April 30, 2004

Mr. M. R. Blevins
Senior Vice President
& Principal Nuclear Officer
TXU Energy
ATTN: Regulatory Affairs
P. O. Box 1002
Glen Rose, TX 76043

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION, UNIT 1 - REVIEW OF STEAM GENERATORS' 90-DAY REPORT AND OPERATIONAL PERFORMANCE REPORT (TAC MB8456)

Dear Mr. Blevins:

By letters dated February 17 and March 18, 2003, TXU Generation Company LP (the licensee) submitted reports, as required by the plant technical specifications, pertaining to steam generator (SG) inspections performed at Comanche Peak Steam Electric Station (CPSES), Unit 1, during the ninth refueling outage (1RF09). The February 17, 2003, report is the licensee's 90-day report discussing implementation during 1RF09 of the Generic Letter 95-05, "Voltage-Based Repair Criteria for Westinghouse [Westinghouse Electric Company] Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking," alternate repair criteria at the tube support plate (TSP) intersections. The report also discusses the operational assessment for the degradation mechanism during Cycle 10 operation. The March 18, 2003, report is the twelve-month report documenting the SG inspections performed during 1RF09. The March 18, 2003, report also enclosed the licensee's operational assessment for degradation mechanisms other than Outside Diameter Stress Corrosion Cracking at the TSP's supporting Cycle 10 operation.

The Nuclear Regulatory Commission (NRC) staff has reviewed the licencee's February 17 and March 18, 2003, submittals, including the operational assessments therein. In addition, the NRC staff inspected the Westinghouse report SG-SGDA-03-9, Revision 1, "Comanche Peak Unit 1 Steam Generator Tube Examination," dated June 2003. The Westinghouse report documented the results of laboratory examinations of tube specimens removed from the field during 1RF09. This latter report is a proprietary report. It was inspected at the Westinghouse office in Rockville, Maryland, since it is not publicly available.

Based on its review, the NRC staff concludes that there is reasonable confidence that tube integrity at CPSES, Unit 1, will be maintained until the next scheduled inspection at 1RF10 in 2004.

Although the staff has an adequate basis to conclude that tube integrity will be maintained during the current cycle, the staff has several observations regarding the licensee's assessment of tube integrity. The licensee may find these observations helpful for future assessments as currently identified degradation mechanisms become more advanced. These observations are described in Enclosure 2.

The staff review report and the staff observation report are enclosed for your use.

Sincerely,

***/RA/***

Mohan C. Thadani, Senior Project Manager, Section 1
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Enclosures:
1. Staff Review Report
2. Staff Observations Report

Docket No. 50-445

cc w/encls: See next page

Although the staff has an adequate basis to conclude that tube integrity will be maintained during the current cycle, the staff has several observations regarding the licensee's assessment of tube integrity. The licensee may find these observations helpful for future assessments as currently identified degradation mechanisms become more advanced. These observations are described in Enclosure 2.

The staff review report and the staff observation report are enclosed for your use.

Sincerely,

***/RA/***

Mohan C. Thadani, Senior Project Manager, Section 1
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Enclosures: 1. Staff Review Report
2. Staff Observations Report

Docket No. 50-445

cc w/encls: See next page

DISTRIBUTION:

| | | |
|---|---|---|
| PUBLIC | RidsNrrPMMThadani | DRIP/RORP/TSS |
| PDIV-1 Reading | RidsNrrLADJohnson | EMurphy |
| RidsNrrDlpmPdivLpdiv1 (RGramm) | RidsOgcRp | WJohnson Region IV |
| RidsNrrDlpmPdiv (HBerkow) | RidsAcrsAcnwMailCenter | |
| RidsRgn4MailCenter (AHowell) | G.Hill(4) | |

Accession No.:ML041260576 *no significant change in the input

| OFFICE | PDIV-1/PM | PDIV-1/LA | EMCB/SC* | PDIV-1/SC |
|---|---|---|---|---|
| NAME | MThadani | DJohnson | LLund | RGramm |
| DATE | 4/29/04 | 3/1/04 | 01/26/04 | 4/29/04 |

OFFICIAL RECORD COPY

# COMANCHE PEAK STEAM ELECTRIC STATION, UNIT 1
# STAFF REVIEW OF STEAM GENERATORS' 90-DAY REPORT
# AND OPERATIONAL PERFORMANCE REPORT

## 1.0 INTRODUCTION

By letters dated February 17 and March 18, 2003 (References 1 and 2), TXU Generation Company LP (the licensee) submitted reports, as required by the plant technical specifications, pertaining to steam generator (SG) inspections performed at Comanche Peak Steam Electric Station (CPSES), Unit 1, during the ninth refueling outage (1RF09). Reference 1 is the 90-day report discussing implementation during 1RF09 of the Generic Letter (GL) 95-05, "Voltage-Based Repair Criteria for Westinghouse [Westinghouse Electric Company] Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking," alternate repair criteria for outer diameter (OD) stress corrosion cracking (ODSCC) at the tube support plate (TSP) intersections. The report also discusses the operational assessment for the degradation mechanism during Cycle 10 operation. Reference 2 is the twelve-month report documenting the SG inspections performed during 1RF09. Reference 2 also enclosed the licensee's operational assessment for degradation mechanisms other than ODSCC at the TSPs, supporting Cycle 10 operation.

The January 9, 2003, special team inspection report for CPSES, Unit 1 (Reference 3), committed the staff to reviewing the results of the licensee's examinations of pulled tube specimens removed from the CPSES, Unit 1, SGs during 1RF09 in 2002. In addition, Reference 3 committed the staff to reviewing the licensee's operational assessment performed to support full term operation of the CPSES, Unit 1, SGs to the next refueling outage (1RF10) scheduled for 2004. The staff has completed these reviews and the results are documented herein.

## 2.0 THE STAFF REVIEW

The staff's review of the 1RF09 inspection results, the pulled tube examinations, and the Cycle 10 operational assessments is described herein.

### 2.1 The Staff Review of Pulled Tube Examination

Sections of two tubes were pulled from CPSES, Unit 1, during 1RF09: R25C30 and R11C42. The results of the tube pull examinations were described in Westinghouse Report SG-SGDA-03-9, Revision 1, dated June 2003. This report is proprietary and was not submitted to the NRC. A copy of the report was made available for NRC staff inspection at the Westinghouse office in Rockville, Maryland.

Tube Section R25C30 was found by field bobbin and +Point inspection to contain a short axial indication (<0.3 inches) in a less than 1 volt ding. The +Point voltage response was small, 0.27 volts, which translates to approximately a 60% deep flaw. Burst testing of the pulled tube specimen yielded a burst pressure of 10989 pounds per square inch (psi) which is near its

virgin strength of 12178 psi. Examination of the fracture surface indicated the crack to have a maximum depth of 56% throughwall with a length of 0.095 inches. The crack was not associated with observable discontinuities or stringers.

Tube Section R11C42 was found by bobbin and +Point inspections in the field to contain a series of axial indications above the 3H and 5H TSPs on the hot leg side. (There is no 4H TSP.) Some of these indications were just above and some were just below the threshold of detection during the initial primary and secondary data analysis performed during 1RF09. Laboratory examination revealed these indications to be associated with an axial discontinuity. Subsequent to burst testing, the fracture faces were found to contain evidence of longitudinal stringers aligned with the discontinuity. The stringers were predominantly near the OD surface and were believed by the investigators to be associated with tube manufacture. No unusual OD mechanical damage or cold work was found associated with the discontinuity.

The tube sections above H3 and H5 exhibited laboratory burst pressures of 8546 psi and 8177 psi, respectively. The section above H5 exhibited ODSCC along the entire length, typically at levels ranging between 5% to 20%, but ranging to 48% at the center of the burst opening and to 55% and 56% at other locations in the span. The best estimate depth based on field +Point amplitude measurements was 50% at the burst location; very close to the actual maximum depth at this location. Crack depth measurements, based on phase angle range to 90%, significantly overestimating the actual depth.

Overall, the staff believes the results of the tube pull examinations to be consistent with expectations, supportive of the licensee's conclusions with respect to its condition monitoring assessment for 1RF09, and having no adverse impact on the assumptions in the licensee's operational assessment supporting operation to 1RF10.

## 2.2 The Staff Review of 1RF09 Inspection Results and Cycle 10 Operational Assessment

### ODSCC at Dings

This was the mechanism that caused tube R41C71 to fail to meet the structural and accident leakage integrity performance criteria during 1RF09 (See Reference 1 for background information). Sixteen additional indications of this type were found by inspection during 1RF09. Whereas the ODSCC flaw in R41C71 measured about 0.9 inches in length, the other sixteen flaws were found by +Point inspection to be relatively short, ranging to a maximum length of 0.25 inches. This is well below the critical crack length of 0.43 inches at the 3 times normal operating pressure (3 delta P) structural integrity performance criterion. Furthermore, review of previous data for these sixteen indications indicates little growth in the length direction. So, the main concern with respect to this particular mechanism is the occasional outlier that may have a length larger than 0.43 inches, as was the case for R41C71. The licensee believes that the relatively long length of R41C71 is due to the presence of an additional stress riser (unidentified) apart from the ding. The licensee's operational assessment is predicated on the assumption that relatively long indications similar to R41C71, as it existed in 2001, would have been detected during 1RF09. Thus, the licensee's operational assessment focused on relatively short flaws of less than 0.3 inches in length. The licensee's analysis indicates that such flaws will remain of sub-critical length by end-of-cycle and, in addition, will not impair leakage integrity.

Given the occurrence of one crack in excess of the critical length during recent operating cycles, the staff believes that one must consider that a similarly long crack may grow into the detectable range during the operating cycle. Thus, the staff considered the question of how large such a crack might be and how it may affect tube integrity.

As discussed in Reference 3, there were at least two missed opportunities, dating back to 1999, to have detected and plugged R41C71 prior to 1RF09 in the fall of 2002. Growth rate information on this flaw is highly uncertain by virtue of the distorted nature of the bobbin signals during 1RF08 and 1RF07. However, the revised data analysis procedures implemented during 1RF09, coupled with the actions taken to improve the quality of the data analysis, ensure that flaws similar to that in R41C71, as it existed in 1999, will be detected.

In Reference 4, the licensee estimated that the R41C71 flaw had a growth rate, in terms of maximum depth of 27% per effective full power year (EFPY), and that the flaw first reached 100% throughwall mid-way through the last operating cycle. This would mean that maximum flaw depth would have been on the order of 40% during 1RF07 in 1999. The staff has no information as to whether the flaw was detectable prior to 1999 (1RF07) when using the current data analysis procedures. Should there now exist a relatively long crack under circumstances similar to R41C71, but at an earlier stage of evolution with depth not exceeding 40%, which is of yet undetected, and which has a growth rate as high as 27% per EFPY, the maximum depth at 1RF10 would be expected to be about 80% and the burst average depth would typically be more than 10% less based on industry data. Making a conservative assumption that the burst average depth is 72% over a length of 0.9 inches, the staff would expect such a flaw to meet 3 delta P (3800 psi) based on a best estimate burst prediction model assuming lower bound material properties. Application of a ligament tearing model indicates that this flaw would not be expected to leak under main steam line break (MSLB) conditions.

The staff notes that use of a lower bound burst prediction model, rather than best estimate, leads to a predicted burst pressure of 3300 psi, which is less than the 3 delta P limit. The staff believes this latter estimate to be overly conservative in view of the other conservatisms included in this deterministic analysis; i.e., the assumption that the cycle began with the presence of an undetected flaw 0.9 inches in length and 40% throughwall, the assumption of a very high growth rate, the assumption that the ratio of average depth over the burst effective length is 0.9, and the use of industry lower bound (0.95 probability at 0.95 confidence level) material properties. Statistical methods for propagating the uncertainties through the analysis rather than compounding the uncertainties from each input parameter and from the model would provide for a more realistic treatment of the limiting flaw burst pressure at end-of-cycle and associated uncertainty compared to the above deterministic approach.

The method used to estimate the aforementioned growth rate involved considerable uncertainty due to the distortion of the 1RF07 and 1RF08 bobbin signals by the dent and probe wobble. If overestimated, then the above threshold of detection estimate for flaw depth (i.e., 40%) may be non-conservative. Typical growth rates for ODSCC, based on industry data, range from 5% per EFPY average to 15% per EFPY 95% upper bound. Assuming that the growth rate for R41C71 actually fell within this range, the maximum flaw depth during 1RF07 would have been in the range of 55% (for 15% per EFPY growth) to 88% (for 5% per EFPY growth). The bobbin coil qualification data set for ODSCC in dings indicates a probability of detection (POD) of 0.95 for a maximum depth of 75% and a POD of 0.92 for flaws in the range of 60% to 100% deep. However, the ODSCC flaws in the qualification data set had lengths which were generally less

than 0.2 inches. Flaws which are significantly longer than 0.2 inches, such as the 0.9 inch long flaw for R41C71, would be expected to exhibit a larger voltage response at a given depth than those with lengths less than 0.2 inches. Longer flaws would be expected to exhibit higher PODs as a function of depth than would shorter flaws. Thus, the staff concludes that a relatively long flaw should be reliably detectable with a maximum depth of 60% or greater.

Making the very conservative assumption that there was an undetected long flaw just below the detection threshold during 1RF09, the maximum flaw depth at the end of the current eighteen-month operating cycle for an undetected long flaw would not be expected to exceed 80%. Whereas the ratio of average depth over the burst effective length to maximum depth is generally less than 0.9 based on industry pulled tube data, 72% is a conservative estimate of average depth given a bounding maximum depth estimate of 80%. As discussed earlier, such a flaw with a burst effective length of 0.9 inches would be expected to meet the 3 delta P criterion using a best estimate burst model. The earlier discussion regarding uncertainties applies equally to this estimate.

2.3 Freespan ODSCC (Not Influenced by Detectable Dings or Dents)

A total of six tubes were found during 1RF09 to contain freespan ODSCC indications in the absence of dents. For four of the tubes, multiple indications were found. Each indication was pressure tested and satisfied the 3 delta P criterion and did not leak at MSLB pressure. One of these tubes was pulled for laboratory examination. For one section of tube between support plates, the ODSCC was found to exist at least at low levels (5% to 20%) along the entire span. Destructive examination indicated a maximum depth of 48% in that span. Depth profiles from +Point correlated fairly well (and somewhat conservatively) with the destructive examination when based on signal amplitude. The depth profile from phase angle analysis overestimated flaw depth, particularly at locations where the signal amplitudes were small (less than .15 volts at 300 kilo Hertz (KHz)). Portions of the crack that were less than 20% deep were generally not detectable with the +Point.

The most significant of the freespan indications found by inspection was for tube R7C112. This tube contained a flaw measuring 2.5 inches in length with +Point, a relatively large +Point voltage response of .82 volts, and a maximum measured depth of 62% based on +Point phase angle analysis and 85% based on +Point voltage amplitude. Based on the amplitude-based depth measurements, the licensee estimated that the remaining burst pressure capacity was 4788 psi, exceeding the 3 delta P criterion of 4100 psi. As previously noted, in-situ pressure testing was successfully conducted to the 3 delta P pressure with no leakage or burst.

Look back analyses of the bobbin data indicate that the R7C112 indication was present since at least 1RF07 in 1999. The licensee estimates the maximum flaw depth at that time of 66%. The licensee's estimate is based on bobbin voltage amplitude at 130 KHz, using a relationship between bobbin voltage amplitude and maximum depth developed from pulled tube freespan crack data from McGuire Nuclear Station (McGuire).

The licensee's operational assessment was performed using a variety of different methods which considered bobbin detection thresholds or POD functions to estimate the maximum flaw sizes that could potentially have escaped detection during 1RF09. The licensee estimates a bobbin POD of 0.95 for freespan flaws with a maximum depth of 50%. The staff did not review the basis for this estimate in detail. However, the staff believes that the detection threshold was

approximately 50% at the time the initial primary and secondary analyses were performed, and that subsequent data analyses substantially improved the detection of 50% deep flaws. In a separate approach, the licensee assumed a bobbin detection threshold corresponding to the 0.2 voltage threshold (130 KHz) at which automatic data screening reports all indications. The licensee stated that all freespan differential signals with this voltage or greater were ultimately inspected by +Point during 1RF09. The licensee estimates the maximum depth associated with a 0.2 volt bobbin indication to be less than 62% with 90% probability, based on a relationship between bobbin voltage amplitude and maximum depth that was developed from pulled tube freespan crack data from McGuire. The staff notes that this bounding estimate assumes that +Point itself has a POD of 1.0 for flaws with a maximum depth greater than 62% which the licensee did not demonstrate. However, the staff believes that this assumption is reasonable for flaws of sufficient length to potentially challenge the tube integrity performance criteria as they become deeper and deeper.

The licensee performed look back analyses for each of the indications found to assess growth rates. The upper 95/95 (probability/confidence) bound on the voltage growth rate distribution for the freespan indications between 1RF08 and 1RF09 was 0.14 volts at 130 KHz. Based on the aforementioned relationship between bobbin voltage and maximum depth, the licensee estimates maximum depth of a currently undetected flaw could grow from 62% to 74% by 1RF10.

Based on the flaw length distribution during 1RF09, as measured by +Point, the licensee estimates the upper 95% cumulative probability value of flaw length to be 1.75 inches. The licensee estimated that the ratio of maximum depth to average depth over the measured flaw length to be 1.4, based on analysis of the CPSES data and, thus, estimates a bounding average depth of 53% at 1RF10. The licensee estimates the burst pressure of a flaw measuring 1.75 inches long with an average depth of 53% to be 5986 psi; well above the 3 delta P criterion. The staff notes that this approach is not necessarily conservative. A more appropriate approach is to employ the “weak link” approach which is in common use throughout the industry. The weak link approach is characterized by a burst effective length and an associated average depth over that length. Such an approach will sometimes yield a lower burst pressure than the approach used by the licensee, depending on the actual depth profile. However, independent staff estimates indicate that use of such an approach would be expected to indicate that the 3 delta P criterion will be met at 1RF10 if a best estimate burst model is used in conjunction with lower bound material properties (at 0.95 probability/0.95 confidence). Earlier staff comments pertaining to treatment of uncertainties apply equally to this estimate.

Qualitative considerations provide a reality check on the above quantitative analysis. All tubes with freespan ODSCC during 1RF09 were demonstrated to satisfy the tube integrity performance criteria by pressure testing, including the 3 delta P criterion. In addition, the reliability of the inspections implemented during 1RF09 have been substantially upgraded relative to previous inspections.

### 2.4 Circumferential ODSCC at the Top of the Tubesheet (TTS)

This mechanism continues to be the dominant degradation mechanism in terms of the number of indications detected and plugged or sleeved. A total of 667 tubes with indications of this type were reported and were plugged or sleeved. Measured percent degraded areas (PDAs) ranged to 42% (without adjustment for uncertainty) and +Point voltage amplitudes ranged to 0.56 volts.

The licensee calculated a structural PDA limit of 82% corresponding to 3 delta P using mean material properties. Allowing for material strength at a lower 0.95 probability/0.95 confidence value and for +Point measurement error at a 0.95 probability bound, the licensee estimates the allowable measured PDA to be 56%. Thus, the licensee concluded the measured maximum PDA of 42% satisfied the 3 delta P criterion. In addition, the licensee in-situ pressure tested eight tubes with circumferential indications at the TTS, including three tubes with the largest PDA indications and three tubes with the largest +Point voltage amplitudes. Each of these tubes was successfully pressure tested to 3 delta P without burst or leakage.

The total number of indications has increased rather rapidly in recent inspections; 86 indications in 1RF06, 96 indications in 1RF07, 178 indications in 1RF08, and 667 indications in 1RF09. The maximum reported +Point amplitude increased from 0.39 volts in 1RF08 to 0.56 volts in 1RF09. No information was provided on the maximum PDA measured during 1RF08 versus the maximum 42% measured during 1RF09.

The staff did not review the licensee's operational assessment in detail; however, a cursory, qualitative review of the licensee's assessment did not reveal any significant concern with respect to whether the tube integrity performance criteria will continue to be met at 1RF10. Pulled tube data presented by the licensee indicates that a +Point voltage on the order of 4 volts is needed to reduce the burst pressure, evaluated at a lower 90% probability/50% confidence level (90/50), to 3 delta P. The licensee performed a variety of estimates of maximum +Point voltage and corresponding burst pressure for the upcoming 1RF10 using different assumptions. The most limiting estimate was a +Point voltage of 0.78 volts with a corresponding lower 90/50 burst pressure of 6700 psi. With respect to accident induced leakage, the licensee provided data (in-situ, pulled tubes) indicating that such leakage would not be expected for +Point voltages less than 2 volts.

### 2.5 Axial ODSCC at the TTS

Only seven indications of this type were reported during 1RF09. These indications were plugged or repaired. All were measured to be relatively short, 0.27 inches maximum, compared to the critical flaw length of 0.42 inches. Reported crack depths (62% maximum) were well below the licensee's screening criteria for performing in-situ leak testing. The licensee's operational assessment indicates that the structural and accident leakage performance criteria will continue to be met at 1RF10. The staff did not review the licensee's operational assessment in detail; however, a cursory, qualitative review of the licensee's assessment did not reveal any significant concern with respect to whether the tube integrity performance criteria will continue to be met at 1RF10.

### 2.6 Axial Pressurized Water Stress Corrosion Cracking (PWSCC) at the TTS

Two axial PWSCC indications were found during 1RF09 at the expansion transition region and were plugged or repaired. One measured 1.75 volts with the +Point, with a length of 0.16 inches and a depth (based on voltage amplitude) of 82%. The other measured 0.42 volts, with a length 0.16 inches and depth (based on phase) of 40% to 45% through wall (TW). The licensee's operational assessment predicts that the maximum flaw length and depth for currently undetected PWSCC will not exceed 0.33 inches in length and 70% TW in depth at 1RF10. The 0.33-inch length is less than the licensee's estimate of critical crack length of 0.43 at 3 delta P. In addition, the licensee estimates no leakage from this flaw under accident

conditions. The staff did not review this assessment in detail and, thus, did not immediately understand why the licensee does not expect maximum crack depth to be at least as deep as the 82% TW flaw found during 1RF09. However, staff calculations indicate that ligament tearing and leakage under MSLB would not be expected for a crack depth of 93% or less. Should the crack be entirely TW during an MSLB, the nominal leakage, as determined from CRACKFLO (Electric Power Research Institute (EPRI) Report NP-6864-L-Rev 2) and from the Argonne National Laboratory model in NUREG/CR-6664, indicates a leakage rate at about the 1.0 gallons per minute accident leakage performance criterion. Actual cracks tend to exhibit significant scatter relative to analytical estimates. However, the above analytical leakage estimates ignore the effect of tubesheet proximity reinforcement as described in EPRI NP-6864-Rev 2. The staff estimates that the above analytical leakage estimates are reduced by over an order of magnitude when this effect is considered. In summary, the staff's review did not reveal any significant concern with respect to whether the tube integrity performance criteria will continue to be met at 1RF10.

## 2.7 ODSCC at the TSP Intersections

In Reference 2, the licensee submitted its 90-day report concerning its implementation of voltage-based plugging limits for ODSCC at the TSP intersections during 1RF09. This report includes a summary of the inspection results for this degradation mechanism in 1RF09 and the operational assessment for this mechanism to support operation to 1RF10. This 90-day report was submitted in accordance with Attachment 1 to NRC GL 95-05.

A total of 234 ODSCC indications were found during the 1RF09 inspection. Only one indication, measuring 1.06 volts, exceeded the 1 volt tube repair criterion. No indications were found which had inside diameter phase angles, were circumferential, or which extended outside the thickness of the tube support plates.

The number and size of the indications found during 1RF09 were well within what was predicted during the previous operational assessment. Similarly, the calculated conditional probability of burst and conditional leak rates for an assumed MSLB corresponding to the as-found indications were less than had been predicted during the previous operational assessment and were orders of magnitude below reportable limits. This was due in large measure to the fact that the previous operational assessment was based on bounding industry growth rates and that actual growth was relatively small in comparison.

The licensee now has sufficient CPSES, Unit 1-specific growth rate data in accordance with GL 95-05 to justify use of this data in lieu of industry data. The operational assessment supporting operation through 1RF10 is based on CPSES, Unit 1, growth rate distributions for the last two operating cycles. The licensee's operational assessment for the current operating cycle shows that the probability of burst for each SG to be at least 2 orders of magnitude less than the reporting criterion in the technical specifications and that the conditional MSLB-induced leak rate to be negligible compared to the applicable reporting criterion.

## 2.8 Tube Wear Due to Loose Parts or Foreign Objects

Tube wear caused by loose parts or foreign objects was observed at the TTS and in the upper bundle region. In all cases, the indications found could be traced back to the previous inspection. The deepest and longest of the indications found was measured to be 28% TW and

0.313 inches long. Based on the Examination Technique Specification Sheet (ETSS) qualification data, the licensee reports that this indication is less than 42% TW with a probability of 0.9. The qualification data indicates that the length measurement is likely an over estimate. These indications were left in service. Reference 1 makes no mention of any effort to retrieve the causal loose parts. The licensee estimates the allowable depth of a wear scar measuring 0.313 inches in length to be 80% of the initial wall thickness at 3 delta P, based on the uniform thinning equation in NUREG/CR-0718. Based on the fact that these indications can be traced to the previous inspections, the staff concurs that the tubes containing these indications are not expected to impair tube integrity prior to the next scheduled inspection.

### 2.9 Wear at the Pre-Heater Baffles and Anti-Vibration Bars (AVBs)

Wear at the pre-heater baffle plates and AVBs appears to be well behaved with relatively small growth rates. The maximum reported depth at the baffle plates was 43%; just above the 40% plugging limit. The maximum AVB indication depth was 33%. The staff did not review the licensee's operational assessment in detail; however, based on the above, it is clear that these mechanisms are very unlikely to impair tube integrity prior to 1RF10.

## 3.0 CONCLUSIONS

The staff has reviewed the results of tube specimens removed from the CPSES, Unit 1, SGs during 1RF09, the 1RF09 SG inspection results, and the licensee's operational assessment supporting operation of the SGs to the next scheduled inspection (1RF10). The staff concludes on the basis of this review that there is reasonable confidence that tube integrity at CPSES, Unit 1, will be maintained until the next scheduled inspection at 1RF10 in 2004.

## 4.0 REFERENCES:

1. TXU Energy letter, TXX-03043, from C. Lance Terry to the NRC, dated February 17, 2003, "Submittal of Unit 1 Ninth Refueling Outage (1RF09) GL 95-05 Report." Accession Number ML030550755.

2. TXU Energy letter, TXX-03064, from C. Lance Terry to the NRC, dated March 18, 2003, "Unit 1 Ninth Refueling Outage (1RF09) Steam Generator Twelve Month Report." Accession Number ML030850058.

3. NRC letter from Dwight D. Chamberlain to C. L. Terry, TXU Energy, dated January 9, 2003, "Comanche Peak Steam Electric Station - Special Team Inspection Report." Accession Number ML030090566.

4. TXU Energy letter, TXX-03072, from C. Lance Terry to the NRC, dated April 9, 2003, "Additional Information Concerning CPSES Ninth Refueling Outage (1RF09) Steam Generator Tube Conditions." Accession Number ML031060044.

Principal Contributor: E. Murphy

Date: April 30, 2004

COMANCHE PEAK STEAM ELECTRIC STATION, UNIT 1 (COMANCHE PEAK)
STAFF OBSERVATIONS RELATING TO STEAM GENERATORS' (SG)
OPERATIONAL ASSESSMENT FOR CYCLE 10 OPERATION

1. On page 9 of SG-SGDA–03-03-P regarding the Cycle 10 operational assessment for circumferential outer diameter stress corrosion cracking (ODSCC) at the top of the tubesheet (TTS), the report states that Figure 4 shows that the upper (90% probability/50% confidence) Comanche Peak 1RF09 population of non-destructive examination (NDE) adjusted percent degraded area (PDA) values lies within the bounds of the pulled tube PDA values from destructive examination. It is not clear why the NDE-adjusted PDA values are not biased to the high side of the PDA values from destructive examination, given that the NDE-adjusted values are supposed to be an upper 90% probability bounding estimate of PDA based on the NDE measurements.

2. On page 9 of SG-SGDA–03-03-P under the heading of "PDA Path," a beginning of cycle (BOC) value of PDA of 51.9% is assumed. This value corresponds to the 95% cumulative probability value of NDE-adjusted PDAs for the population of circumferential TTS indications found during 1RF09. However, the report does not provide the basis for assuming that an NDE-adjusted PDA of 51.9% conservatively bounds the largest PDA indication that went undetected during 1RF09. In addition, the report does not provide the probability of detection (POD) for an indication with a PDA of 51.9% and the basis for this POD estimate.

3. On page 9 and 10 of SG-SGDA–03-03-P under the heading of "+Pt Amplitude Path," a maximum BOC voltage of 0.25 volts is assumed. This value corresponds to the 95% cumulative probability value of voltage amplitudes for the population of circumferential TTS indications found during 1RF09. However, the report does not provide a basis for assuming that an indication with a voltage response of 0.25 volts conservatively bounds the largest voltage indication which went undetected during 1RF09. In addition, the report does not provide the POD for an indication with a PDA of 51.9% and the basis for this POD estimate. (Note, this observation is made simply from the standpoint of trying to understand the methods used by the licensee to perform operational assessments. The staff acknowledges that the licensee has shown that even if an indication with a voltage response equal to the maximum voltage detected during 1RF09 is assumed to have been undetected at that time and assuming an absolute bounding growth rate, the projected burst pressure at end-of-cycle (EOC) still satisfies the applicable performance criteria.)

4. Figure 2 of SG-SGDA-03-03-P shows that the probability distribution of indications as a function of voltage response for 1RF09 is similar to that for 1RF08. Assuming that this probability distribution will continue to hold during Cycle 10 and given that the number of circumferential indications at the TTS is rapidly increasing (86 indications in 1RF06, 96 indications in 1RF07, 178 indications in 1RF08, and 667 indications in 1RF09), it is to be expected that indications will occur further and further out along the tail of the distribution with each successive outage. That is, if the probability distribution of voltage responses

remains the same from outage to outage, but the total number of indications increases with each outage, then it is to be expected that the largest voltage indications during each outage will increase from outage to outage. Thus, the licensee's projected maximum EOC-10 voltage of 0.38 volts, based on use of the 95% cumulative probability voltage amplitude and 95% cumulative probability voltage growth rate, appears unreasonably low since it is less than the maximum voltage indication (0.56 volts) found during 1RF09. (This issue does not create a concern for EOC-10 since the licensee also performed more conservative, bounding estimates (based on an assumption of an undetected indication with a voltage response equal to the maximum voltage detected during 1RF09 and an absolute bounding growth rate), demonstrating the necessary burst pressure capability at EOC-10. However, this bounding approach may not work for Cycle 11 if the maximum voltage found during the upcoming 1RF10 outage should significantly exceed 0.56 volts.)

5. On page 13 and 16 of the Cycle 10 operational assessment for freespan axial cracks (Westinghouse Report SG-SGDA-03-P), a maximum to average depth ratio of 1.4 is assumed based on amplitude depth sizing of R11C42 and R7C112, and McGuire Nuclear Station data. The report does not state whether average depth in this context refers to average depth of the burst effective length of the crack or to the average depth over the entire crack length. The average ratio of maximum depths to average depths over the burst effective lengths is also not clear in the report. In addition, for a deterministic analysis such as that described on pages 13 to 15, the justification for using an average ratio rather than a 90% or 95% upper bound value of this ratio is not clear. (The staff notes that an upper 90% bounding estimate of the ratio of average depth over the burst effective length to maximum depth is about 0.9, based on industry-wide pulled tube data compiled in WCAP-15128, Revision 2.)

6. The discussion on page 13 and 14 of SG-SGDA–03-03-P assigns an upper bound average flaw depth to an upper bound flaw length of 1.75 inches, leading to a burst pressure estimate of 5986 pounds per square inch (psi) at EOC-10. The discussion states that this is a conservative estimate of EOC burst pressure. The staff notes this is only true if the average depth is the average depth over the burst effective length rather than the average depth over the full crack length. It is well known that the burst pressure of a crack is established by a weak link represented by an equivalent rectangular crack of length equal to the burst effective length and a depth equal to the average depth over that length. A similar issue exist for the 4623 psi burst pressure estimate on page 16 and the 6084 psi burst pressure estimate on page 17. The report does not make clear what are the maximum burst effective lengths and corresponding average depths expected at EOC-10 for each of the three cases described above, nor does it make clear what are the corresponding burst pressures.

7. SG-SGDA–03-03-P does not describe the burst model that was used to compute the reported burst pressures referred to in observation 6, either directly or by reference. The report does not discuss the conservatism of the model, such as whether the reported burst pressure predictions are "best estimate" or "lower bound" (say 90% or 95% lower bound) estimates.

8. The bobbin POD discussion on page 16 of SG-SGDA–03-03-P appears to be based on an assumption that +Point POD is 1.0, irrespective of flaw depth. SG-SGDA–03-03-P does not discuss how consideration of actual +Point POD performance (e.g., from

Examination Technique Specification Sheet or NUREG/CR-6791) would affect the POD estimates given in Figure 14 (page 44).

9. SG-SGDA–03-03-P does not provide data similar to that provided in Figure 13 of SG-SGDA–03-03-P for the other cracks evaluated destructively from R11C42 and R25C30.

10. The operational assessment for ODSCC at dings on page 18 excludes consideration of cracks longer than the critical length on the basis that precursor signals exhibited by R41C71 as they existed in 1RF07 and 1RF08 would have been detected (and plugged) based on the final bobbin reporting criteria used in 1RF09. The staff notes, however, that ODSCC at dings is an active degradation mechanism. Although all tubes where such indications have been detected have been plugged, additional indications not yet detectable are likely to enter into the detectable range by 1RF10. Based on experience at Comanche Peak to date, approximately one out of each seventeen such indications are expected to be longer than the critical length. SG-SGDA–03-03-P does not discuss how many ODSCC indications at dings are expected at 1RF10, how many of these are anticipated to exceed critical length, and the minimum burst pressure that is anticipated for such cracks.

11. The operational assessments in SG-SGDA-03-03P are generally deterministic, even the so-called statistical assessment on pages 15, 16, and 17 for axial freespan cracks in the absence of dings or dents. For example, in the case of the freespan axial cracks, flaw detection thresholds were assumed for flaw depths corresponding to 0.95 POD; assumed growth rates were evaluated at the upper 95% bound of the distribution; material flow strength was evaluated at the lower 90% bound; and the assumed relationship between average depth and maximum depth was an average value of existing data. As previously discussed (see observation 7), it is not clear for this case whether the burst pressure estimates (for a given set of input parameters) are from a best estimate or lower bound burst model. Deterministic analyses of this kind are frequently very conservative due to the compounding of conservatisms for each of the input parameters and predictive models. This is not always true, however, particularly in cases where some of the input parameters or predictive models are best estimate or average values and, in addition, in cases where the tail of one or more of the input parameter distributions beyond the 90% or 95% bounding value assumed in the deterministic assessment may significantly affect the minimum burst pressure or accident induced leakage rate. Thus, the conservatism of the operational assessment, or lack thereof, is difficult to assess without further statistical analysis. Statistical sampling methods can be applied to input parameter distributions and model prediction distributions to develop a lower 90% or 95% probability estimate of the minimum burst pressure expected among the population of indications expected at EOC. Similarly, such statistical sampling methods can be used to develop an upper 90% or 95% probability estimate of the total accident-induced leak rate for the population of indications expected at EOC. Such estimates are more realistic than those yielded by deterministic analyses and minimize the likelihood of either non-conservative or overly conservative results.

Principal Contributor: E. Murphy

Date: April 30, 2004

cc:

Senior Resident Inspector
U.S. Nuclear Regulatory Commission
P. O. Box 2159
Glen Rose, TX 76403-2159

Regional Administrator, Region IV
U.S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 400
Arlington, TX 76011

Mr. Roger D. Walker
Regulatory Affairs Manager
TXU Generation Company LP
P. O. Box 1002
Glen Rose, TX 76043

George L. Edgar, Esq.
Morgan Lewis
1111 Pennsylvania Avenue, NW
Washington, DC 20004

County Judge
P. O. Box 851
Glen Rose, TX 76043

Environmental and Natural
Resources Policy Director
Office of the Governor
P. O. Box 12428
Austin, TX 78711-3189

Mr. Richard A. Ratliff, Chief
Bureau of Radiation Control
Texas Department of Health
1100 West 49th Street
Austin, TX 78756-3189

Mr. Brian Almon
Public Utility Commission
William B. Travis Building
P. O. Box 13326
1701 North Congress Avenue
Austin, TX 78701-3326

Ms. Susan M. Jablonski
Office of Permitting, Remediation
and Registration
Texas Commission on Environmental
Quality
MC-122
P. O. Box 13087
Austin, TX 78711-3087

Terry Parks, Chief Inspector
Texas Department of Licensing
and Regulation
Boiler Program
P. O. Box 12157
Austin, TX 78711