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June 23, 2006

PG&E Letter DCL-06-080

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Docket No. 50-275, OL-DPR-80
Diablo Canyon Unit 1
PG&E Response to NRC Request for Additional Information Regarding, "Special Report 06-01 - Results of Steam Generator (SG) Tube Inspections for Diablo Canyon Power Plant Unit 1 Thirteenth Refueling Outage"

Dear Commissioners and Staff:

Pacific Gas and Electric Company (PG&E) Letter DCL-06-029, dated February 24, 2006, submitted, "Special Report 06-01 - Results of Steam Generator (SG) Tube Inspections for the Diablo Canyon Power Plant Unit 1 Thirteenth Refueling Outage." The NRC requested additional information regarding the Special Report 06-01 by letter dated April 18, 2006, that was received April 25, 2006.

Enclosed are the NRC questions and PG&E's response to each question.

If you have any questions or require additional information, please contact John Arhar at (805) 545-4629.

Sincerely,

Donna Jacobs

ddm1/469/A0667274
Enclosure
cc/enc: Terry W. Jackson, NRC Senior Resident
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A001

PG&E Response to NRC Request for Additional Information (RAI) Regarding 1R13 SG Tube Inspections

NRC letter to Pacific Gas and Electric Company (PG&E) dated April 18, 2006, requested additional information regarding the 2005 steam generator (SG) tube inspections performed during the Unit 1 Thirteenth Refueling Outage (1R13). PG&E responses to the NRC questions are provided in this enclosure.

Axial Primary Water Stress Corrosion Cracking (PWSCC) Alternate Repair Criteria (ARC)

Question 1:

Please clarify the number of axial PWSCC indications detected and plugged during your 2005 inspections in refueling outage 13 (1R13). The staff notes the following:

On page 2-5 of Enclosure 2 to your February 24, 2006 letter, 240 axial PWSCC indications were reported as being detected in 1R13.

On page 2-6 of Enclosure 2 to your February 24, 2006 letter, 217 axial PWSCC indications were reported as being left in service in 1R12. Of these 17 were plugged.

On page 2-6 of Enclosure 2 to your February 24, 2006 letter, 25 new axial PWSCC indications were detected in 1R13 (25 + 217 = 242 not 240). Of these 5 were plugged.

On page 2-7 of Enclosure 2 to your February 24, 2006 letter, 218 axial PWSCC indications were returned to service: 196 repeat, 2 repeat merged, and 20 new indications. (198 returned to service + 17 plugged = 215 not 217).

On page 2-12 of Enclosure 2 to your February 24, 2006 letter, 240 axial PWSCC indications were reported as being detected in 1R13, 215 from repeat indications and 25 new indications.

PG&E Response:

In 1R13, 240 axial PWSCC indications at dented tube support plates (TSPs) were detected, and 22 were plugged.

Table 1 provides a summary of axial PWSCC indications at dented TSPs returned to service at beginning of cycle (BOC) 13 and BOC 14, and number of

indications detected and plugged at end of cycle (EOC) 13. Table 1 notes that the number of repeat indications detected at EOC 13 (215) is less than the number of indications returned to service at BOC 13 (217) because 4 indications merged into 2 indications during Cycle 13, resulting in 2 less indications.

Merged indications were identified in Table 5 and Table 6 of Enclosure 2 to PG&E's February 24, 2006, letter (1R13 PWSCC ARC 120-day report), and it was noted that 1R13 SG 1-2 R8C61 Crack1 was previously Crack1 and 2 in Unit 1 Twelfth Refueling Outage (1R12), and 1R13 SG 1-2 R37C69 Crack1 was previously Crack1 and 2 in 1R12.

Question 2:

On page 2-8 of Enclosure 2 to your February 24, 2006 letter, it was indicated that the cycle 13 growth rate data included 213 data points from repeat indications. Since there were 217 indications left in service, it is not clear why there were only 213 data points. Presumably part of this difference is that in two instances an intersection had two flaws during 1R12 and these two flaws subsequently merged and appeared as one indication in 1R13. Please clarify.

PG&E Response:

The presumption is correct. The 4 indications that merged into 2 indications during Cycle 13 are excluded from the growth assessment, such that 213 data points were included in the Cycle 13 growth rate assessment. The excluded indications are identified in response to Question 1. Table 6 of Enclosure 2 to the February 24, 2006, letter does not provide a growth rate for the merged indications.

Question 3:

Please confirm that the column titled "1R13 OA (ANL/TW Model)" in Table 5 in Enclosure 2 to your February 24, 2006 letter, reflects the projection for the end-of-cycle 14 (i.e., it uses the "1R14 Final OA" growth rate distribution in Table 2).

PG&E Response:

Yes. The column titled, "1R13 OA (ANL/TW Model)," in Table 5 in Enclosure 2 to the February 24, 2006, letter reflects the projection for EOC 14, and uses the "1R14 Final OA" growth rate distribution in Table 2 of that letter.

<u>Question 4</u>:

Given that it appears that the growth rate from cycle 13 was greater than that in cycle 12, discuss the need to account for this increasing growth rate from cycle-to-cycle in your analysis (i.e., similar to the delta-volts adjustment used in implementing the voltage-based ARC).

<u>PG&E Response</u>:

Table 2 of Enclosure 2 to the February 24, 2006, letter provides the 90 and 95 percentile growth rates for length, maximum depth, and average depth for Unit 1 Cycles 11, 12, and 13. While the length shows an increasing trend, the maximum and average depths do not.

The existing PWSCC ARC methodology to account for increasing growth is described in Section 7.12 in WCAP-15573, Revision 1. The method requires an evaluation of growth rates as a causal factor if significant underpredictions of burst or leakage are found. If the underprediction is attributable to underestimates of growth, the 120-day report will provide a corrected growth rate distribution to better predict the next EOC conditions. At the next EOC, if the 90th percentile measured growth is greater than the 90th percentile predicted growth, which indicates at least two successive cycles of increasing growth rates, the measured growth rate for the just completed cycle is to be increased by a factor of 1.1 or more. This methodology is considered adequate to account for potentially increasing growth rate trends.

<u>Question 5</u>:

A number of circumferential indications were detected at the tube support plates elevations during the 1R13 inspections when compared to several previous years. Please discuss whether there was any specific reason for this trend (e.g., less noise in the eddy current data, expected increase in degradation with time, etc.).

<u>PG&E Response</u>:

As noted in Table 7 of Enclosure 2 of the February 24, 2006, letter, there were 37 circumferential ODSCC indications detected in 1R13 (at 31 TSPs). Historically, there have been 50 TSPs with circumferential ODSCC indications in Unit 1 (3 in SG 1-1, 35 in SG 1-2, 12 in SG 1-4): 5 in 1R10, 4 in Unit 1 Eleventh Refueling Outage (1R11), 10 in 1R12, and 31 in 1R13. As a comparison, there have been 21 TSPs with circumferential ODSCC indications in Unit 2 (all in SG 2-2): 5 in Unit 2 Ninth Refueling Outage, 2 in Unit 2 Tenth Refueling Outage, 1 in Unit 2 Eleventh Refueling Outage (2R11), 1 in Unit 2 Twelfth Refueling Outage (2R12), and 12 in Unit 2 Thirteenth Refueling Outage (2R13).

PG&E evaluated these circumferential ODSCC TSP indications to determine if noise was a reason for the increase in number of indications in 1R13 and 2R13 compared to prior inspections. The potential impact of the prior cycle (1R12 and 2R12) chemical cleaning (CC) on reducing noise in the eddy current data was evaluated, even though the CC did not include a crevice cleaning step such that the crevice deposits were presumably not significantly affected. In Unit 1 SGs 1-1 and 1-2, and Unit 2 SGs 2-1 and 2-2, eddy current testing (ECT) was conducted after CC. In the other SGs, ECT was conducted prior to CC. Therefore, SG 1-4 is the only SG with 1R13 ODSCC circumferential indications in which the prior cycle ECT was conducted before CC. Based on prior cycle lookup evaluations, only 2 of 9 (22 percent) TSPs were nondetectable degradation (NDD) in SG 1-4, and only 8 of 36 (22 percent) TSPs were NDD in the other 3 SGs with circumferential ODSCC (SGs 1-1, 1-2, and 2-1). Because most indications were detectable in prior cycle lookups and the percentage of NDD lookups is the same for SGs that were ECT inspected either before or after CC, it can be established that CC (and noise) were not factors for the increase in indications detected in 1R13 and 2R13.

The increase in number of TSP circumferential ODSCC indications detected in 1R13 and 2R13 is most likely attributable to increased operating time. Since the circumferential indications at TSP intersections have been consistently short and shallow with no challenge to tube integrity, a further increase in the number of circumferential indications would not be a significant concern for structural and leakage integrity.

Outside Diameter Stress Corrosion Cracking (ODSCC) ARC

Question 1:

> *Table 3-18 of Enclosure 4 to your February 24, 2006 letter, lists indications that were re-inspected following a failed probe wear check. In evaluating the data in Table 3-18, it appears that all indications are greater than 75% of the tube repair criteria (1.5 volts). Please confirm that the tubes re-tested with a "good (non-worn)" probe only had indications greater than 1.5 volts. If there were other indications (i.e., less than 1.5 volts), please update Table 3-18 and Figure 3-37 with this data. This analysis is consistent with the staff's approval of the alternate probe wear criteria.*

PG&E Response:

The purpose of Table 3-18 was to provide a list of all 1R13 ODSCC indications greater than or equal to 75 percent of the tube repair criteria (1.5 volts) that failed the probe wear check, as these required retesting in 1R13 with a good (non-worn) probe. Indications less than 1.5 volts that were inspected with a worn

probe do not require retesting with a good probe, unless they are in a same tube as a greater than or equal to 1.5 volt indication tested with a worn probe, because retesting with a good probe is performed the entire length of the tubing. Because of this, there were 5 indications less than 1.5 volts that were originally inspected with a worn probe which were retested with a good probe, due to the indications being located in tubes already identified in Table 3-18. Table 2 provides these indications. Figure 1 is an update to Figure 3-37 and includes these 5 indications.

<u>*Question 2:*</u>

Table 3-19 of Enclosure 4 to your February 24, 2006 letter, shows that a 1.78 volt indication was detected during 1R13 in a tube that had been inspected with a worn probe during the prior inspection. With hindsight, please discuss whether an indication is present at this location in the 1R12 data and the size of this indication. Please discuss the extent to which probe wear may have been a reason for missing the indication at this location in 1R12 (if one was present).

<u>PG&E Response:</u>

In 1R13 in SG 1-1 R26C46 1H, a distorted outside diameter (DOS) indication was reported by bobbin (1.78 volts) and confirmed by +Point™ (0.66 volts for the single axial indication). This indication was previously reported in 1R12 as axial ODSCC not detected by bobbin (AONDB), with a +Point™ voltage of 0.67 volts. As such, this indication is listed in Table 3-23 of Enclosure 4 of the February 24, 2006, letter (1R13 ODSCC ARC 90-day report), because it was a 1R12 AONDB indication that was reported by bobbin in 1R13. Table 4 provides a revised Table 3-23 to include the 1R12 bobbin lookup volts based on hindsight review. A bobbin flaw signal is present in R26C46 1R12 data (1.80 volts) based on a hindsight review. There is no change in the indication as demonstrated by the similar bobbin and +Point™ voltages from both inspections as shown in Table 4. Probe wear is not a factor for the indication being reported as AONDB in 1R12. The bobbin voltage is conservative and is influenced by a complex signal including flaw, mix residual, and dent in both inspections. This indication is treated as a missed indication for probability of prior cycle detection (POPCD), as discussed in response to ODSCC ARC RAI 4.

<u>*Question 3:*</u>

The growth rate of axial indications that were detected by bobbin in 1R13 and were only detectable with a rotating probe in 1R12 axial ODSCC indications not detected by Bobbin (AONDBs) is approximately 50% higher than that of the population of indications detected by bobbin in both outages. Some of the larger growth rate differences were in tubes in which the 1R13 bobbin voltage

was influenced by the presence of a dent. Since the reason for the analysis of the AONDB voltage changes is to determine whether the use of the rotating probe to bobbin voltage correlation is reasonable, discuss whether additional limitations should be placed on the use of the correlation (i.e., to those intersections where the dent would not significantly influence the voltage). In addition, discuss whether additional limitations are needed on this correlation for multiple axial indications since these indications had some of the largest growth rate differences. The staff notes that comparing "inferred to inferred" bobbin voltages could be misleading since the whole purpose of the correlation is to determine the "true" bobbin voltage (which is directly related to the integrity of the flaw). In addition, discuss whether Figure 3-39 should be used to place an upper limit on the inferred bobbin voltages beyond which the affected indication would be removed from service (i.e., at an inferred bobbin voltage of approximately 0.6 volts, the measured bobbin voltage could exceed 2.0 volts, which is the plugging limit).

With respect to Table 3-23 of Enclosure 4 to your February 24, 2006 letter, please clarify the following column: "Cycle 13 Avg Voltage Change (v/EFPY)."

PG&E Response:

In the column labeled, "Cycle 13 Avg Voltage Change (V/EFPY)," in Table 3-23, the intent is to present the average voltage growth for all indications detected by bobbin for each individual SG, to compare with the voltage growth for 1R12 AONDB indications that were reported by bobbin in 1R13.

The NRC's observation that, "*the growth rate of axial indications that were detected by bobbin in 1R13 and were only detectable with a rotating probe in 1R12 axial ODSCC indications not detected by Bobbin (AONDBs) is approximately 50% higher than that of the population of indications detected by bobbin in both outages,"* is based on information provided in Table 3-23, which shows that the average apparent growth rate (inferred to DOS) is 0.096 v/effective full power year (EFPY), greater than the 0.063 v/EFPY growth rate of indications detected by bobbin in both inspections. PG&E has reviewed this information in detail, and is providing Table 4 to revise and supersede Table 3-23. Table 4 provides the reported dent voltage, 1R12 bobbin lookup voltage based on a hindsight reviewed conducted in 1R13, a new inferred bobbin voltage based on a revised correlation as discussed below, revised growth rates based on the new inferred voltages, and peak +Point™ voltage growth rates.

For complex TSP signals such as AONDBs that are reported as DOS in a subsequent inspection, the reported bobbin voltage is conservative because of the influence of several TSP condition factors, including mix residuals, denting, and TSP edge effects. However, conservative bobbin voltage reporting should not imply that the growth rate of these indications is increasing at a greater rate

than the general population. Table 4 provides the 1R12 bobbin lookup voltages based on a hindsight review conducted in 1R13. Negligible changes are noted in the bobbin voltages, as evidenced by an average growth rate of 0.028 v/EFPY for this population, which is less than the average growth rate (0.063 v/EFPY) for all DOS indications. For lookups reported as NDD, another lookup review was conducted which reported a bobbin signal in each case, with a lookup bobbin voltage similar to the 1R13 bobbin voltage, again indicating negligible growth. Negligible changes are also noted in the +Point™ voltages, as evidenced by an average peak +Point™ voltage growth rate of 0.023 v/EFPY.

In response to the NRC's statement that, "*Since the reason for the analysis of the AONDB voltage changes is to determine whether the use of the rotating probe to bobbin voltage correlation is reasonable, discuss whether additional limitations should be placed on the use of the correlation (i.e., to those intersections where the dent would not significantly influence the voltage),*" PG&E reviewed data from the last 3 inspections at Unit 1. Based on this evaluation, it was determined that the voltage obtained from the current correlation is slightly nonconservative for Unit 1. The current correlation includes both Unit 1 and 2 data from 1R9 to 1R11, and is mostly represented by 2R11 data due to the large amount of +Point™ data obtained in that inspection. By using only Unit 1 data from 1R11, 1R12 and 1R13, the slope and intercept of the updated mean regression line was sufficiently different, such that for a 0.5 volt +Point™ indication, the assigned mean bobbin voltage is about 19 percent higher compared to the current correlation. Table 3 provides the slope and intercept for the current correlation, the updated Unit 1 correlation, and comparison affect for a 0.50 +Point™ voltage indication. In practice, an upper 95th confidence value on the mean correlation is used for assigning a bobbin voltage, which would result in a slightly higher bobbin voltage. Table 4 provides the new inferred bobbin volts using the updated Unit 1 correlation, along with a new inferred to DOS average growth rate of -0.004 V/EFPY, which is much less than 0.096 V/EFPY using the current correlation, and much less than the 0.063 V/EFPY average growth rate for the DOS indications over the same cycle.

Additionally, a review of all AONDB that have ever been identified at Unit 1 was performed to determine any potential trends since 1R10. Since that inspection, there have been greater than 300 TSP intersections identified as AONDB. The repair history indicates that the main reasons for plugging of AONDB intersections are due to a greater than 5 volt dent at the TSP, or due to an inside diameter single axial indication at the TSP. The majority of the flaws have remained AONDB in successive outages with minor changes in their inferred voltages, with only about 50 having been reported by bobbin in a subsequent inspection, of which only 4 exceeded the 2 volt bobbin plugging limit (3 in 1R12, and 1 in 1R13). This review provides additional historical perspective to support the conclusion that AONDBs are not exhibiting growth rates that are higher than the general population.

In response to the NRC's request to, *"discuss whether additional limitations are needed on this correlation for multiple axial indications since these indications had some of the largest growth rate differences,"* PG&E reviewed historical AONDBs with multiple axial indications (MAI). Unit 1 has had 18 AONDB intersections that contained MAI and remained in service for a subsequent cycle, with most exhibiting negligible changes in the +Point™ voltages in subsequent inspections. Of the 10 AONDB with MAI that were reported by bobbin in a subsequent inspection, 3 exhibited apparent growth rates (inferred to DOS) that were much higher than the general population. Two of these high apparent growth rates were due to conservatively reported bobbin voltages (affected by complex TSP signals). The third location (1R12 SG 1-1 R8C69 1H) experienced significant +Point™ voltage growth during Cycle 12 as discussed in Section 3.2 of the 1R12 ODSCC ARC 90-day report; however, there were several other non-AONDB ODSCC indications that experienced a large voltage growth in Cycle 12, so R8C69 is not an outlier. These 3 indications were plugged because they exceeded the 2 volt repair limit. Since only one of the 18 prior AONDB/MAI locations had a significant change in the +Point™ voltages, no additional limitations are needed on the application of the correlation to intersections containing MAIs.

In response to the NRC's request to, *"discuss whether Figure 3-39 should be used to place an upper limit on the inferred bobbin voltages beyond which the affected indication would be removed from service,"* PG&E notes that the intent of Figure 3-39 is to assess whether the voltages obtained using the correlation are generally conservative with respect to the bobbin voltages measured by the analysts, especially in the voltage range where the correlation was applied. Figure 3-39 was developed using all indications that were bobbin detected and confirmed with +Point™. The +Point™ voltage was then converted to a bobbin voltage to assess whether the correlation would over or under estimate the correlated voltage of the confirmed flaws. In the region of interest, (less than1.03 inferred volts using the current correlation), the graph indicated that the correlated volts were over predicted about 52 percent of the time. The example referred to in the RAI, *"at an inferred bobbin voltage of approximately 0.6 volts, the measured bobbin voltage could exceed 2.0 volts, which is the plugging limit,"* is a reflection of the fact that some of the indications have a higher (more conservative) measured bobbin coil voltage than +Point™ voltage (and thus inferred voltage), due to more significant influence of TSP conditions on the bobbin signal. In general, for complex TSP intersections that are influenced by mix residuals or denting, it can be noted that the inferred bobbin voltage is likely to be more representative of the true bobbin voltage because of the conservative reported DOS voltage. After applying the updated Unit 1 specific AONDB correlation discussed in detail above, Figure 2 is provided (to replace Figure 3-39) which depicts the same 1R13 data set using updated inferred voltages. Figure 2 shows that the updated inferred voltage provides a more

conservative estimate than the current correlation, and results in 67 percent over prediction with an average 0.070 volts over prediction. The updated correlation also results in an improvement in the region of interest defined by the largest inferred voltage of 1.24 volts. The amount of over prediction in this region is 68 percent or 0.065 volts.

Based on this evaluation, the updated Unit 1 correlation will be applied in the next Unit 1 inspection (1R14) for AONDB detected. The current EOC 14 operational assessment leak and burst predictions for the limiting SG are not significantly affected because the voltages of the AONDB indications do not increase enough to cause higher EOC voltages that would contribute to higher results. A sensitivity calculation for limiting SG 1-1 with the updated AONDB voltages in the BOC distribution confirmed the EOC-14 POB was 2.42×10^{-3}, versus 2.32×10^{-3} using the correlation reported in the 90-day report.

In conclusion, there is sufficient basis to conclude that additional limitations on the AONDB correlation are not needed. There is no need to define a dent voltage threshold at which the dent would not significantly influence the bobbin voltage. TSP conditions that can significantly influence (increase) the bobbin voltage are likely to be repaired sooner than the general population of ODSCC indications.

<u>Question 4</u>:

> *Figure 6-1 of Enclosure 4 to your February 24, 2006 letter, indicates that for the recently completed cycle that the probability of detecting larger voltage indications may be declining. In light of this potential decrease in performance, discuss why the composite probability of prior cycle detection curve was used in the end-of-cycle 14 projections rather than the data from the recently completed cycle (labeled as "1R12 POPCD" in Figure 6-1). Please clarify the nomenclature in Table 6-8, Table 7-1, and Figure 6-1 of Enclosure 4 to your February 24, 2006 letter. For example, is the "composite POPCD through 1R13 (Eight Inspections)" in Figure 6-1 identical to the "Updated POPCD Through 1R12 (8 inspections)" in Table 6-8 (and similarly in Table 7-1).*

<u>PG&E Response</u>:

The nomenclatures in Table 6-8, Table 7-1, and Figure 6-1 of Enclosure 4 to the February 24, 2006, letter (ODSCC ARC 90-day report) are slightly different, but were intended to identify the same POPCD curve, that is, composite POPCD through 1R12 (8 inspections). The use of the term, 1R12, is more accurate than the term, 1R13, because POPCD is defined for the prior cycle.

The composite POPCD through 1R12 (8 inspections) was used in the EOC 14 projections rather than the single cycle 1R12 POPCD based on the requirement that a minimum of 2 inspections on each unit are needed to apply a plant specific POPCD (this requirement is satisfied for DCPP Units 1 and 2). The requirement is defined in PG&E letter DCL-03-121, and in EPRI ODSCC Addendum 6 guidelines. PG&E letter DCL-04-028 also notes that the multi-cycle development of a POPCD database over sequential inspections provides additional assurance that the potential for large undetected indications is included in POPCD. NRC safety evaluation approving the Unit 2 Cycle 12 POPCD (reference NRC letter to PG&E dated October 21, 2003) acknowledged PG&E's conclusion that, "*a multi cycle database...is more reliable because SG conditions at tube support plate intersections are not significantly degrading with operating time and the POPCD distribution would not be as dependent on the number and size of indications identified in a given inspection.*"

Figure 6-1 of Enclosure 4 to PG&E's February 24, 2006, letter was intended to support an assessment of the POPCD method for potential changes over time. That is, the previous composite POPCD distribution should be compared with the single-cycle POPCD distribution obtained from the just completed cycle. Section 6.1.1 of the ODSCC ARC 90-day report states, "*for indications above 0.7 volts, the updated composite POPCD is essentially unchanged from the previous composite POPCD curve.*" For this voltage range, however, PG&E did not provide an explicit comparison of the previous composite POPCD and the just completed 1R12 POPCD distributions. This assessment is provided below.

The reason that the 1R12 single-cycle POPCD distribution has a lower probability of detection (POD) in the upper tail of the distribution when compared to the previous composite POPCD is due to 3 no detection indications in the 1R12 POPCD, 2 in the 1.71 to 1.80 volt bin, and 1 in the 1.81 to 1.90 volt bin (see Table 6-1 of the 1R13 ODSCC ARC 90-day report). These 3 indications represent the largest voltage no detection indications in the composite POPCD database for DCPP Units 1 and 2. However, detailed review of each indication, as discussed below, shows that the reason for no detection classifications are due to application of conservative methodologies, and are not due to emerging issues that could reflect a decrease in bobbin detection performance.

- SG 1-2 R20C63 2H. Section 6.1 of the 1R13 ODSCC ARC 90-day report previously described the largest no detection indication in SG 1-2 R20C63 2H. In 1R12, this tube received two bobbin inspections; a 1.46 volt DOS, and a 1.90 volt DOS were reported in the first inspection (from hot leg) and second inspection (from cold leg), respectively. An ARC voltage of 1.90 volts was conservatively used. The indication was not confirmed by +Point™. In 1R13, a 1.31 volt DOS was reported (from hot leg inspection),

and +Point™ inspection was not conducted nor required. This indication was conservatively treated as a 1.90 volt no detection, based on PG&E's commitment to the NRC in order to expedite NRC approval of POPCD. The original EPRI industry proposed POPCD method would define this indication as detection, as shown in Table 6-10 of the 1R13 ODSCC ARC 90-day report. EPRI ODSCC Addendum 6 guidelines indicate that PG&E's conservative methodology approximates double accounting because the indication is also included in the BOC population. It is noted that if +Point™ inspection had been conducted in 1R13 and did not confirm the indication, then the indication would be excluded from POPCD.

- SG 1-1 R26C46 1H and SG 1-4 R11C46 1H. These indications were AONDB in 1R12 and were reported as bobbin DOS indications in 1R13. As such, they are included in Table 4. The 1R12 bobbin lookup volts were 1.80 volts and 1.72 volts, respectively. Therefore, they are treated as large voltage (1.80 and 1.72 volts) no detection indications for POPCD. As discussed in response to ODSCC RAI 2, the R26C46 bobbin voltage is conservative and is influenced by a complex signal including flaw, mix residual, and dent in both inspections. The R11C46 reported bobbin voltage (2.01 volts) is also conservative and is influenced by denting, and the indication was plugged because the bobbin voltage exceeded the repair limit. For each indication, the signals showed negligible changes in both inspections.

Other Inspection Findings (not related to an ARC)

Question 1:

Three tubes were preventively plugged in 1R13. Please discuss the reason for plugging these tubes.

PG&E Response:

SG 1-3 R3C67 and SG 1-4 R1C89 were preventively plugged in 1R13 due to the 0.620 inch +Point™ probe stalling in the U-bend region. A 0.620 inch +Point™ probe was used in the prior outage U-bend exams of these tubes with no stalling.

SG 1-3 R29C84 was preventively plugged in 1R13 due to a small bobbin indication (outside diameter phase angle) in the U-bend coincident with a small 0.88 volt ding. The +Point™ inspection did not detect any degradation at this location; nonetheless, the tube was preventively plugged.

<u>Question 2:</u>

Please discuss the process used for determining an indication is a result of cold-leg thinning. For example, discuss how the shape, phase angle, and amplitude of the signal are evaluated to result in a classification of cold-leg thinning.

<u>PG&E Response:</u>

In PG&E's response in DCL-03-139 to a prior NRC RAI discussing how cold-leg thinning (CLT) is distinguished from intergranular attack (or closely spaced cracks), PG&E stated the following, "*Cold leg thinning can be distinguished from closely spaced cracks based on bobbin and + Point™ signals. The shape, phase angle and amplitude of the bobbin signal associated with cold leg thinning indicate that they are a volumetric wastage type of signal and not a volumetric crack like signal as seen in OTSG units. Also, the terrain plot, phase angle and amplitude of the + Point™ data are indicative of cold leg thinning and not closely spaced cracks. If it were closely spaced cracks, the bobbin and + Point™ signals would be jagged and irregular. Also, both bobbin and + Point™ data from the in-generator indications are consistent with the bobbin and + Point™ data from the cold leg thinning samples that have been prepared for the development of cold leg thinning sizing techniques in Westinghouse report SG-SGDA-02-41.*"

The above information is augmented by the following response, to provide additional information regarding the process used for determining whether an indication is a result of CLT. The process combines aspects of flaw location (within bundle and within TSP) and bobbin and + Point™ signal characteristics (shape, phase, and amplitude).

<u>Location</u>

CLT is located at lower cold leg TSPs in peripheral tubes. To validate the CLT region in 2R12 and 1R13, +Point™ inspections were conducted on all cold leg TSP bobbin indications that had never received a previous +Point™ inspection. Bobbin TSP indications located in the periphery of the bundle at lower TSP elevations were verified to be volumetric indications by +Point™, indicative of CLT. All other bobbin TSP cold leg indications were NDD by +Point™. All CLT indications are located within the support plate (at the lower, middle, or upper edge of the support plate).

<u>Signal shape</u>

As discussed above, ODSCC signals and volumetric CLT signals have different +Point™ terrain plot appearances. ODSCC signals look jagged, complex, and often can only be detected by a bobbin mix channel. On the other

hand, CLT indications are more straightforward and easy to detect. +Point™ inspections have shown that there may be multiple ODSCC indications at the same intersection, whereas CLT is always a single indication. For CLT, +Point™ data shows the volumetric signal evidenced by a characteristic differential +Point™ signal. For ODSCC, +Point™ data shows the linear signal evidenced by a characteristic absolute rotating coil signal going in only one direction.

Signal phase angle

In general, the phase angle of a flaw is affected by the maturity of the signal. When a flaw is at an early stage, the phase angle of the signal cannot be relied on to estimate the depth of the flaw. The phase versus depth curve can be reliably applied only if the flaw has grown to a substantial depth. The phase angle of ODSCC is also affected by the mix residual, while the phase angle of cold leg thinning is affected by its location within the support plate such as near the center or near the edge of the TSP. Cold leg supports are not affected by magnetite; therefore, it is easy to detect CLT. CLT signals located in the middle of the TSP are clearer than typical ODSCC signals.

Signal amplitude

The amplitude of cold leg thinning is consistently predictable due to the relatively small growth rates between inspections, and the amplitude is large even for shallow depths compared to crack indications. The amplitude of TSP ODSCC signal has shown more variances between inspections due to voltage-dependent growth phenomena.

Table1
Axial PWSCC Indications at Dented TSPs

	Indications RTS at BOC 13	Indications detected EOC 13	Indications plugged EOC 13	Indications RTS at BOC 14
Repeat		215 (Note 1)	17	198
New		25	5	20
Total	217 (Note 1)	240	22	218

Note 1: The number of repeat indications detected at EOC 13 (215) is less than the number of indications returned to service at BOC 13 (217) because 4 indications merged into 2 indications during Cycle 13, resulting in 2 less indications.

Table 2
DOS <1.5 Volts in ARC Out Tubes

SG	Row	Col	Ind	Elev	Volts	ARC Out	Probe	Cal No.	% Diff
1-1	10	39	DOS	2H	0.49	Yes	720RF	CL-24	
			DOS	2H	0.45		720RF	CL-41	-8.2
	17	56	DOS	2H	0.64	Yes	720RF	CL-28	
			DOS	2H	0.63		720RF	CL-41	-1.6
	22	69	DOS	2H	0.68	Yes	720RF	CL-29	
			DOS	2H	0.69		720RF	CL-41	1.5
	38	36	DOS	2H	0.46	Yes	720RF	CL-11	
			DOS	2H	0.47	Yes	720RF	CL-27	2.2
			DOS	2H	0.49		720RF	CL-36	6.5
1-2	5	20	DOS	4H	0.56	Yes	720RF	HL-3	
			DOS	4H	0.43		720RF	HL-20	-23.2

Table 3
Slope and Intercept for Bobbin to +Point™ Correlations

AONDB Correlation	Slope	Intercept	+Point™ Voltage	Assigned "Mean" Bobbin Voltage
R9-R11 Both Units	1.016	0.2835	0.50	0.79
1R11-1R13	1.194	0.348	0.50	0.94

Table 4
1R12 AONDB Reported as DOS in 1R13

SG	Row	Col	TSP	Bobbin Dent Voltage	1R13 Bobbin		1R13 +Point			1R12 Bobbin Lookup Volts		1R12 +Point				Change from R12 to R13 (v/EFPY)			Cycle 13 Avg Voltage Change (v/EFPY)	1R12 Postulated AONDB Voltage	Delta Voltage
					Ind	Volts	Ind	+Pt Volts	Inferred Volts	Volts	Growth (v/EFPY)	Ind	+Pt Volts	Previous Inferred Bobbin Volts	New Inferred Bobbin Volts	New Inferred to DOS	Inferred to Inferred	Peak +Pt to +Pt			
11	3	62	1H	0.53	DOS	0.17	SAI	0.23	0.65	NDD *	-	SAI	0.14	0.44	0.54	-0.28	0.08	0.07	0.07	0.08	0.46
11	4	20	1H	1.79	DOS	0.2	SAI	0.22	0.64	0.19	0.01	SAI	0.17	0.47	0.58	-0.28	0.04	0.04	0.07	0.11	0.47
11	5	34	1H	1.36	DOS	0.32	MAI	0.23/0.10	0.82	0.32	0.00	SAI	0.19	0.49	0.60	-0.21	0.16	0.03	0.07	0.23	0.37
11	8	32	3H	0.46	DOS	0.5	SAI	0.13	0.53	0.33	0.13	SAI	0.15	0.45	0.55	-0.04	-0.02	-0.01	0.07	0.41	0.14
11	13	41	2H	1.13	DOS	0.21	SAI	0.19	0.60	0.21	0.00	SAI	0.15	0.45	0.55	-0.26	0.03	0.03	0.07	0.12	0.43
11	17	27	3H	1.62	DOS	0.8	SAI	0.31	0.74	NDD *	-	SAI	0.28	0.58	0.71	0.07	0.03	0.02	0.07	0.71	0.00
11	21	49	1H	1.89	DOS	0.61	SAI	0.21	0.62	0.61	0.00	SAI	0.18	0.48	0.59	0.02	0.03	0.02	0.07	0.52	0.07
11	26	33	1H	0.92	DOS	0.35	SAI	0.16	0.57	0.21	0.10	SAI	0.14	0.44	0.54	-0.14	0.02	0.01	0.07	0.26	0.28
11	26	46	1H	2.01	DOS	1.78	SAI	0.66	1.17	1.80	-0.01	SAI	0.67	0.98	1.18	0.45	-0.01	-0.01	0.07	1.69	-0.51
11	36	48	2H	1.04	DOS	0.82	MAI	0.16/0.17/0.21	1.02	0.92	-0.07	MAI	0.17/0.14/0.17	0.81	0.98	-0.12	0.03	0.01	0.07	0.73	0.25
11	42	51	1H	0.63	DOS	0.43	MAI	0.18/0.25	0.89	0.29	0.10	SAI	0.19	0.49	0.60	-0.13	0.22	0.04	0.07	0.34	0.26
12	4	85	3H	1.02	DOS	0.31	SAI	0.18	0.59	NDD *	-	SAI	0.15	0.45	0.55	-0.18	0.03	0.02	0.04	0.26	0.29
12	14	84	2H	1.8	DOS	0.62	SAI	0.23	0.65	0.62	0.00	SAI	0.21	0.51	0.62	0.00	0.02	0.01	0.04	0.57	0.05
12	15	42	2H	0.92	DOS	0.43	SAI	0.26	0.68	NDD *	-	SAI	0.27	0.57	0.69	-0.20	-0.01	-0.01	0.04	0.38	0.31
12	27	83	2H	1.49	DOS	0.84	SAI	0.22	0.64	1.00	-0.12	SAI	0.19	0.49	0.60	0.18	0.03	0.02	0.04	0.79	-0.19
12	30	72	2H	1.03	DOS	0.29	SAI	0.21	0.62	NDD *	-	SAI	0.18	0.48	0.59	-0.22	0.03	0.02	0.04	0.24	0.35
12	31	62	1H	1.95	DOS	0.95	SAI	0.35	0.79	0.91	0.03	SAI	0.26	0.56	0.68	0.20	0.08	0.07	0.04	0.90	-0.22
13	13	10	1H	2.48	DOS	0.5	SAI	0.22	0.64	0.43	0.05	SAI	0.14	0.44	0.54	-0.03	0.07	0.06	0.06	0.42	0.12
14	5	79	1H	1.96	DOS	0.79	SAI	0.17	0.58	0.81	-0.01	SAI	0.19	0.49	0.60	0.14	-0.02	-0.01	0.08	0.68	-0.08
14	9	37	1H	2.11	DOS	1.46	MAI	0.12/0.16/0.42	1.16	NDD *	-	MAI	0.11/0.14/0.31	0.86	1.05	0.31	0.08	0.03	0.08	1.35	-0.30
14	11	46	1H	2.41	DOS	2.01	MAI	0.35/0.39	1.15	1.72	0.22	MAI	0.34/0.41	0.96	1.16	0.64	-0.01	0.00	0.08	1.90	-0.74
											0.028	Average				-0.004	0.043	0.023	0.063		

* For lookups reported as NDD, another lookup review was conducted which reported a bobbin signal in each case, with a lookup bobbin voltage similar to the 1R13 bobbin voltage, indicating negligible growth.

Figure 1

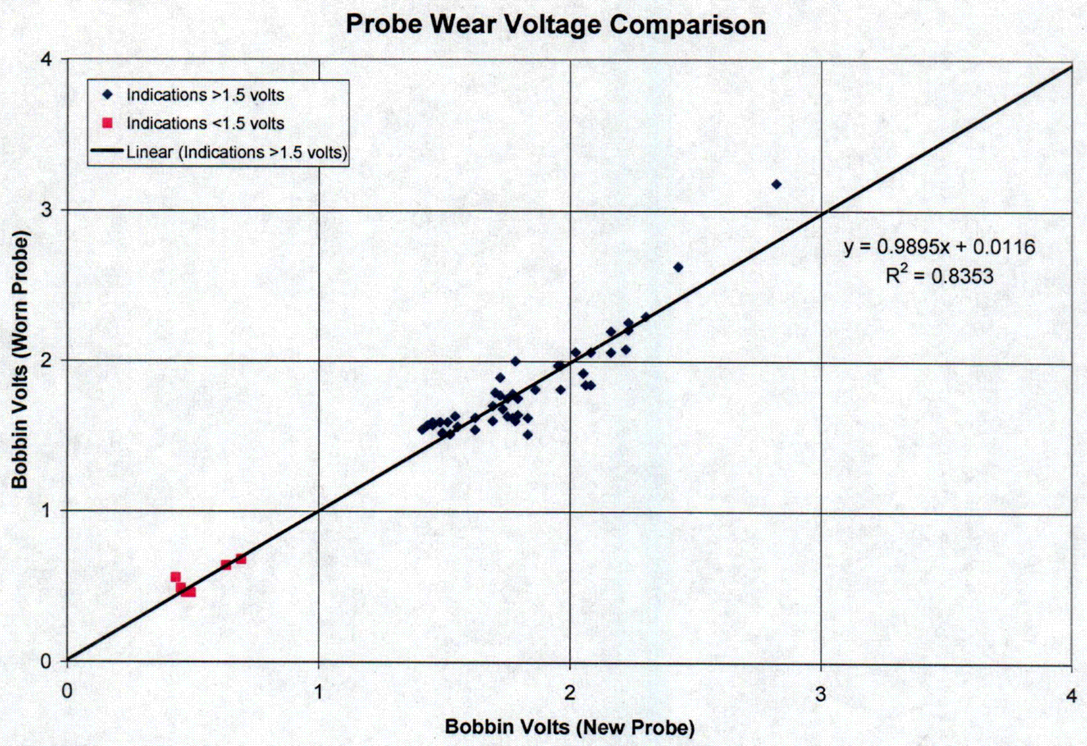

Figure 2