a second bobbin reevaluation in which history review was conducted back to the first inservice inspection of the tube. This second reanalysis identified only one short (0.20"), shallow (0.14 +Pt volts) freespan axial ODSCC indication (SG2 R11 C94 at H1 +13.6"). All freespan indications with the exception of R11 C94 were in situ pressure tested. The length of the flaw in R11 C94 is much shorter than the 100%TW critical flaw length, thus, condition monitoring is satisfied for all observed axial freespan ODSCC indications.

Bobbin data was compiled for all reported freespan axial ODSCC degradation. All freespan ODSCC +Pt signals with an amplitude of >0.10 volts had a corresponding bobbin signal in 2002, and in many cases, a corresponding bobbin signal in 2001. Thus, from this information, it can be concluded that all degradation greater than approximately [ ]a,c,e had a corresponding bobbin signal.

Using the actual material property values for R7 C112, the operating temperature adjusted burst pressure based on the amplitude sizing was 4123 psi. The amplitude sizing of R7 C112 produced significantly deeper depths than the phase sizing. A history review of the bobbin data for R7 C112 was performed. Bobbin signals are present in the 2001 and 1999 inspection data. Therefore, this indication was in service for no less than 2 full operating cycles. Since the final bobbin reanalysis would have identified indications suggestive of R7 C112 as far back as 1999, it is reasonable to conclude that no indications similar to R7 C112 are present within the Comanche Peak Unit 1 SGs. The post in situ +Pt amplitude of R7 C112 was 1.83 volts, which is a significant increase compared to the pre in situ +Pt amplitude of 0.81 volts. The significant change suggests that some disturbance of the flaw occurred. It is likely that the tube began to experience bulging, with plastic deformation of the flaw. The resultant condition likely included separation of the crack faces, thus the increase in amplitude. At the peak amplitudes reported, the amplitude correlation indicates that 100%TW depths would have been present, however, no leakage was reported. Thus it is reasonable to conclude that the amplitude increase was a result of deformation of the flaw in the hoop direction, not due to increased depth penetration or ligament tearing due to the proof test. The depth from phase profiles of R7 C112 and R7 C17 produce similar depths, but significantly varying +Pt amplitude responses for the pre and post in situ condition. The large increase in +Pt amplitude post in situ further suggests that amplitude sizing of axial ODSCC indications provides an inherently more accurate measure of true maximum depth compared to phase based analysis. In summary, structural and leakage performance criteria are satisfied at EOC-09 conditions for freespan axial ODSCC.

Table 8 presents a summary of the freespan ODSCC +Pt amplitudes and depths from phase analysis for the pre and post in situ examinations. As discussed above, the reliability of the +Pt depth profile from phase is in question for the low voltage responses of these freespan signals. The data of Table 8 includes that maximum depth at the point of maximum +Pt amplitude for each of the indications. This is intended to show that the depth at maximum amplitude, which should represent the deepest flaw segment, are relatively unchanged for the pre and post in situ testing conditions. For the longest of the indications in each tube, which also had the largest pre in situ test +Pt amplitudes, the depth at maximum amplitude either remained constant, or was reduced for the post in situ test examination.

4.2.1.b Freespan Volumetric Indications

Several indications were reported by bobbin as FSD or DFI signals and confirmed by +Pt as volumetric in nature. These indications occur in the freespan area away from structures, with no evidence of foreign objects in either this tube or surrounding tubes. For all of these indications, the baseline bobbin data showed a similar signal as was reported from the 1RF09 bobbin data. Thus it can be concluded that these indications are not representative of an on-going degradation mechanism. The cause of these signals may be attributed to laps or gouges resultant from the tube installation process or manufacturing process. These indications were preventively repaired by plugging.

4.2.2 ODSCC at Freespan Dings

Axially Oriented Indications:

Axial ODSCC at freespan dings was detected in the last three outages at freespan dings in two units with Model E2 SGs. As the CPSES Unit 1 SGs and the Model E2 SG share similar secondary side structure designs, the potential exists that similar indications could be reported in a Model D4 SG. The CPSES 1RF08 inspection monitored freespan ODSCC initiation. Bobbin indications in the freespan were RPC inspected if the low frequency differential bobbin phase angle response was less than 155° at ding locations. This calling criterion was specifically developed to identify axial ODSCC at freespan dings. A total of 3 DNI calls were reported by bobbin. Two were reported as NDD by +Pt and one was confirmed as an axial ODSCC indication. The indication was reported in R49 C44 SG 1 at H11 +32.93".

Upon discovery of the postulated source of the primary to secondary leakage in SG2, the bobbin reporting criteria was changed to remove the requirement that a ding signal be present for an indication to be identified as potential degradation. A number of signals were reported as DNIs, suggesting that the ding signal was readily apparent. Other signals were reported as DFIs, in which case the ding signal may not have been readily apparent, but the change to the bobbin reporting criteria resulted in their classification of a signal that warranted a +Pt examination. One tube was reported with an axial ODSCC signal by +Pt in a larger than 5 volt ding. This ding was inspected as part of the >5V ding +Pt program, therefore, lack of a bobbin call is of no consequence to the inspection since the bobbin qualification includes dings ≤ 5V. Two tubes were reported to contain axial ODSCC indications at dings that were not reported by bobbin; the ding amplitudes were less than 5 volts. These indications were located either adjacent to a structure (AVB), where the influence of the structure on the 130 kHz bobbin signal obscured the channel 5 response but a ding signal was present in the 550 kHz bobbin response, or in close proximity to other large amplitude dings (14 volts in this case). The qualification report for the bobbin ding technique specifies the use of either the mix channel or the 130 kHz channel, but if the mix channel is used, the 130 kHz channel must also be used. One of the ding flaws not reported by bobbin had a mix channel phase angle within the reporting window, thus the bobbin ding technique only failed to identify one of ding flaws. The bobbin data was rereviewed in the vicinity of structures to determine if additional dings were located in close proximity to the structures to determine if an additional +Pt exam was required. No additional tests were required as part of this review. Identification of the second indication in close proximity to a large voltage ding prompted TXU to perform a 100% +Pt examination of all freespan dings >5V. No additional indications were reported. An additional 20% sample of dings ≥0.75 volts and <5 volts were inspected with +Pt; no additional indications were reported. A summary of the bobbin and +Pt examination results of 1RF09 ding flaws is provided in Table 7. The most significant of the ding flaws were in situ tested. No leakage or burst occurred. Comparison of the pre and post in situ +Pt examination data indicates that the +Pt amplitude was relatively unchanged, as well as the +Pt phase angle response (Table 7). The dings flaws reported had ID phase angles. This phenomenon has been evidenced both at other plants and in the laboratory program. The influence of the ding on the +Pt response overpowers the flaw response for short, shallow axial ODSCC. For these cases, the laboratory flaws generally had maximum depths <70%TW, and flaw lengths <0.12". The +Pt lissajous responses for these flaws are consistent with the laboratory ding specimens. Length evaluation of the 1RF09 ding axial ODSCC indicates that the maximum reported ding ODSCC length was 0.25", well less than the 100%TW critical flaw length of 0.43". Plus Point lissajous analysis indicates ID phase angles for dings, suggesting that the flaw depths are less than 70%TW. In summary, structural and leakage performance criteria are satisfied at EOC-09 conditions for axial ODSCC at freespan dings. It should be noted that one of the freespan ding ODSCC indications was pulled for destructive examination (R25 C30 SG2).

With regard to PWSCC, a 20% sample of all hot leg dings from the hot leg top of tubesheet to H3, the first TSP above the flow distribution baffle, and all dents at H3 ≥ 2 volts were +Pt inspected. No degradation was observed.

Circumferentially Oriented Indications:

At the 1999 inspection of a Model E2 SG, OD circumferential indications were reported in the freespan region several inches below the top cold leg TSP. The indications were reported coincident with a circumferentially oriented ding, known as a ding pair. The ding pair is believed to be resultant from out of plane rotation of the tube while engaged with the top TSP during tube insertion. The geometry of this type of ding has been studied by Westinghouse and found to be significantly different from the dings that have historically resulted in axial ODSCC. Based on this similar plant experience, 20% of the hot and cold leg paired dings between the top two TSPs were inspected with

+Pt at 1RF09. No degradation was observed.

4.2.3 Axial PWSCC at the Top of Tubesheet Expansion Transition

Structural integrity of axial flaws is established based on reported NDE length and depth.

During the 1RF09 inspection, 2 axial PWSCC indications were reported at the expansion transition, one in SG2, one in SG3. The most significant of these was a 1.75 volt, 0.16" long indication. Use of the 80 mil high frequency coil indicates 3 closely spaced axial flaws with a maximum reported depth of 60%TW.

The second indication had a +Pt amplitude of only 0.42 volts. At such low volts the +Pt depth response should be in the range of 40 to 50%TW. Significant depths were reported. Profiling using the 600 kHz +Pt channel reported similar depths, but the flaw amplitudes were less than the 300 kHz channel. For an ID flaw, the higher frequency channels should produce larger flaw amplitudes. As with OD signals, weak ID signals can also be affected by the carbon steel response of the tubesheet. The most conservative profile for this tube was obtained using the 80 mil high frequency +Pt coil. This profile also reported flaw lengths that were approximately 1.5 times longer than the 300 kHz +Pt coil response. Thus this profile was used for the integrity evaluation. Using the 80 mil high frequency coil, the flaw length of 0.29" is significantly less than the 100%TW critical flaw length of 0.43", reduced for length measurement uncertainty. The predicted burst pressure of this flaw is well above the performance criterion. The predicted burst pressure was predicted to be 5731 psi, and includes both material property and NDE sizing error at the lower 90% probability, 50% confidence level. The reported flaw length and average depth values were singularly adjusted for NDE sizing error in this case. Therefore, condition monitoring requirements are satisfied.

During the 1RF08 inspection, one axial PWSCC indication with a flaw amplitude of 0.63 volts and length of 0.13" was reported.

4.2.4 Small Radius U-bend PWSCC

No small radius U-bend PWSCC indications were reported.

4.2.5 Tube Wear at AVBs, Preheater Baffles, and Due to Loose Parts/Foreign Objects

Tube wear due to foreign object interaction was reported in SGs 1, 3, and 4. The tubes with wear indications were located at the top of tubesheet and in upper bundle regions. In all cases, the wear mechanism could be tracked to the previous inspection. These indications were sized using the EPRI volumetric standard and guidance provided in ETSS 21998.1. The deepest and longest indication was reported at 28%TW, 0.313".

The wear mechanisms observed by bobbin coil generally had small bobbin amplitudes, i.e., less than 0.6 volt in the primary mix channel. As a comparison, the volumetric wall loss associated with the 40% depth, 0.187" diameter flat bottom hole of the ASME standard is approximately 3 volts. Based on flaw geometry characterization with RPC and relation to laboratory wear scars, the axial extents of the wear indications were about 0.21" max, with a maximum circumferential involvement of about 50 degrees. The uniform thinning burst model of NUREG-0718 can be used to estimate the burst pressure. At up to 83% TW degradation for a 0.26" axial involvement, burst pressure using LTL material properties exceeds the Comanche Peak 1 3ΔP value of 3816 psi. At 85% TW, the bobbin amplitude would be expected to be substantially larger than 3 volts. Using the ETSS 21998.1 depth measurement uncertainties at 90% probability, 50% confidence, the maximum depth is estimated to be bounded by 40%TW. At the approximated maximum depth of 40%, a 0.21" axial length uniform thinning flaw with LTL material properties has a predicted burst pressure of 8338 psi.

Tube wear at non-expanded baffles represents a low growth mechanism. The largest reported depth at 1RF08 was 43% TW. This indication was also the largest reported depth at 1RF07 of 37%. The largest reported depth at 1RF09 was 41% TW, in SG 4. The growth associated with this indication was 6% TW for Cycle 9, 5% for Cycle 8. One additional repairable indication was reported in SG 2 at 40%TW. The Cycle 9 growth for this indication was 13%, with no growth reported for Cycle 8. The average and 95% confidence growth rates for all baffle wear indications combined for Cycle 9 is 2.14% and 6.45%, respectively, while the largest reported growth was only 13% TW. The baffle wear growth statistics were conservatively adjusted by setting negative growth values to 0 in the average growth calculation. Using the uniform thinning burst equation, TSP wear of up to about 69% TW would be expected to provide structural integrity at the Comanche Peak 1 3ΔP value of 3816 psi.

The largest baffle wear average growth was reported in SG 3, with a value of 2.50% per cycle using all growth values, 2.68% per cycle if negative growths are set to 0. The largest reported growth in SG 3 was 10%.

The maximum AVB wear depth reported was 33% TW in SG 3. The growth associated with this indication was 1% TW. The largest reported AVB wear growth reported was 2% TW. As only 12 AVB wear indications were reported with corresponding depth values in 1RF08, a statistical growth evaluation can not be performed. Instead, a bounding growth of 15% will be used in the operational assessment.

In summary, structural and leakage performance criteria are satisfied at EOC-09 conditions for preheater baffle wear and AVB wear.

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

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

The only degradation mode classified as potential for CPSES 1RF09 is cold leg TTS SCC. At the 1RF08 inspection, a C-3 condition was reported in SGs 2, 3, and 4, and a 20% cold leg TTS +Pt inspection program was implemented. No degradation was reported in this program. SGs 2, 3, and 4 also reported C-3 conditions at 1RF09. A 20% cold leg TTS +Pt program will be implemented at 1RF10.

4.4 Summary of Limiting Indications

Table 5 presents a summary of the limiting indications for the 1RF09 inspection. All indications with the exception of R41 C71 SG2 had predicted burst capabilities of greater than the $3\Delta P_{NormOp}$ value of

3816 psi using material properties consistent with the EPRI tube integrity guideline. Table 5 also provides the burst pressure assessment per Table 8-1 of the EPRI tube integrity guideline, using NDE sizing uncertainty, material properties, and relation error at the lower 90% probability, 50% confidence level. The values in parentheses present the lower 90% probability, 50% confidence level burst pressures. The values listed for max length, max depth, and average depth are the as-reported NDE values.

Table 5
Summary of Limiting Indications at 1RF09 Using As-Reported Data and 90/50 Material Properties

Mechanism	Tube	Max Length	Max Depth	Avg. Depth	Calculated Burst Pressure	SLB Leakage gpm
Circ ODSCC at hot leg TTS	SG2 R2 C77	352°	76%	41.6%	6236 psi (4641 psi)	0
Axial ODSCC at TTS	SG3 R24 C60	0.30"	75% (1)	44%	7750 psi (7750 psi)	0
Freespan Axial ODSCC	SG3 R7 C112	2.81"	84% (2)	59.1%	(4123 psi)	0
Axial ODSCC in Dings	SG2 R41 C71	0.91"	100% (3)	80.2%	3101 psi (2727 psi) (5)	5.1 gpm at ΔP = 2350 psi (6)
Axial PWSCC at TTS	SG3 R5 C82	0.29"	69%	43.5%	7252 psi (5731 psi)	0
Axial ODSCC at TSP	SG4 R38 C41	0.21"	42%	N/A	5377 psi (4)	0
Baffle Wear	SG4 R48 C74	<0.75"	41%	<41%	7308 psi (5231 psi)	0
AVB Wear	SG3 R43 C59	0.288"	33%	<33%	8666 psi (6840 psi)	0

1): Phase analysis of depth likely resulted in gross overestimate of max depth. Reported maximum depth from profiling occurred at flaw tail, with voltage response significantly less than maximum voltage.
2): Successfully leak tested at a test pressure of 2841 psig with no leakage reported.
3): Based on observed leakage
4): For the lower 95% confidence interval correlation from Addendum 4 to the TSP ODSCC database
5): Burst pressure profile is based on the conservatively adjusted profile as discussed.
6): Calculated value

4.5 SLB Leakage Discussion

For all degradation mechanisms observed at 1RF09 with the exception of R41 C71 SG2, any potential for SLB leakage at end of Cycle 9 conditions is judged to be negligible. The circumferential ODSCC indications at the TTS are of sufficiently low magnitude that no leakage contribution is expected. In situ testing confirmed that no leakage was observed. Based on the available industry database, SLB leakage is not expected for maximum +Pt amplitudes of about 1 volt. The +Pt amplitudes of the in situ leak tested circumferential flaws ranged from 0.18 to 0.56 volts. The largest +Pt amplitude observed for all SGs was 0.56. At 1RF06, three flaws with +Pt amplitudes of 0.47 volts were in situ tested with no leakage. No leakage was reported at either the 1RF06, 1RF07, 1RF08, or 1RF09 in situ testing campaigns.

The largest axial ODSCC flaw at the TTS had a +Pt amplitude of 0.40 volts, with a maximum depth of 32% TW. At such low amplitude, this flaw would not have contributed to leakage at SLB conditions. Based on the lower 90% probability, 50% confidence line relating maximum to +Pt amplitude, the estimated maximum depth is 64%, well below a level that could support leakage at SLB conditions. The largest axial PWSCC flaw at the TTS had a +Pt amplitude of 1.75 volts, but included contribution from 3 closely spaced axial flaws. Using the 80 mil high frequency coil, the maximum depth was estimated at 60% TW. Maximum +Pt amplitudes for axial PWSCC indications at the TTS in 7/8" hardroll expanded tubes of up to 6 volts did not leak during in situ test. Extending this point to ¾" OD tubing would suggest a lower leakage threshold for axial degradation at the TTS of about 5 volts, when the amplitude response is adjusted by the ratio of tube ODs. For both tube sizes, the voltage calibration is consistent. That is, for both tube sizes, the 100% TW axial notch +Pt amplitude response is set to 20 volts.

Based on the in situ testing results for R41 C71 SG2, the leak rate was projected for the Comanche Peak Unit 1 SLB differential of 2350 psi with PORV availability using the methodology applied to axial ODSCC indications at TSP intersections that is part of the alternate repair criterion methodology. The projected leak rate is 5.1 gpm. This evaluation uses the elevated temperature tube material property values to estimate volumetric flow and then adjusts these values to room temperature conditions to provide an evaluation bases consistent with the offsite dose leakage limit. The offsite dose leakage limit for Comanche Peak Unit 1 is 27 gpm. Thus, while this indication would have provided leakage in excess of the NEI 97-06 performance criterion, doses at the site boundary would not have exceeded the licensing basis.

<u>In Situ Testing Summary:</u>

The in situ testing performed for the 1RF09 outage supports the conclusion that postulated SLB condition primary to secondary leakage will remain below 1 gpm for all SGs, excluding the results of R41 C71 SG2.

4.6 Estimate of Structural Integrity of R41 C71 SG2

The as-reported +Pt depth profile of R41 C71 SG2 is provided in Figure 8. The profile does not indicate 100%TW degradation, although the observed primary to secondary leakage at the end of the cycle and observation of dripping water during shutdown indicates that 100%TW degradation is present. The maximum observed in situ test pressure for this tube was 2150 psi, with a measured leak rate of 2.6 gpm. The estimated 100%TW length to provide 2.6 gpm at a differential pressure of 2150 psi is 0.50 to 0.55". Based on the maximum depth versus +Pt amplitude correlation of Reference 4, the estimated 100%TW flaw length based on +Pt amplitude response is [

]^{a,c,e}. Thus, for estimation of burst capability of R41 C71, a bounding 100%TW flaw length of 0.64" was assumed with the maximum depth versus amplitude correlation used to adjust flaw depths for amplitudes less than the 100%TW value. The as-reported and adjusted +Pt profile for R41 C71 SG2 is provided in Figure 8. Since the 100%TW length will dominate the estimation of burst pressure, this adjustment is considered conservative. Actual material properties for this tube are available from certified material test reports. The 650°F temperature adjusted flow stress is 74.4 ksi. This value was used for the burst pressure evaluation. Subsequent visual examination of the ID surface of R41 C71 SG2 clearly shows 2 collinear axial cracks at the elevation in question. The upper 100%TW tip of the lower crack is at the same elevation or slightly below the lower 100%TW tip of the upper crack. A non-degraded ligament is clearly visible between the 2 cracks. Based on burst testing results performed as part of the original F* alternate repair criterion development, it was concluded that collinear axial cracks act independently of each other with regard to burst capability. Based on the visual examination, the conservatively adjusted profile for R41 C71 SG2 using the estimated 100%TW length from the maximum depth versus +Pt amplitude correlation is therefore judged to be a valid conservative model, and burst pressure evaluation can therefore be judged to represent a conservative lower bound estimate of true burst capability.

The minimum burst pressure obtained using a Monte Carlo simulation including relation uncertainty is 1922 psi, while the lower 90% probability, 50% confidence burst pressure is 2395 psi. The mean burst pressure for this simulation is 2727 psi. At the Comanche Peak SLB pressure differential with PORV availability of 2335 psi, there is a 6.3% probability of burst. As this flaw has been modeled such that the 100%TW length extends for most of the flaw, the influence of uncertainty modeling for relation error is likely resulting in an underestimation of burst pressure, i.e., the burst capability of the flaw will be dominated by the 100%TW, and the relation error associated with a part throughwall depth burst model is not valid. If no relation error is modeled, the burst pressure using the conservatively adjusted profile is 2727 psi, and no burst is expected at the SLB pressure differential with PORV availability of 2335 psi.

As the visual examination showed the flaw to be comprised of 2 separate collinear axial flaws (Figure 9), the voltage profile of Figure 8 may be used to estimate the point in the profile at which the ligament may exist. Based on the voltage profile, this is judged to be at approximately 5.06". The laboratory ding program showed the flaws to be fairly symmetric. Therefore, if the flaw amplitude profile from 4.57" to 4.78" is used to estimate the shape of the dominant flaw, a 100%TW length of 0.47" is established, with a total flaw length of 0.71", and average depth of 90.1%. For this case, which represents the singular burst capability of the dominant flaw, the minimum burst pressure is 2264 psi, with a lower 90% probability, 50% confidence burst pressure of 2820 psi, mean burst pressure of 3211 psi, and burst probability using the PORV availability pressure of 2335 psi of 0.1%. As stated above, if relation error is not considered due to the flaw shape and dominance by the 100%TW length, the burst pressure is 3212 psi. Figure 9 is a negative of the actual video camera image. The negative more clearly shows the distinction between the 2 collinear flaws.

The growth performance of R41 C71 and its difference from the remainder of the ding ODSCC population can be seen in Figure 10. Figure 10 plots the 130 kHz phase change for all reported ding flaws comparing the 2002 and 2001 130 kHz phase responses. Figure 10 shows that only 2 indications had a 130 kHz bobbin phase change of greater than 20°. These two indications are represented by R41 C71 and another indication. The other indication was reported in a <1 volt ding. Once ODSCC initiated in this ding, the limited ding influence would result in significant phase change. The other dings were located in dings up to 6.2 volts, and therefore would result in lesser amounts of phase change due to the combination of the ding and flaw vectors. Since the ding amplitude of R41 C71 was estimated at 1.7 volts, the amount of phase change for this tube is significantly different from the rest of the 1RF09 ding ODSCC population, and significantly different from the ding flaws reported at other plants.

During the development phase of the bobbin ding qualification, the only way in which long, significantly deep flaws could be produced in a doped steam environment was if an additional stress riser were applied to the tube prior to application of the ding. Dings without the additional stress riser tended to blunt at about 70 to 80%TW once the flaw had penetrated through the stress influence of the ding. A similar observation can be seen in the Comanche Peak 1RF09 ding flaws since the phase change is very limited based on the comparison of 2002 and 2001 130 kHz phase responses. The limited amount of phase change suggests limited additional flaw growth from 2001 to 2002, with the exception of R41 C71. Thus, based on the difference in phase response and proximity to WEXTEX tubes, it can be surmised that the tube removal/replacement program that was performed in the manufacturing shop likely added an additional stress riser influence to R41 C71, thus its performance is dramatically different than the rest of the ding ODSCC population. Again, as the 2002 bobbin reporting criteria was changed to identify the type of signal seen in R41 C71 in the 1RF07 (1999) inspection, the safety significance of additional tubes with potential stress risers is extremely low as these types of indications would have been reported at 1RF09.

4.7 1RF09 Condition Monitoring Conclusion

Based on the CPSES 1RF09 inspection results, all tubes with the exception of R41 C71 SG2 satisfied the NEI 97-06 structural and leakage performance criteria. The changes implemented to the 1RF09 bobbin analysis guidelines will identify indications similar to R41 C71 at the 1RF07 and 1RF08 inspections, thus, indications similar to R41 C71 in past inspections are expected to be present in the Comanche Peak Unit 1 SGs.

The relative severity levels of the observed degradation for existing degradation mechanisms was judged consistent with or bounded by the levels associated with the 1RF08 inspection. Structural and leakage integrity for circumferential ODSCC indications at the hot leg top of tubesheet and freespan axial ODSCC indications were confirmed through both calculational methods and in situ pressure testing.

4.8 Degradation Mechanism Classification for 1RF10

Based on the 1RF09 inspection results, the following mechanisms are considered active for the 1RF10 inspection per the ERPI Rev.5 ISI Guidelines:

- Circumferential ODSCC at hot leg TTS expansion transitions
- Axial ODSCC at hot leg TTS expansion transitions
- Axial PWSCC at hot leg TTS expansion transitions

- Axial ODSCC at hot leg TSP intersections
- Axial ODSCC at freespan dings
- Axial ODSCC in straight leg freespan section in the absence of dings

As depth sizing methods are not considered qualified for continued operation justification, all crack like indications are considered active mechanisms.

Based on the 1RF09 inspection results, the following mechanisms are considered non-active per the ERPI Rev.5 ISI Guidelines:

- Tube wear at nonexpanded preheater baffles
- Tube wear at AVB intersections
- Tube wear due to foreign objects/loose parts

Based on accepted depth sizing techniques for preheater baffle wear and AVB wear, the reported growth statistics do not classify these mechanisms as active. The largest reported baffle or AVB wear growth for Cycle 9 was 13%TW, however overall baffle wear growth statistics are consistent with Cycle 9. The foreign objects/loose parts wear observed could not be considered to be within the qualification scope of the available bobbin analysis techniques. Supplemental evaluations performed using rotating probes and sizing methodology of ETSS 21998.1 indicate a maximum depth of 28%TW. All foreign object/loose part wear indications had precursor signals in the 1RF08 history review.

5.0 CYCLE 10 PRELIMINARY OPERATIONAL ASSESSMENT

The indication observed in R41 C71, SG2 did not meet the NEI 97-06 performance criteria for structural integrity or leak rate at SLB conditions. The changes made to the 1RF09 bobbin reporting criteria would have identified this indication in both the 1999 and 2001 inspections, and required a +Pt examination. This reporting criterion will identify such indications prior to significant depth or length growth can occur. Therefore, indications such as that found in R41 C71 at EOC-9 conditions will not be expected to present in the Comanche Peak Unit 1 SGs at EOC-10, and will not be expected to represent a challenge to tube structural or leakage integrity.

Leakage integrity of freespan ODSCC indications was established by in situ testing. All of the tubes reported to contain freespan axial ODSCC were in situ pressure tested in a full tube mode with the exception of R11 C94 SG2. The flaw length was <0.20", and flaw maximum depth from phase analysis was 57%TW, while the depth based on +Pt amplitude was 40%TW. All but R11 C42 were tested to the proof testing pressure of 4070 psi with no reported leakage or burst. R11 C42 was leak tested to 2841 psi with no leakage reported. After in situ testing of R11 C42, the hot leg section below H8 was removed from the SG for destructive examination. Laboratory burst pressure was 8177 psi. Previous discussion has concluded that the phase based depth profile values are unreliable, and that the more appropriate methodology for assessment of flaw depth is based on the +Pt amplitude. Using these profiles, margin to the structural and leakage integrity performance criteria are provided. It should be noted again that the post in situ test depth profiles for these tubes indicated *shallower* depth reports for the post in situ condition. Review of historical bobbin data for R7 C112 SG3 indicates that reportable bobbin signals were present in the 1RF07 (1999) inspection. The changes made to the bobbin reporting criteria during the 1RF09 outage will identify indications such as that found in R7 C112 at much earlier stages in their growth evolution. All freespan axial ODSCC indications with a +Pt amplitude of $\geq$0.10 volts had a corresponding bobbin signal. Using the +Pt amplitude to maximum depth relation, a 0.10 volt indication corresponds to a maximum depth of 36%TW. Thus it is unlikely that freespan axial ODSCC indications with greater than 40%TW maximum depth are not likely present in the Comanche Peak Unit 1 SGs.

The number of circumferential ODSCC indications at the hot leg TTS reported at 1RF09 was approximately 3.7 times the number of circumferential ODSCC indications reported at 1RF08 (668 in 1RF09 vs 178 in 1RF08), however, the maximum +Pt amplitudes and maximum reported PDA values have been consistent for the last 3 inspections, suggesting that upper bound growth rates are not increasing. While the number of circumferential indications increased from 1RF09 to 1RF08, Figure 2 shows that the 1RF09 circ ODSCC +Pt amplitude cumulative probability distribution is bounded by the 1RF08 distribution up to the 99% cumulative value. Figure 4 shows that 95% of the 1RF09 circumferential ODSCC indications have a peak to peak amplitude of less than 0.3 volts, suggesting that these indications have low PDA values and are likely highly segmented. Figure 2 shows that 95% of the 1RF09 indications have a PDA value of less than 28%. PDA values for all 1RF09 circumferential indications were developed using the methodology described in Reference 5.

The number of axial ODSCC indications at the hot leg TTS reported at 1RF09 was increased compared to 1RF08 (7 versus 1), however, the flaw amplitudes, depths, and lengths show that large margin against the structural and leakage performance criteria are provided. As no change in circumferential ODSCC growth rate trends are apparent, there is no basis to assume that axial flaw growth rates would be contradictory. Therefore, structural and leakage integrity of axial flaws at the hot leg top of tubesheet expansion transition is expected to be provided at EOC-10.

The number of bobbin DSI calls at TSP intersections was approximately equal at 1RF09 versus 1RF08. Only one DSI was reported with an amplitude of >1V, with an actual value of 1.06 volts. Considering the low numbers of axial ODSCC at TSP indications, and the low voltage growth rates, it is unlikely that any reported DSI at 1RF10 will exceed the voltage based structural limit, and projected SLB condition leakage is expected to be several orders of magnitude below the site allowable leakage limit. Table 4 shows that for SGs 1, 2, and 4, the voltage growth statistics are essentially 0, with the largest singular DSI amplitude growth of 0.44 volts. The beginning of Cycle 9 DSI voltages were all less than 1 volt, therefore, small changes in absolute voltage growth can represent rather large apparent growth values.

As in situ testing for all indications with the exception of R41 C71 SG2 at 1RF09 showed no leakage and no evidence of structural failure, structural and leakage integrity requirements of NEI 97-06 were met using deterministic methods, and are expected to continue to be met at EOC-10.

Despite the apparent confirmation that structural and leakage integrity consistent with NEI 97-06 and the current CPSES licensing basis, growth rates for the observed circumferential ODSCC mechanism was evaluated for the Cycle 6, Cycle 7, and Cycle 8 operating periods. Assessments of growth have been provided in previous assessments. A growth assessment for the 1RF09 circumferential ODSCC indications will be provided and evaluated in the final operational assessment. The axial freespan ODSCC mechanisms will also be evaluated in the final operational assessment. A growth evaluation will be included.

6.0 Potential New Degradation Mechanism Assessment

In SG 2 and SG3, freespan ODSCC in absence of dings was reported. This represents a new degradation mechanism for Comanche Peak Unit 1. This mechanism was identified as a relevant mechanism in the 1RF09 degradation assessment. Per the degradation assessment, a relevant degradation mechanism may not have been identified to date, but past experience at similar plants suggests that there is a potential for this mechanism to be present, and thus, qualified probes and techniques are required for the inspection.

The most significant of these indications was evaluated using all available probe technology, including bobbin and +Pt RPC techniques. In situ testing was performed for both tubes with these indications, and one of these tubes will be removed from the SG for destructive examination. Discussion provided in Section 4 indicates that multiple profiles and adjustments were considered, and in each case the burst capability of R11 C42 was found to be greater than the performance criterion. R7 C17 SG3 was proved to satisfy the structural integrity performance criterion by in situ pressure tests. Both of these tubes were tested in a full tube mode.

While this mechanism is new to Comanche Peak Unit 1, it is not new to the industry. Freespan axial ODSCC has been reported in several plants with similar SGs. Both of these plants have replaced SGs. A contributing cause was reported as axial scratches or gouges on the tube OD. It should be noted that although these plants experienced large leakage events approaching the makeup capacity, full cycle operation was endorsed by the US NRC. Another plant with a slightly different SG design also experienced freespan ODSCC, however this plant had significant OD scale and deposit conditions on the tubes. It is believed that the significant OD deposits and scale created extended crevice conditions conducive to the collection of aggressive species. This plant also had extensive axial ODSCC reported at the tube support plate intersections. This plant also experienced a primary to secondary leakage event that approached 120 gpd. Again, after the leakage event, no mid-cycle outage requirement was imposed by the US NRC. Both of these experiences differ from the Comanche Peak Unit 1 experience in that the freespan ODSCC at Comanche Peak is of a much lesser depth of penetration at the point of identification using the bobbin coil.

7.0 Comanche Peak 1 In Situ Pressure Testing History

Table 6 presents a summary of the in situ testing history at Comanche Peak Unit 1. The flaw parameters for the tested circumferential ODSCC indications are consistent for each inspection, suggesting that the upper bound flaw severity has not changed over at least 4 inspections.

No leakage or burst was reported for any circumferential ODSCC in situ pressure test at Comanche Peak Unit 1.

8.0 References

1. SG-01-02-004, "Comanche Peak Steam Electric Station Unit 1 Steam Generator Degradation Assessment 1RF08 Refueling Outage", February 2001 (Westinghouse Proprietary)

2. SG-01-03-003, "Performance Evaluation of Segment Method for Circumferential ODSCC Sizing in Hardroll Expansion Joints", March 2001 (Westinghouse Proprietary)

3. SG-01-03-002, "Circumferential ODSCC Profiling Method for Hardroll Expansion Joints", March 2001 (Westinghouse Proprietary)

4. SG-01-01-001, "Site Specific Eddy Current Noise Evaluation Methodology Relating to SG Tube Integrity", January 2001 (Westinghouse Propreitary)

5. CN-SGDA-02-93, "Circumferential ODSCC Sizing Uncertainties", April 2002 (Westinghouse Proprietary)

6. EPRI TR-107621R1, "Steam Generator Integrity Assessment Guidelines", March 2000

7. EPRI TR-107569-V1R5, "PWR Steam Generator Examination Guidelines", September 1997

Table 6

Tube	SG	Degradation Mode	Location	Flaw Length	Max Depth (NDE)	+Pt Volts	Leak Test Pressure	Proof Test Pressure	Leakage	Burst
CPSES 1RF09 In Situ Testing Summary										
R41 C55	1	Axial ODSCC	H10 +38"	0.10"	~70%	0.93	4070	4070	No	No
R41 C75	1	Axial ODSCC	C10 +38"	0.23"	~70%	0.48	4070	4070	No	No
R42 C59	1	Axial ODSCC	AV3 +1.6"	0.27"	~70%	0.52	4070	4070	No	No
R45 C24	1	Axial ODSCC	AV3 +1.7"	0.20"	~70%	0.43	4070	4070	No	No
R5 C70	2	Circ ODSCC	HTS –0.29"	360°	61%	0.18	2970	4375	No	No
R7 C73	2	Circ ODSCC	HTS –0.29"	330°	76%	0.32	2970	4375	No	No
R11 C42	2	Axial ODSCC	H5 +10.63"	1.63"	64%	0.21	2841	N/A	No	N/A
R41 C71	2	Axial ODSCC	AV3 +26"	0.91"	100%	6.5	2150	N/A	Yes	N/A
R44 C83	2	Axial ODSCC	AV2 +27"	0.25"	~70%	0.45	4070	4070	No	No
R7 C17	3	Axial ODSCC	H5 +11.73"	1.14"	68%	0.26	4070	4070	No	No
R4 C51	3	Axial ODSCC	H9 +9"	0.89"	71%	0.24	2841	4070	No	No
R2 C77	3	Circ ODSCC	HTS –0.31"	270°	60%	0.38	2970	4375	No	No
R38 C77	3	Circ ODSCC	HTS –0.25"	270°	76%	0.42	2970	4375	No	No
R7 C90	3	Axial ODSCC	H3 +29.2"	2.81"	60%	0.26	2841	4070	No	No
R23 C90	3	Circ ODSCC	HTS –0.29"	120°	76%	0.44	2970	4375	No	No
R36 C93	3	Circ ODSCC	HTS –0.14"	210°	82%	0.22	2970	4375	No	No
R7 C112	3	Axial ODSCC	H8 +8.56"	2.88"	62%	0.81	2841	4070	No	No
R32 C65	4	Circ ODSCC	HTS –0.46"	330°	76%	0.56	2970	4375	No	No
R4 C77	4	Circ ODSCC	HTS –0.25"	330°	48%	0.26	2970	4375	No	No
CPSES 1RF08 In Situ Testing Summary										
Tube	SG	Degradation Mode	Location	Flaw Length	Max Depth (NDE)	+Pt Volts	Leak Test Pressure	Proof Test Pressure	Leakage	Burst
R18 C84	4	Circ ODSCC	HTS –0.28"	270°	91%	0.19	2955	4395	No	No
R2 C72	4	Circ ODSCC	HTS –0.02"	270°	42%	0.31	2955	4395	No	No

CPSES 1RF07 In Situ Testing Summary										
Tube	SG	Degradation Mode	Location	Flaw Length	Max Depth (NDE)	+Pt Volts	Leak Test Pressure	Proof Test Pressure	Leakage	Burst
R22 C89	4	Circ ODSCC	HTS –0.23”	339°	69%	0.23	2925	4385	No	No
R32 C77	4	Circ ODSCC	HTS –0.14”	292°	63%	0.32	2925	4385	No	No
R38 C78	4	Circ ODSCC	HTS +0.11”	265°	71%	0.17	2925	4385	No	No
CPSES 1RF06 In Situ Testing Summary (limiting indications)										
Tube	SG	Degradation Mode	Location	Flaw Length	Max Depth	+Pt Volts	Leak Test Pressure	Proof Test Pressure	Leakage	Burst
R1 C69	2	Circ ODSCC	HTS +0.12”	296°	61%	0.43	2925	4315	No	No
R1 C73	2	Circ ODSCC	HTS –0.17”	326°	67%	0.47	2925	4315	No	No
R1 C95	2	Circ ODSCC	HTS –0.32”	337°	64%	0.44	2925	4315	No	No
R3 C96	2	Circ ODSCC	HTS –0.25”	350°	71%	0.38	2925	4315	No	No
R3 C103	2	Circ ODSCC	HTS –0.14”	360°	71%	0.43	2925	4315	No	No

Notes:

1. R41 C71 leaked at a maximum rate of 0.03 gpm at pressure differential of 1439 psi (normal operating temperature adjusted). Leak test was stopped at 2150 psi due to leakage exceeding pump capacity of 2.6 gpm. Burst could not be established. Predicted burst pressure is approximately 2727 psi.

2. All axial ODSCC tests were conducted using full tube setup, thus leak and proof test pressures are equal.

3. All maximum depths based on phase analysis for most reliable depth points.

Table 7
1RF09 Axial ODSCC in Dings Pre and Post In Situ +Pt Parameters

					Pre In Situ				Post In Situ	
SG	Row	Col	Location	Elevation	130 kHz Volts	130 kHz Phase	+Pt Volts	Phase (1)	+Pt Volts	Phase
1	41	55	H10	+37.97	1.15	166° (2)	0.93	6°	1.01	9°
1	41	75	C10	+37.90"	0.51	152°	0.48	5°	0.62	10°
1	42	59	AV3	+1.9"	0.58	155°	0.52	21°	0.55	26°
1	45	24	AV3	+1.7"	0.24	61°	0.43	24°	0.42	37°
1	49	74	AV4	+2.84"	0.40	125°	0.41	35°	N/A	N/A
1	49	43	AV4	-0.82"	0.85	165° (3)	0.34	35°	N/A	N/A
1	32	74	H1	+5.12"	0.35	130°	0.25	24°	N/A	N/A
1	41	77	C10	+37"	0.58	145°	0.54	17°	N/A	N/A
1	41	79	C10	+38"	0.54	153°	0.59	8°	N/A	N/A
1	41	94	C10	+38"	0.77	150°	0.67	14°	N/A	N/A
1	41	95	C10	+27.6"	0.77	145°	0.76	10°	N/A	N/A
2	25	30	C7	+23.4"	0.20	82°	0.27	16°	N/A	N/A
2	44	83	AV3	-2.31"	0.45	113°	0.45	39°	0.53	63°
2	44	83	AV3	-0.28"	N/A (4)	N/A	0.33	4°	0.29	18°
2	33	100	H1	+13.6"	0.65	134	0.63	19°	N/A	N/A
4	41	85	AV4	+11"	0.21	67°	0.21	45°	N/A	N/A

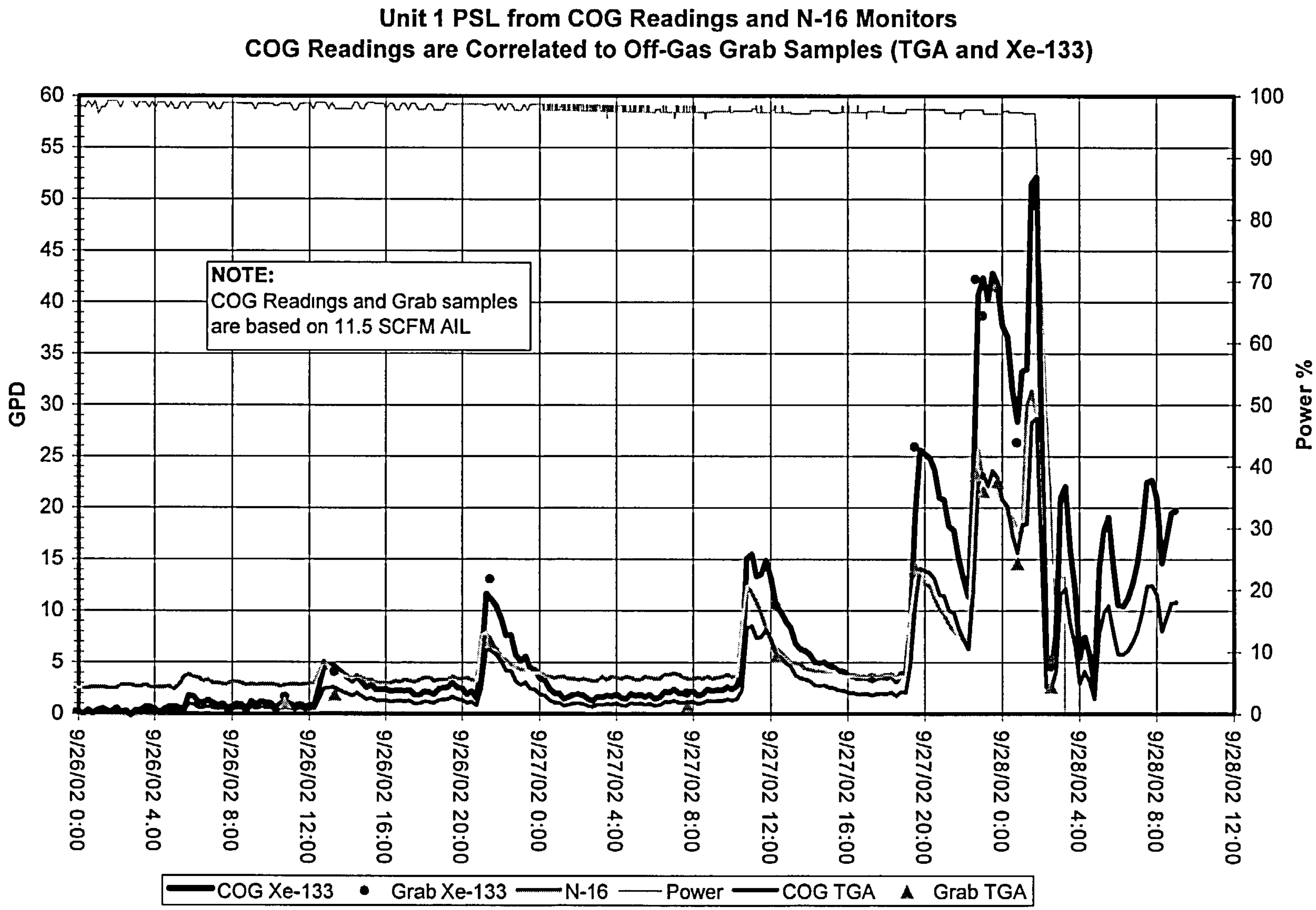
Note:
1) Ding flaw +Pt phase is often in ID plane for shallow OD flaws. Bobbin response indicates classic ODSCC influence.
2) R41 C55 ding amplitude is 6.2 volts, thus bobbin technique is not applicable for detection
3) Due to proximity with AVB, 130 kHz channel could not be used. Mix channel data is provided and shows reportable phase rotation.
4) Due to proximity with AVB, 130 kHz channel could not be used. Mix channel data shows a ding.

Table 8
Axial ODSCC in Freespan in Absence of Dings: Pre and Post In Situ +Pt Parameters

					Pre In Situ			Post In Situ		
SG	Row	Col	Location	Elevation	Volts	Depth	Length	Volts	Depth	Length
2	11	42	H3	+2.16"	0.06	44%	0.69"	0.08	44%	0.89"
			H3	+3.14"	0.09	45%	0.26"	0.12	58%	0.33"
			H3	+7.34"	0.17	43%	0.56"	0.19	41%	0.59"
			H3	+8.92"	0.06	65%	0.20"	0.07	49%	0.20"
			H5	+10.63"	0.21	61%	1.63"	0.26	61%	1.69"
			H5	+12.46"	0.17	56%	0.39"	0.20	55%	0.39"
			H5	+14.64"	0.11	71%	0.49"	0.15	61%	0.49"
2	11	94	H1	+13.6"	0.14	57%	0.20"	N/A	N/A	N/A
3	4	51	H9	+8.9"	0.24	61%	0.89"	0.34	46%	0.89"
			H9	+20.2"	0.13	19%	0.58"	0.17	17%	0.62"
			C7	+37.5"	0.08	20%	0.62"	0.10	N/A	N/A
			C7	+37.74"	0.05	46%	0.22"	0.11	N/A	N/A
			C7	+38.43"	0.09	29%	1.24"	0.14	N/A	N/A
3	7	17	H5	+11.73"	0.26	64%	1.14"	0.40	54%	1.20"
			C8	+25.90"	0.18	51%	0.41"	0.23	41%	0.48"
			C8	+28.41"	0.04	54%	0.16"	0.07	34%	0.32"
3	7	90	H1	+14.93"	0.14	53%	0.54"	0.22	36%	0.65"
			H1	+15.3"	0.03	10%	0.21"	N/A	N/A	N/A
			H1	+16.31"	0.04	34%	0.30"	0.05	41%	0.38"
			H1	+20.29"	0.05	38%	0.33"	N/A	N/A	N/A
			H1	+22.35"	0.03	42%	0.21"	N/A	N/A	N/A
			H1	+22.99"	0.03	37%	0.13"	N/A	N/A	N/A
			H1	+27.07"	0.05	35%	0.17"	N/A	N/A	N/A
			H1	+28.31"	0.09	24%	0.20"	N/A	N/A	N/A
			H1	+28.62"	0.05	54%	0.14"	N/A	N/A	N/A

			H3	+5.26"	0.06	33%	0.21"	N/A	N/A	N/A
			H3	+24.65"	0.10	69%	2.30"	N/A	N/A	N/A
			H3	+27.09"	0.17	41%	1.10"	0.20	44%	1.19"
			H3	+29.21"	0.26	60%	1.50"	0.36	58%	1.66"
			C8	+6.71"	0.08	69%	0.29"	0.07	N/A	N/A
			C8	+34.48"	0.10	44%	0.36"	0.13	N/A	N/A
3	7	112	H8	+8.56"	0.81	60%	2.70"	1.83	61%	2.77"
Note: Depth reported by phase at point of maximum +Pt volts. Elevation reported at point of max volts										

Figure 1


Unit 1 PSL from COG Readings and N-16 Monitors
COG Readings are Correlated to Off-Gas Grab Samples (TGA and Xe-133)
NOTE:
COG Readings and Grab samples are based on 11.5 SCFM AIL
GPD
Power %
60
55
50
45
40
35
30
25
20
15
10
5
0
100
90
80
70
60
50
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9/26/02 0:00
9/26/02 4.00
9/26/02 8:00
9/26/02 12:00
9/26/02 16:00
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9/27/02 0:00
9/27/02 4:00
9/27/02 8:00
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9/28/02 4:00
9/28/02 8:00
9/28/02 12:00
COG Xe-133
Grab Xe-133
N-16
Power
COG TGA
Grab TGA

Figure 2

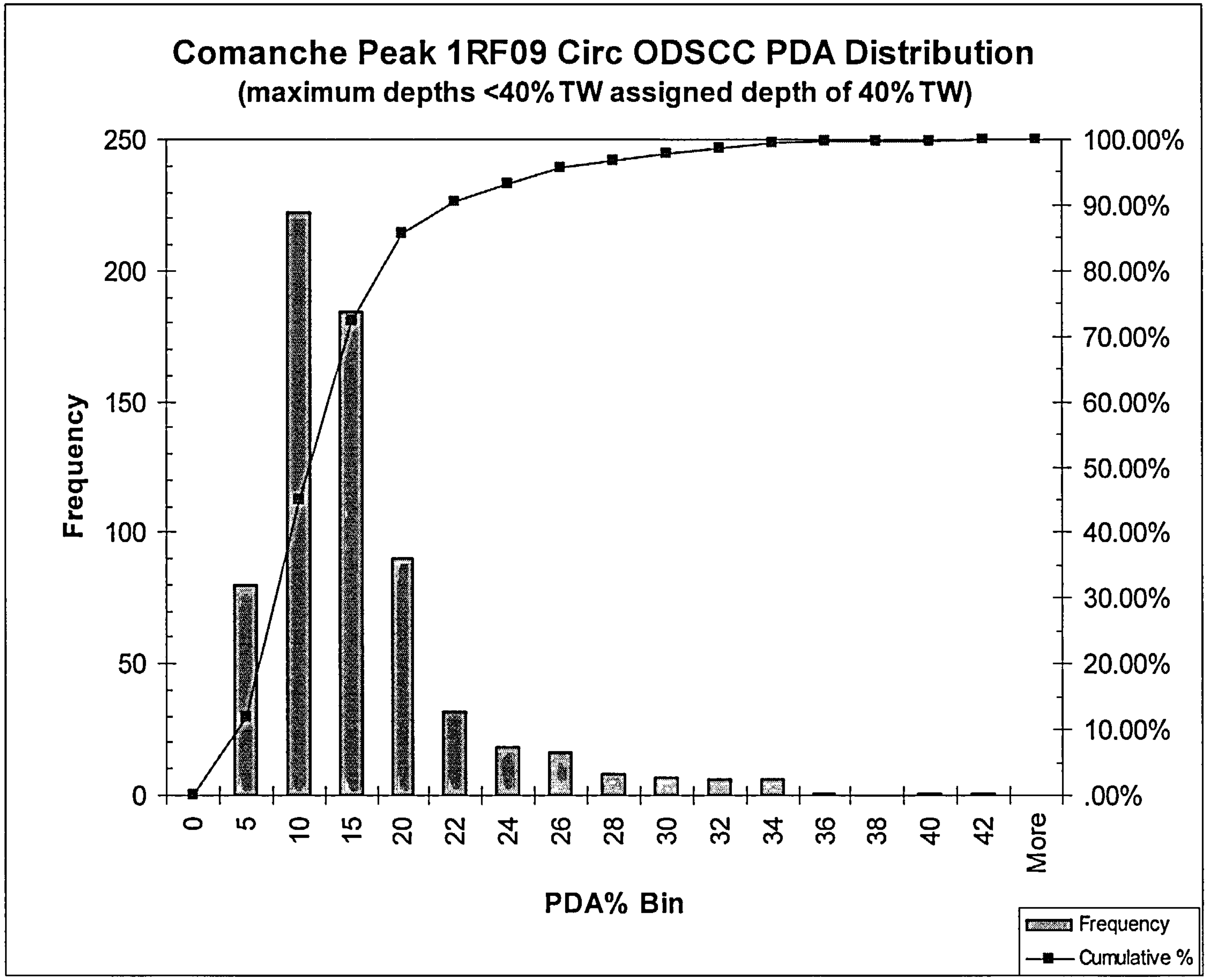

Comanche Peak 1RF09 Circ ODSCC PDA Distribution
(maximum depths <40% TW assigned depth of 40% TW)
250
200
150
100
50
0
Frequency
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
.00%
0
5
10
15
20
22
24
26
28
30
32
34
36
38
40
42
More
PDA% Bin
Frequency
Cumulative %

Figure 3

a,c

Figure 4

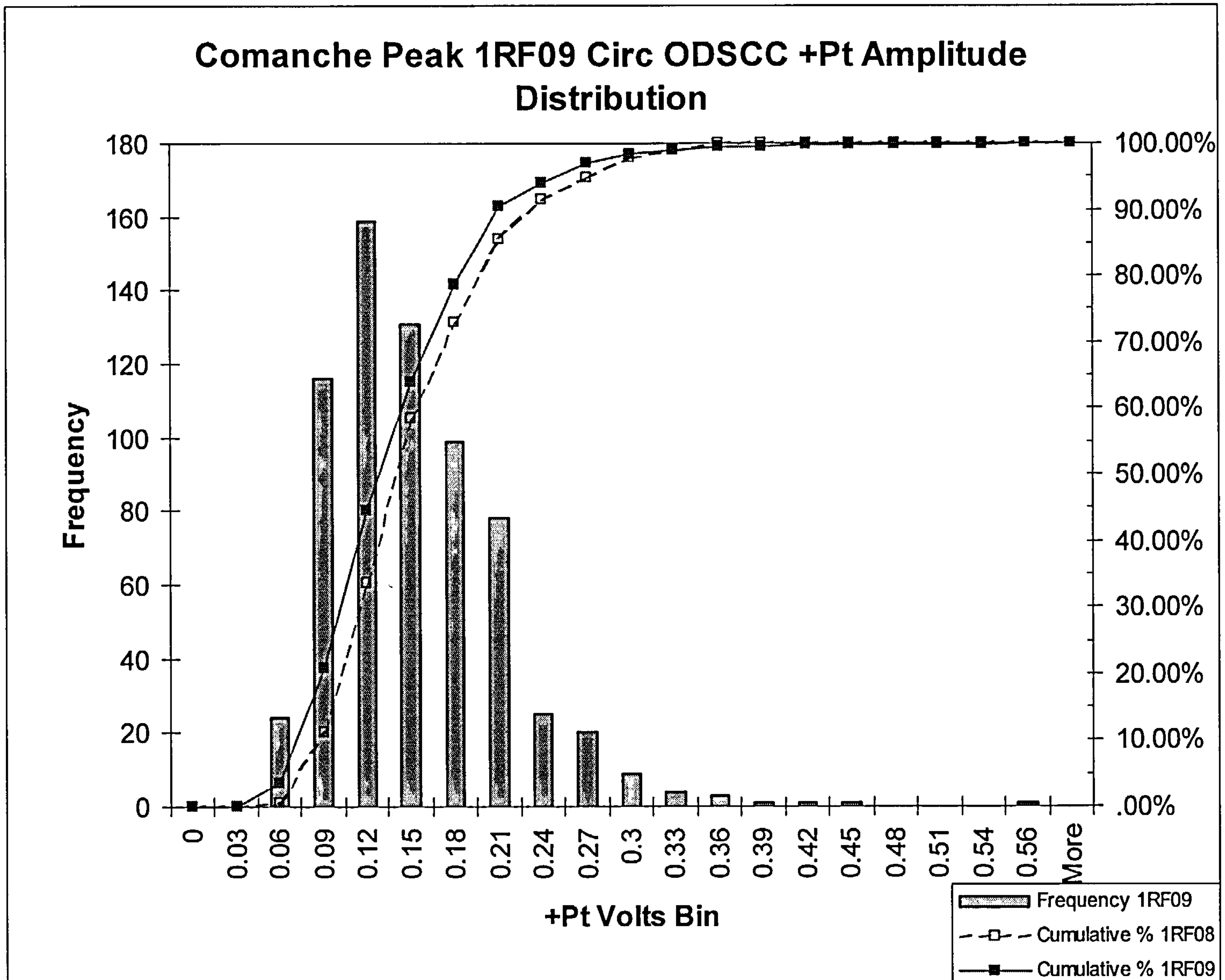
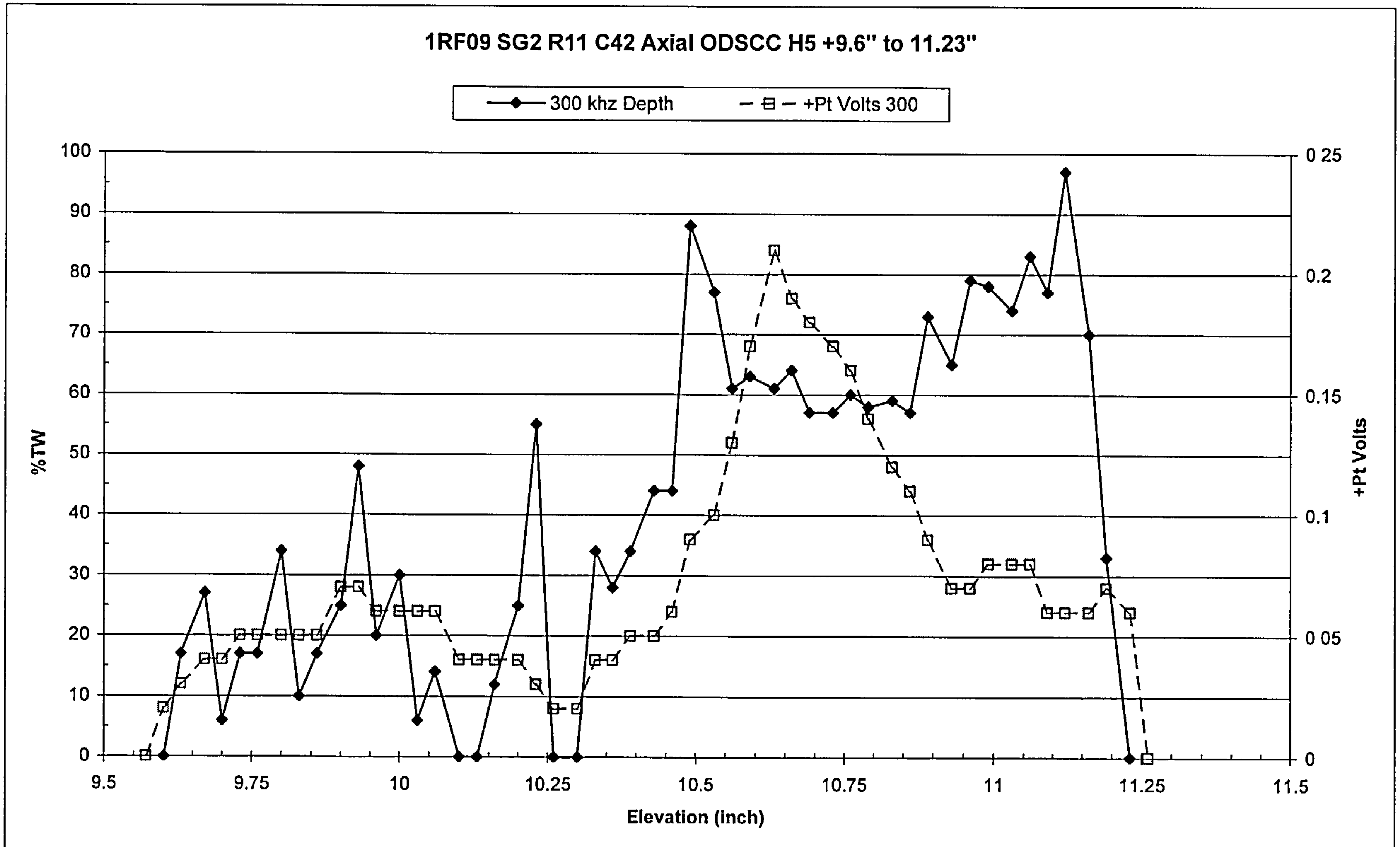

Comanche Peak 1RF09 Circ ODSCC +Pt Amplitude Distribution
Frequency
180
160
140
120
100
80
60
40
20
0
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
.00%
0
0.03
0.06
0.09
0.12
0.15
0.18
0.21
0.24
0.27
0.3
0.33
0.36
0.39
0.42
0.45
0.48
0.51
0.54
0.56
More
+Pt Volts Bin
Frequency 1RF09
Cumulative % 1RF08
Cumulative % 1RF09

Figure 5


1RF09 SG2 R11 C42 Axial ODSCC H5 +9.6" to 11.23"
300 khz Depth
+Pt Volts 300
%TW
+Pt Volts
Elevation (inch)
100
90
80
70
60
50
40
30
20
10
0
0 25
0.2
0.15
0.1
0 05
0
9.5
9.75
10
10.25
10.5
10.75
11
11.25
11.5

a,c,e

Figure 6

[ ]

Figure 7

a,c,e

Figure 8

a,c,e

[ ]

Figure 9

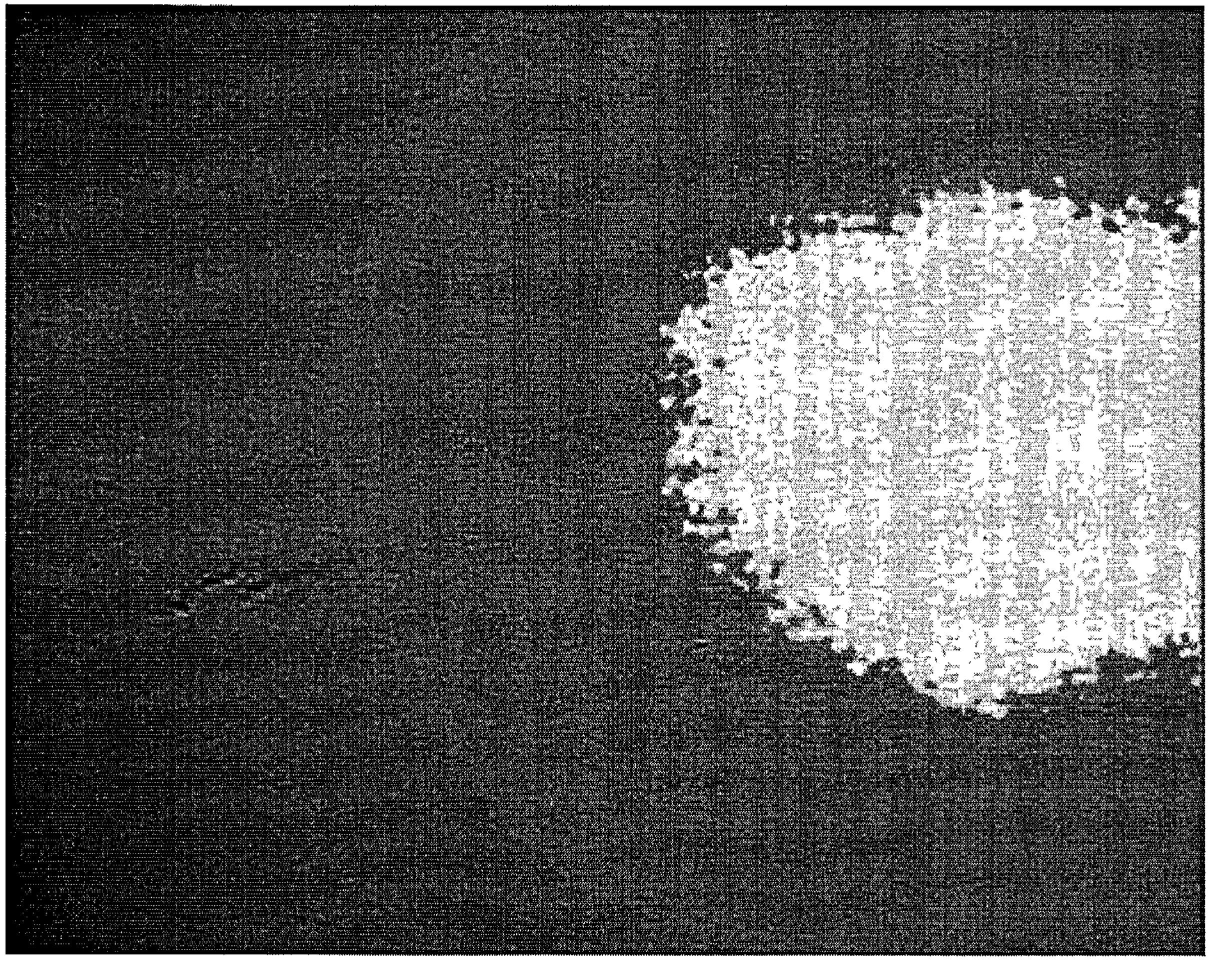
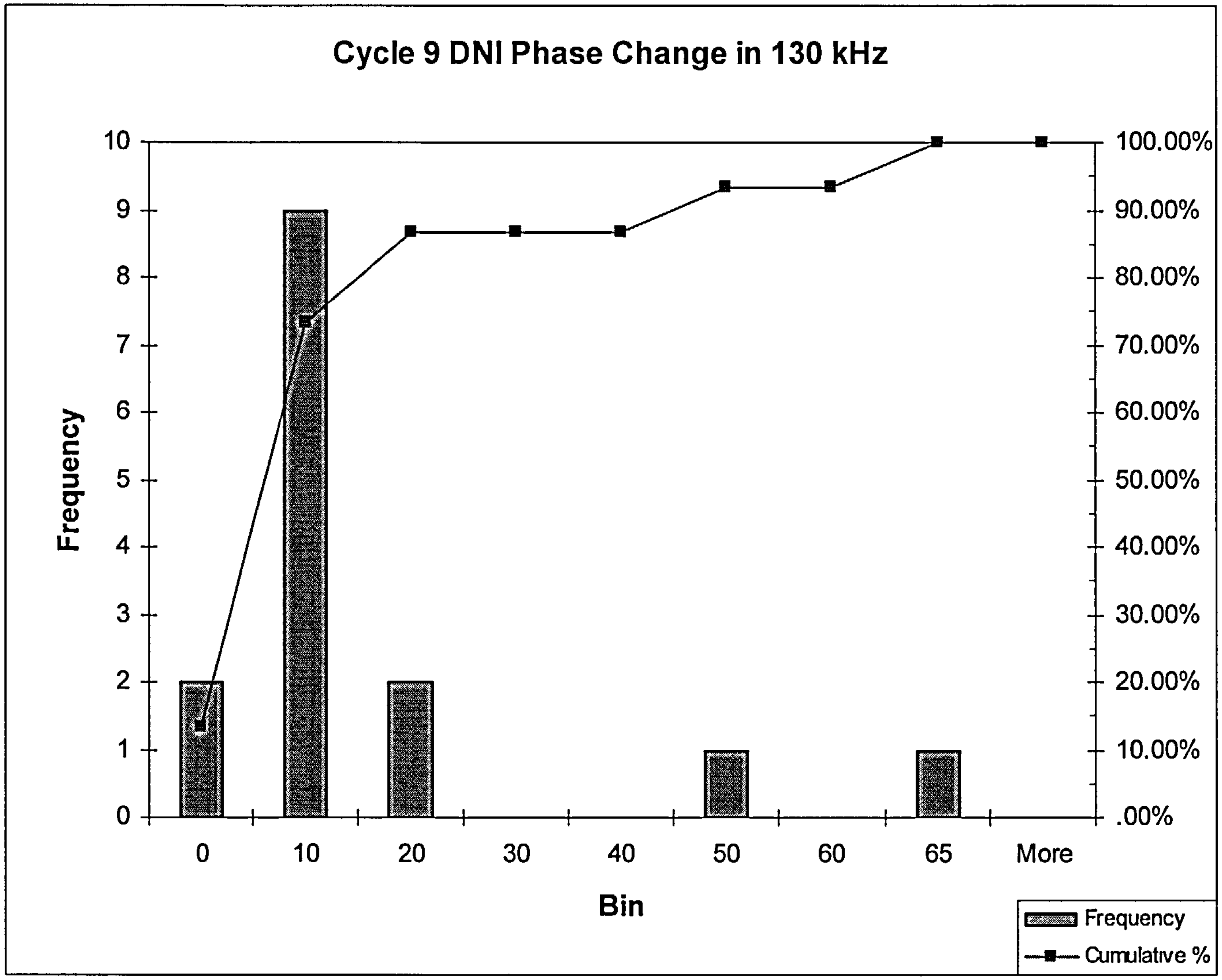


Figure 10


Cycle 9 DNI Phase Change in 130 kHz
Frequency
10
9
8
7
6
5
4
3
2
1
0
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
.00%
0
10
20
30
40
50
60
65
More
Bin
Frequency
Cumulative %