



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
OF THE STEAM GENERATOR 90-DAY REPORT
PACIFIC GAS AND ELECTRIC COMPANY
DIABLO CANYON UNIT 2
DOCKET NO. 50-323

1.0 INTRODUCTION

By letter dated June 26, 1998, Pacific Gas and Electric Company submitted for staff review the report for Diablo Canyon Unit 2, "90-Day Report for Voltage-Based Alternate Repair Criteria - Unit 2 Eighth Refueling Outage." The report was submitted in accordance with Generic Letter (GL) 95-05, "Voltage-Based Repair Criteria for Westinghouse Steam Generator Tubes Affected by Outside Diameter Stress Corrosion Cracking," as a result of implementing the voltage-based alternate repair criteria in the Diablo Canyon Unit 2 technical specifications.

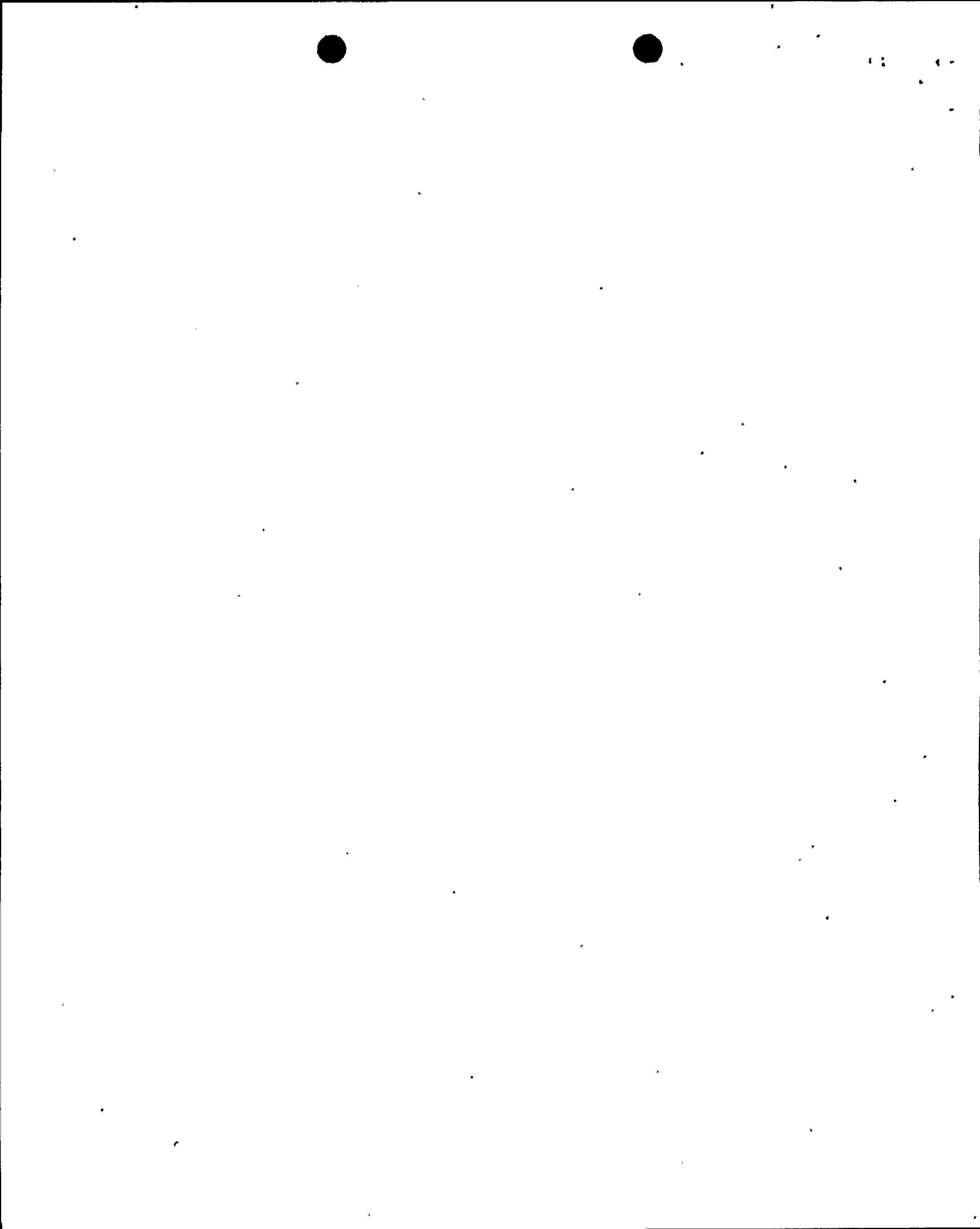
GL 95-05 allows steam generator tubes having outside diameter stress corrosion cracking (ODSCC) that is predominately axially oriented and confined within the tube support plates to remain in service on the basis of, in part, bobbin coil voltage response. GL 95-05 specified that inspection results and associated tube integrity analyses should be submitted within 90 days of each plant restart following a steam generator tube inspection. The report should include, at a minimum, the projected end of cycle (EOC) calculations on voltage distribution and the associated tube leakage and tube burst probability under main steam line break (MSLB) conditions.

2.0 GENERAL PLANT DESCRIPTION

Diablo Canyon Unit 2 has been in operation since March 1986. Diablo Canyon Unit 2 has four Westinghouse Model 51 steam generators. The tubes are 7/8-inch diameter and were fabricated from mill annealed alloy 600 material. The steam generators have drilled hole carbon steel tube support plates.

On March 12, 1998, the staff approved a permanent change to the licensee's technical specifications which implemented a steam generator voltage-based alternate repair criteria in accordance with GL 95-05.

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3.0 STAFF ASSESSMENT

3.1 Inspection Scope and Results

In accordance with the alternate repair criteria (ARC) guidance provided in GL 95-05, the EOC-8 inspection of the Diablo Canyon Unit 2 steam generators (SGs) consisted of a complete, 100 percent eddy current (EC) bobbin probe, full length examination of the tube bundles in all Unit 2 SGs except for U-bends in rows 1 and 2 which were inspected using a rotating +point probe (+point). The +point probe was also used to examine tube support plates (TSPs) in support of the voltage-based ARC. The +point examination at TSPs encompassed: 100 percent of the distorted support signal (DSS) indications called by bobbin; 100 percent of the TSP bobbin dent indications greater than or equal to five volts; 100 percent of the less than five volt TSP dent indications detected during the bobbin probe examination up to the TSP elevation where primary water stress corrosion cracking (PWSCC) had been detected in each specific steam generator, plus a 20 percent sample at the next highest TSP elevation; and all TSP indications containing mix residual signals exceeding a voltage threshold that could mask a 1.0 volt bobbin outer diameter DSS signal.

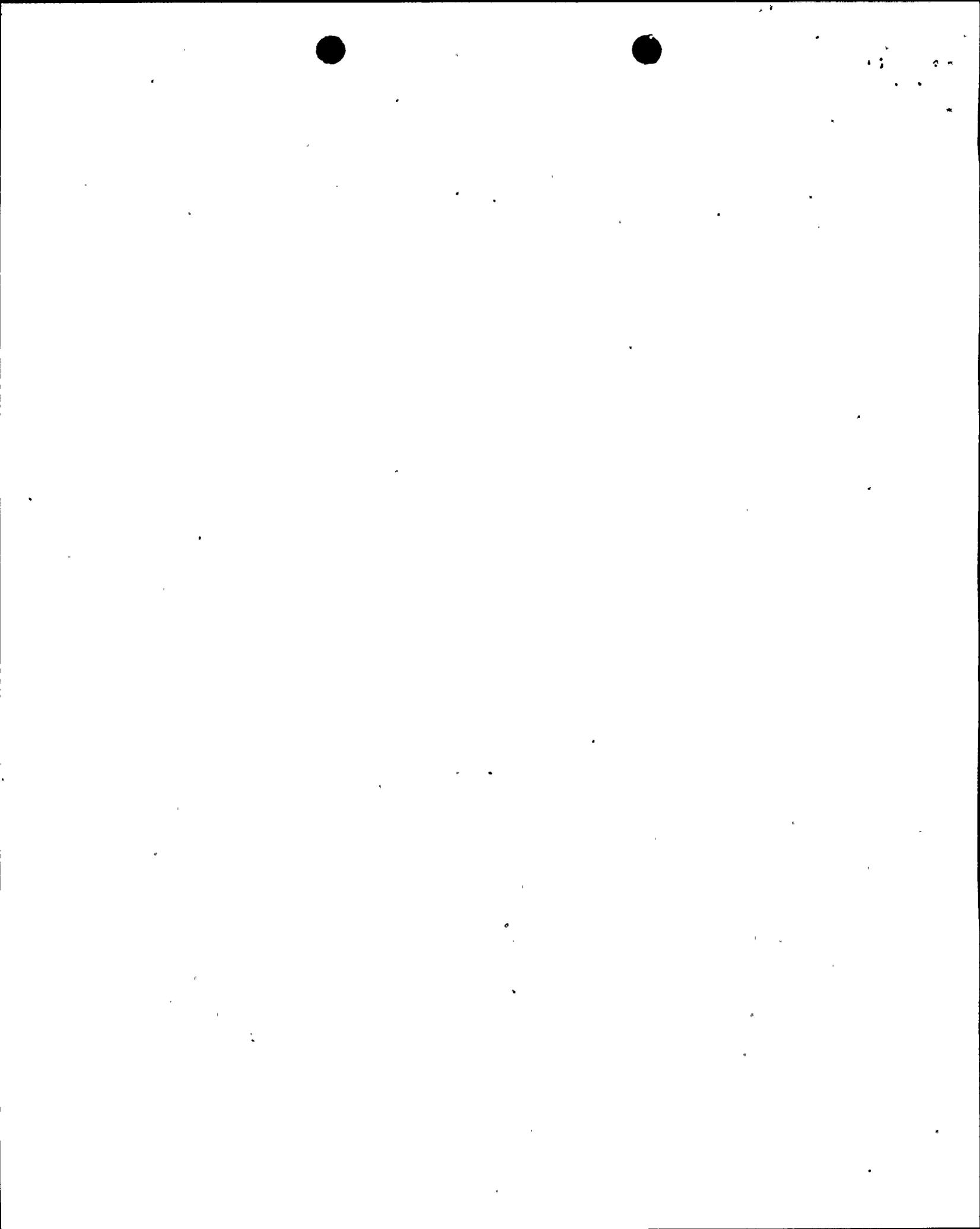
The licensee detected a total of 199 indications at TSP intersections in the hot leg applicable to the voltage-based repair criteria during the EOC-8 inspection. Of those, tubes containing nine indications were removed from service. No indications exceeded the bobbin 2.0 volts repair limit. One tube containing a non-confirmed ODSCC indication was repaired due to PWSCC at another TSP location, one tube was repaired due to PWSCC detected at the same intersection as the ODSCC indication, one tube was repaired due to an ODSCC indication with no bobbin OD signal, four were repaired for ODSCC at TSP intersections at wedge locations, and two were repaired due to tube pulls. The licensee saved 118 tubes by implementing the voltage-based alternate repair criteria during the unit's eighth refueling outage. The ARC was also applied to nine cold-leg TSP indications for a total of 199 ODSCC bobbin indications returned to service for Cycle 9 operation.

As per the GL 95-05, the licensee calculated the upper repair limit using the more conservative of the plant-specific average growth rate per effective full power year (EFPY), or 30 percent per EFPY. The licensee utilized the 30 percent growth per EFPY for this first outage using the voltage-based repair criteria. The licensee documented in their report the average growth rates from Cycle 8 which showed that the 30 percent per EFPY value is bounding for Diablo Canyon Unit 2 at this time. Using the 30 percent per EFPY growth rate and following the methodology in GL 95-05 the licensee calculated the upper repair limit to be 4.9 volts.

Based on the number of tubes returned to service with bobbin coil indications, steam generator 2-4 is considered to be the limiting steam generator for cycle 9 operation. As discussed in Section 3.2.3 of this safety evaluation, this conclusion is supported by the calculated estimate of accident tube leakage.

3.2 Evaluation of Probabilistic Methodologies for Estimating Conditional Probability of Burst and Total Leak Rate Under Postulated Steam Line Break Conditions

Acceptable tube integrity at the conclusion of Cycle 9 operation is demonstrated, in part, by a calculated conditional probability of tube burst under MSLB for the limiting steam generator



which is less than the reporting threshold indicated in GL 95-05 and an estimated accident-induced steam generator tube leak rate from ODSCC at tube support plate intersections below plant-specific reporting thresholds. Three distinct probabilistic calculations are necessary to determine these results. The following summarizes the staff's evaluation of the results reported on these calculations.

3.2.1 Projected End-of-Cycle Voltage Distribution

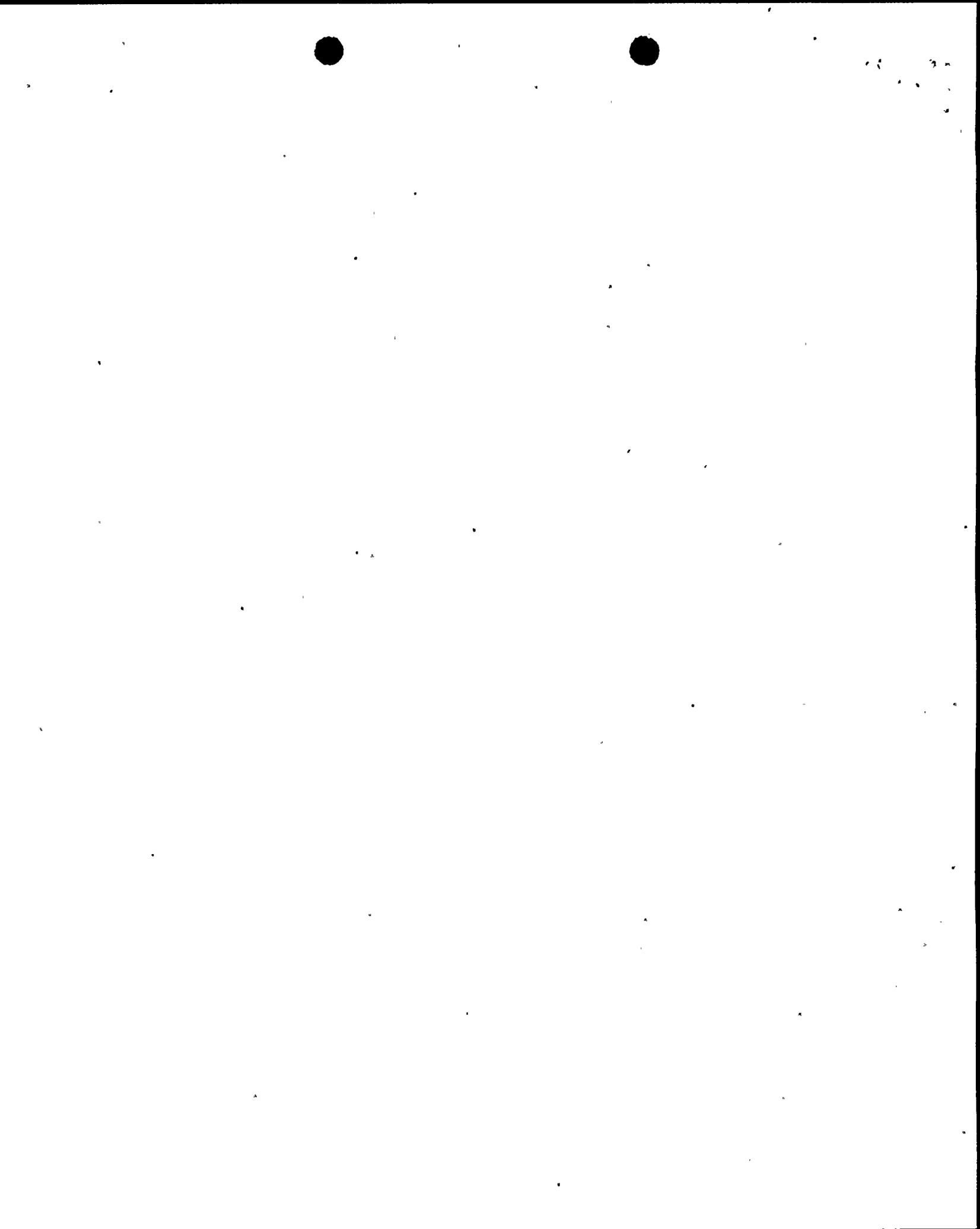
In order to perform the first implementation of the ARC at Diablo Canyon Unit 2 during refueling outage 8 (2R8), the licensee performed a review of the Unit 2 refueling outage 7 (2R7) data to assess the voltage growth. Of the 199 ODSCC indications detected in 2R8, 19 had no degradation detected in 2R7. This left 180 indications to determine the composite average growth rate for Diablo Canyon Unit 2 during Cycle 8. The composite average growth rate for Unit 2 was calculated to be 0.083 volts, or 0.051 volts per EFPY (based on 1.62 EFPY for cycle 8). In order to obtain the most conservative results with respect to the growth rate distribution used in Monte Carlo simulation, the licensee utilized a more conservative bounding probability distribution function of growth rates based on experience to date at similarly designed and operated units. The bounding probability distribution function of growth rates was utilized following the guidance of GL 95-05 since Unit 2 had less than 200 indications to determine the composite average growth rate.

Diablo Canyon Unit 2 evaluated some observations found at other plants with 7/8 inch tubing during recent inspection. Some plants experienced relatively high growth rates for indications in tubes deplugged and returned to service at the beginning of their last operating cycle. The licensee stated that no tubes were recovered during this first outage implementing the voltage based alternate repair criteria at Diablo Canyon Unit 2. Some plants also noted an increase in growth rate with an increase in beginning of cycle (BOC) voltage. Diablo Canyon Unit 2 data thus far has not shown such an effect.

Using the inspection findings in the EOC-8 inspection and the licensee's determined bounding probability distribution function of growth rates, the licensee calculated the projected EOC-9 voltage distribution for bobbin coil probe TSP indications. Based on the overall number of indications anticipated at the EOC-9, the 2-4 steam generator is the limiting steam generator for the next cycle of operation. The staff independently verified the licensee's calculations by completing a Monte Carlo simulation to estimate the EOC-9 voltage distributions. The results of these calculations confirm that the predictive methodology used by the licensee to estimate the EOC voltage distribution is consistent with the guidance provided in GL 95-05.

3.2.2 Conditional Probability of Tube Burst During an MSLB

Conservatively using a bounding growth rate distribution function based on consideration of experience to date at similarly designed and operated units, as opposed to the growth rate distribution determined for each steam generator, the licensee reported the projected EOC-9 conditional tube burst probabilities. The calculated probability of tube burst for steam generators 2-1, 2-2, 2-3, and 2-4 were determined to be 1.5×10^{-4} , 6.4×10^{-5} , 5.4×10^{-5} , and 3.1×10^{-4} respectively. The licensee's projected values are well below the GL reporting



threshold of 10^{-2} , and therefore, the estimated tube burst probability due to ODSCC at tube support plates is within acceptable limits for Cycle 9 operation. The staff ran confirmatory calculations which were in agreement with the licensee's results.

3.2.3 Steam Line Break Leak Rate Projection

The staff evaluated the steam line break induced leak rate reported by the licensee. The licensee determined the steam line break leak rate for SG 2-1, 2-2, 2-3, and 2-4 to be 0.098, 0.047, 0.017, and 0.26 gallons per minute (gpm) (at room temperature). The staff ran confirmatory calculations and was in agreement with the licensee's values. The licensee's values are much smaller than the Diablo Canyon Unit 2 reporting threshold limit of 12.8 gpm (at room temperature) and are acceptable.

3.3 Database for Tube Integrity Calculations

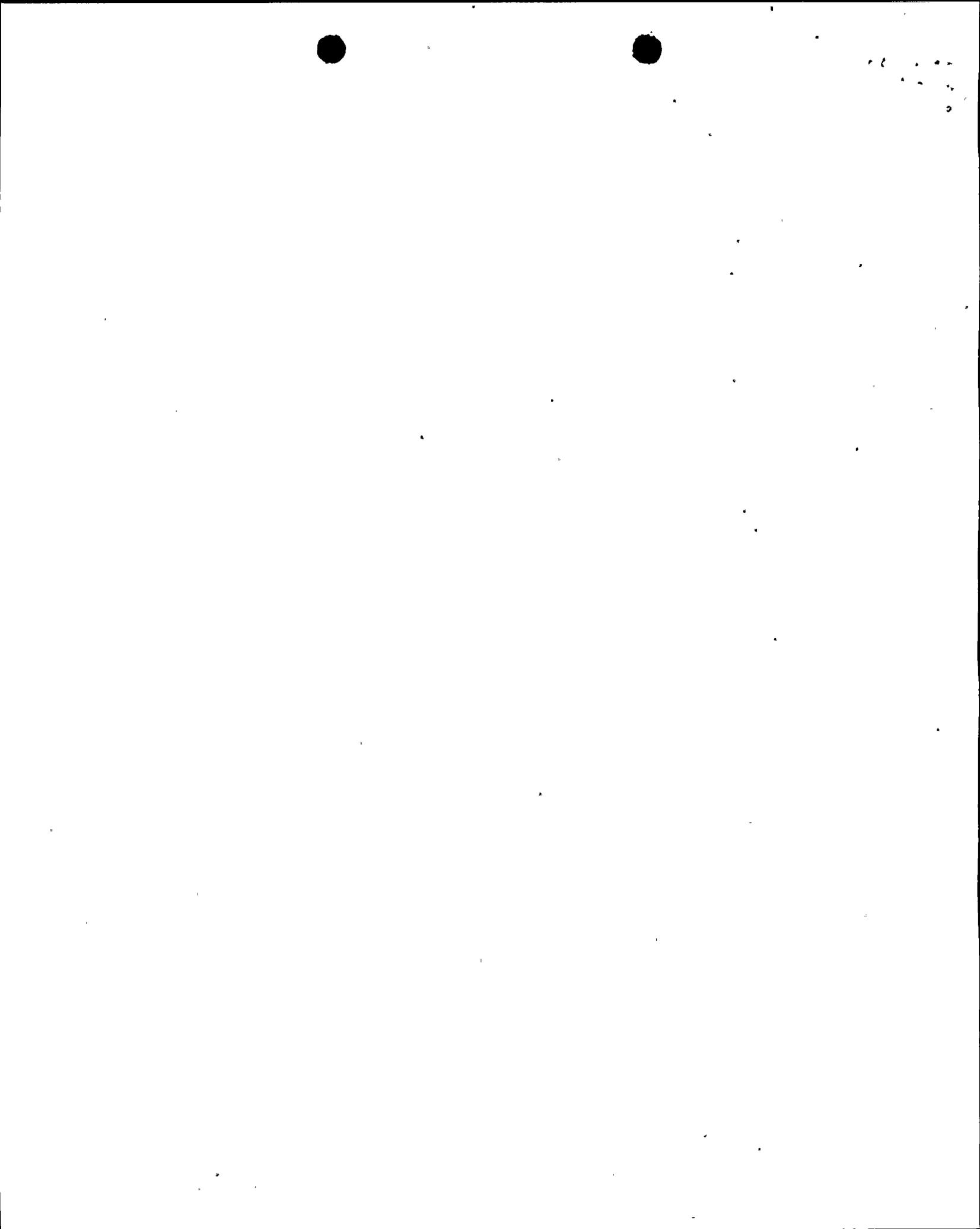
In order to calculate the conditional tube burst probabilities and postulated steam line break primary-to-secondary leak rate, the methodology approved for GL 95-05 requires the use of burst and leak rate data obtained from model boiler tubes and tubes removed from actual steam generators. The industry has developed correlations relating bobbin coil voltage to the measured leak rate, probability of leakage, and burst pressure through testing of these tubes. The leak and burst correlations utilized in the licensee's analyses were based on the Addendum 2 to the Steam Generator Degradation Specific Management (SGDSM) database, "Steam Generator Tubing Outside Diameter Stress Corrosion Cracking at Tube Support Plates Database for Alternate Repair Limits" submitted to the NRC on June 5, 1998, by the Nuclear Energy Institute (NEI). The NRC staff completed its review of the database and associated correlations for $\frac{7}{8}$ - inch diameter tubes and concluded that they were acceptable in a letter to NEI dated November 20, 1998. Therefore, the staff finds the ARC correlations utilized by the licensee are acceptable.

3.4 Tube Pull Results

GL 95-05 requires periodic tube specimen removals to monitor the morphology of ODSCC degradation at tube support plate intersections and to obtain additional data for inclusion in the correlations relating bobbin coil voltage amplitude to tube burst pressure, probability of leakage, and leak rate. The licensee removed two intersections from the hot leg side of tubes' R02C66 and R37C53. The removed tube sections were examined by nondestructive and destructive examination techniques. OD-origin intergranular corrosion was found contained in the tube support plate crevice regions of the mill annealed Alloy 600 tubing. The staff has reviewed the destructive examination results of the pulled tube specimens and concluded that the ODSCC morphology exhibited in the tubes is consistent with the criteria specified in GL 95-05.

3.5 Probe Wear Criteria

The licensee used an alternative method to evaluate probe wear as opposed to the method outlined in GL 95-05. The method was developed by NEI and was found acceptable by the NRC staff as discussed in a letter from Brian Sheron of the NRC to Alex Marion of the Nuclear



Energy Institute dated March 18, 1996. Diablo Canyon was given approval to use this alternative method in the staff's safety evaluation for amendment numbers 124/122, dated March 12, 1998.

The bobbin probe wear guidelines utilized by the licensee state when a probe does not pass the 15 percent wear limit, the licensee is directed to reinspect all tubes with indications above 75 percent of the wear limit inspected since the last successful probe wear check. For Diablo Canyon Unit 2, no tubes required retesting to satisfy the bobbin probe wear criteria because no TSP indications above 1.5 volts were observed with a worn probe during the 2R8 inspection.

4.0 CONCLUSION

The projected EOC-9 conditional probability of burst and projected leak rate under postulated MSLB conditions were less than the GL 95-05 criteria. The staff has reviewed the licensee's methodology, has run confirmatory calculations, and has found the licensee's methodology and results are acceptable.

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Date: March 23, 1999

