Pacific Gas and Electric Company®

Dallas L. Adams
Manager, Program Engineering

Diablo Canyon Power Plant
Mail code 104/4/427
P.O. Box 56
Avila Beach, CA 93424

805.545.6182
Dallas.Adams@pge.com

PG&E Letter DCL-22-091

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

Docket No. 50-323, OL-DPR-82
Diablo Canyon Power Plant Unit 2
Revised Steam Generator Tube Inspection Report for
Diablo Canyon Power Plant Unit 2 Twenty-First Refueling Outage

Dear Commissioners and Staff:

Pacific Gas and Electric Company (PG&E) performed eddy current testing inspections of the Diablo Canyon Power Plant (DCPP) Unit 2 steam generators (SGs) during the DCPP Unit 2 Twenty-First Refueling Outage (2R21) in October 2019. The inspections were conducted in accordance with DCPP Technical Specification (TS) 5.5.9 that was based on Technical Specification Task Force (TSTF) traveler TSTF-449. Since then, TS 5.5.9 and TS 5.6.10 have been revised to adopt TSTF-577, Revision 1, as approved by the NRC in License Amendments 241 and 242 for DCPP Units 1 and 2, respectively, in the letter dated September 6, 2022. PG&E letter DCL-22-011, "License Amendment Request 22-02, Application to Revise Technical Specifications to Adopt TSTF 577, 'Revised Frequencies for Steam Generator Tube Inspections,'" dated March 10, 2022, stated that PG&E would submit a DCPP Unit 2 SG Tube Inspection Report meeting the revised TS 5.6.10 requirements within 30 days after implementation of the license amendment.

The 2R21 SG tube inspection report for the revised TS 5.6.10 requirements is contained in the Enclosure to this letter.

Pacific Gas and Electric Company makes no new or revised regulatory commitments (as defined by NEI 99-04) in this letter.

If there are any questions regarding the enclosure, please contact me at (805) 545-6182.

Sincerely,

Dallas L. Adams
Manager, Program Engineering

12/20/22
Date

kjse/51066426-02
Enclosure
cc: Diablo Distribution
cc/enc: Mahdi O. Hayes, NRC Senior Resident Inspector
Samson S. Lee, NRC Senior Project Manager
Scott A. Morris, NRC Region IV Administrator
State of California, Pressure Vessel Unit

PACIFIC GAS AND ELECTRIC COMPANY

REVISED STEAM GENERATOR TUBE INSPECTION REPORT FOR DIABLO CANYON POWER PLANT UNIT 2 TWENTY-FIRST REFUELING OUTAGE

REVISED STEAM GENERATOR TUBE INSPECTION REPORT FOR DIABLO CANYON POWER PLANT UNIT 2 TWENTY-FIRST REFUELING OUTAGE

Pacific Gas and Electric Company (PG&E) performed eddy current testing (ECT) inspections of the Diablo Canyon Power Plant (DCPP) Unit 2 steam generators (SGs) during the DCPP Unit 2 Twenty-First Refueling Outage (2R21) in October 2019. These were the third in-service inspections conducted on the Unit 2 SGs since they were replaced in the DCPP Unit 2 Fourteenth Refueling Outage (2R14).

The inspections were conducted in accordance with DCPP Technical Specification (TS) 5.5.9 that was based on Technical Specification Task Force (TSTF) TSTF-449. Since then, TS 5.5.9 and TS 5.6.10 have been revised to adopt TSTF-577, as approved by the NRC in License Amendments 241 and 242 for DCPP Units 1 and 2, respectively, in the letter dated September 6, 2022. PG&E letter DCL-22-011, "License Amendment Request 22-02, Application to Revise Technical Specifications to Adopt TSTF 577, 'Revised Frequencies for Steam Generator Tube Inspections'," dated March 10, 2022, stated that PG&E will submit a DCPP Unit 2 SG Tube Inspection Report meeting the revised TS 5.6.10 requirements within 30 days after implementation of the license amendment.

PG&E letter DCL-20-039, "One Hundred Eighty Day Steam Generator Report for Diablo Canyon Power Plant Unit 2 Twenty-First Refueling Outage," dated May 13, 2020, submitted the original SG tube inspection report for 2R21, and was supplemented by PG&E letter DCL-20-088, "Response to NRC Request for Additional Information Regarding 'Diablo Canyon Unit 2 Fall 2019 Steam Generator Tube Inspection Report'," dated October 16, 2020, in response to an NRC request for additional information. The NRC letter dated December 8, 2020, concluded that PG&E provided the information required by the technical specifications.

This revised 2R21 SG tube inspection report follows the reporting template in EPRI SG Integrity Assessment Guidelines, Revision 5, dated December 2021, Appendix G, which augments some of the TS 5.6.10 reporting requirements. Augmented EPRI reporting is shown as "EPRI".

The information submitted in PG&E letters DCL-20-039 and DCL-20-088 satisfy the majority of the reporting information contained in revised TS 5.6.10 and the EPRI template. Each reporting item is listed below, with a reference to PG&E Letters DCL-20-039 and DCL-20-088 as appropriate. Additional information is provided as necessary.

1. Steam Generator design and operating parameters and overview (EPRI).

PG&E letter DCL-20-039 provided most of the SG overview information. For completeness, Table 1 provides the information per the EPRI template.

2. The scope of inspections performed on each SG (TS 5.6.10.a). If applicable, a discussion of the reason for scope expansion (EPRI).

PG&E letter DCL-20-039 provided the scope of inspections performed on each SG, and is provided below for reference. There was no scope expansion.

Bobbin probe inspections:

- Full-length (tube end to tube end) inspection on 100 percent of the in-service tubes in each SG.

+POINT rotating probe inspections:

- 100 percent of bobbin "I" codes.
- 100 percent of dent indications greater than or equal to 5.0 volts.
- 100 percent of ding and dent indications greater than or equal to 1.0 volt that were not previously examined with +POINT.
- 100 percent of U-bend regions that were impacted during manufacturing.
- 100 percent of region of interest locations where the measured tube noise exceeded pre-established threshold values.

3. The nondestructive examination (NDE) techniques utilized for tubes with increased degradation susceptibility (TS 5.6.10.b).

DCPP Unit 2 SG tubing does not have sub-populations with increased degradation susceptibility, such as tubes with potential high residual stress or high growth rates. Industry operating experience suggests that the high flow regions at the top of tubesheet region could have increased susceptibility to foreign object wear. The DCPP SG feedring design includes spray nozzles which have small 0.27-inch diameter holes to help prevent the introduction of foreign material of significant size. No foreign object wear has been detected in the DCPP replacement SGs. As described in PG&E letter DCL-20-039, the NDE technique utilized for this region to detect potential foreign object wear was a bobbin coil 3-frequency mix ("turbo" mix) at the top of the tubesheet expansion transition up to 0.5 inch above the tubesheet.

4. For each degradation mechanism found, the NDE techniques utilized (TS 5.6.10.c.1).

As described in PG&E letter DCL-20-039, the only tube degradation mechanism found in 2R21 was tube wear at tube support plate (TSP) intersections. Tube degradation from potential mechanisms (anti-vibration bar [AVB]) wear and foreign object wear) were not found. PG&E letter DCL-20-039 described the bobbin probe and +POINT probe NDE techniques that were used to detect tube wear at TSP intersections.

5. For each degradation mechanism found, the location, orientation (if linear), measured size (if available), and voltage response for each indication. For tube wear at support structures less than 20 percent through-wall (TW), only the total number of indications needs to be reported (TS 5.6.10.c.2).

PG&E letter DCL-20-039 Table 2 listed the twenty TSP wear indications that were found in 2R21, including the +POINT probe voltage, depth, and length for each indication. All indications were less than 20 percent TW. The largest depth was 14 percent TW.

6. For each degradation mechanism found, a description of the condition monitoring assessment and results, including the margin to the tube integrity performance criteria and comparison with the margin predicted to exist at the inspection by the previous forward-looking tube integrity assessment (TS 5.6.10.c.3). Discuss any degradation that was not bounded by the prior operational assessment in terms of projected maximum flaw dimensions, minimum burst strength, and/or accident induced leak rate. Provide details of any in situ pressure test (EPRI).

PG&E letter DCL-20-039 provided the 2R21 condition monitoring assessment results for TSP wear, including the margin to tube integrity performance criteria.

The previous forward-looking tube integrity assessment, also referred to as the operational assessment (OA), was performed in DCPP Unit 2 Eighteenth Refueling Outage (2R18). To provide margin comparisons, Table 2 provides the 2R21 as-found limiting depth, the condition monitoring (CM) limit for flat wear over the length of the TSP width, and the 2R18 OA projected limiting depth at 2R21. The limiting as-found depth is well below the CM limit, and well below the prior OA projected depth. In situ pressure testing was not required.

7. For each degradation mechanism found, the number of tubes plugged during the inspection outage (TS 5.6.10.c.4). Also, provide the tube location and reason for plugging (EPRI).

No tubes were plugged in 2R21.

8. An analysis summary of the tube integrity conditions predicted to exist at the next scheduled inspection (the forward-looking tube integrity assessment) relative to the applicable performance criteria, including the analysis methodology, inputs, and results (TS 5.6.10.d). The effective full power months of operation permitted for the current operational assessment (EPRI).

Westinghouse performed the OA as documented in Westinghouse Report SG-CDMP-19-15, “Diablo Canyon Unit 2 2R21 Condition Monitoring and Operational Assessment,” Revision 0, November 2019 (Westinghouse Non-Proprietary Class 3).

The OA summary for TSP wear was not previously provided in PG&E Letter DCL-20-039 because OA reporting is a new TS reporting requirement. The OA summary for potential foreign object wear was provided in PG&E Letter DCL-20-088 in response to NRC request for additional information.

The OA for TSP wear and AVB wear was performed to justify four cycles of operation until the end of the plant operating license. The four-cycle operating length estimate was 5.36 effective full power years (EFPY); however, 5.5 EFPY was used in the OA to provide additional margin. AVB wear has not been found on Unit 1, but has been found on Unit 2 which has the same SG design. The OA for AVB wear was conservatively performed for assumed undetected indications at 2R21 and for indications that may initiate over the course of the OA period.

The OA for tube wear was performed using two different simplified analysis procedures: a deterministic procedure and a Monte Carlo procedure. Both procedures project the worst-case degraded tube to the end of the operating period. The analysis methodology, inputs, and results are summarized below.

The deterministic OA method is an arithmetic method that applies the flaw growth over the operating duration to the NDE corrected depth of the largest flaw left in service at the beginning of cycle (BOC) to arrive at an end of cycle (EOC) flaw depth, which is compared to the EOC structural limit. The EOC structural limit is probabilistically determined, using Monte Carlo simulations to apply tube material and burst relation uncertainties at 95/50.

The Monte Carlo OA method uses probabilistic simulations to apply all relevant uncertainties. The relevant uncertainties sampled for each simulation are tube material strength, burst relation, and NDE depth sizing. A constant depth growth rate is used to calculate the 95/50 burst pressure at the end of the OA operating period for a given BOC flaw depth (largest depth left in service) and BOC flaw length. The BOC and EOC flaw lengths are the limiting structure contact lengths: 1.125 inch for TSP wear and 0.8 inch for AVB wear. The result is compared to the minimum required burst pressure necessary to maintain the structural integrity performance criterion of 3 times normal operating pressure differential (3dPNOP), which is 4,350 pounds per square inch. The worst-case degraded tube Monte Carlo calculations are performed using the Westinghouse Electric Company Single Flaw Model software code.

In both simplified analysis procedures, OA projections are performed for the worst-case degraded tube returned to service, and also for the largest flaw that may have gone undetected during the inspection. The size of the undetected flaw is determined by the larger of a site-specific noise-based probability of detection curve, or an NDE analysis reporting threshold.

TSP wear maximum depth growth rate distributions were developed from all available data from the SG inspections at 2R21, 2R18, and DCPP Unit 2 Fifteenth Refueling Outage (2R15). Growth rate assessments were performed using point to point measurements from +Point data (16 points) and bobbin data (28 points), with resulting maximum growth rates ranging from 1.3 percent TW/EFPY (+Point data) to 2.0 percent TW/EFPY (bobbin data). 2.0 percent TW/EFPY was applied in the OA. Since the prior OA performed in 2R18 applied a growth rate of 4 percent TW/EFPY based on limited growth rate data (only 8 +Point data points), the OA also applied the 4 percent TW/EFPY growth rate in separate projections.

Since AVB wear has not been found at DCPP Unit 2, a bounding 5 percent TW/EFPY growth rate was assumed based on experience at other plants of similar design.

Tables 3, 4, 5, and 6 provide a results summary for the deterministic and Monte Carlo OA calculations for TSP and AVB wear.

In the deterministic OA, the projected wear depths for TSP wear and AVB wear at EOC-25 remain well below the structural limits. In the Monte Carlo OA, the projected burst pressures for TSP wear and AVB wear at EOC-25 remain below 3dPNO tube burst criteria. For volumetric wear flaws with pressure-only loading condition, as is the condition for TSP wear and AVB wear, tube burst and ligament tearing (i.e., pop-through) are coincidental, therefore, satisfaction of the tube burst criteria at 3dPNO also satisfies the accident induced leakage performance criteria at steam line break differential pressure. Therefore, the SG performance criteria for structural and leakage integrity will be satisfied for TSP wear and AVB wear at EOC-25.

9. The number and percentage of tubes plugged to date, and the effective plugging percentage in each SG (TS 5.6.10.e).

PG&E letter DCL-20-039 described that three tubes in SG 2-4 were plugged in the factory using weld plugs, the percentage plugging in SG 2-4 is 0.07 percent, and no tubes are plugged in SG 2-1, SG 2-2, and SG 2-3.

10. The results of any SG secondary side inspections (TS 5.6.10.f). The number, type, and location (if available) of loose parts that could damage tubes removed or left in service in each SG (EPRI).

PG&E letters DCL-20-039 and DCL-20-088 provided a description of the SG secondary side inspections which consisted of top of tubesheet visual inspections and foreign object search and removal (FOSAR).

PG&E letter DCL-20-088 provided a table of the foreign material found during FOSAR, identifies the foreign material left in service in the SGs, and describes the OA which addresses foreign material.

11. The scope, method, and results of secondary-side cleaning performed in each SG (EPRI).

PG&E letter DCL-20-039 described the results of sludge lancing performed in each SG.

12. Describe the effect of secondary side deposits that may affect tube integrity (EPRI).

Steam generator tube deposit trending has been accomplished by performing ECT tube deposit mapping and by monitoring feedwater iron transport to the SGs.

In 2R15 and 2R18, SG tube deposit mapping was previously performed as part of the bobbin ECT data collection. The 2R18 deposit mapping indicates that about 2,200 pounds (lbs) of deposits are on the tubing (about 550 lbs per SG).

Through 2R21 (7 cycles of SG operation), about 3,800 lbs of feedwater iron has been transported to the SGs, about 950 lbs per SG. A small percentage of iron is removed by blowdown. Sludge lancing removes only a small fraction of the overall iron that is deposited in the SGs. Sludge collectors also capture small amounts of iron. The majority of iron deposits remain on the tubes as confirmed by ECT deposit mapping.

The amount of tube deposits is well below any thresholds for bundle cleaning and does not represent a tube integrity concern.

13. The results of primary side component visual inspections performed in each SG (EPRI).

PG&E letter DCL-20-039 described the results of visual inspections performed on six factory weld plugs in SG 2-4, and visual inspections performed on each SG channel head in accordance with Westinghouse Nuclear Safety Advisory letter (NSAL 12-1) recommendations.

Table 1
Steam Generator Design and Operating Parameters and Overview

Model	Westinghouse Model Delta 54
Tube material	Alloy 690 Thermally Treated (TT)
Number of SGs per Unit	4
Number of tubes	4,444 per SG
Nominal tube diameter and wall thickness	0.75-inch outer diameter, 0.043-inch wall thickness.
Style of support plate and material	Tri-foil broached stainless steel
Outage the prior (N-1) SG inspections were completed	2R18
Effective full power months (EFPM) of operation since the prior SG inspection	55.6 EFPM, or 4.63 effective EFPY
Cumulative effective full power months	126 cumulative EFPM (10.5 EFPY) since SG replacement in 2R14
Date of initial entry into Mode 4 from current inspection outage	November 18, 2019
SG primary-to-secondary leak rate observed since the last inspection and how it trended with time	None
Nominal hot-leg temperature(s) (Thot) during the prior inspection period	601 °F
Describe any loose parts strainer in the feedwater or internal to the SG	Each SG has a feedwater feedring. Each feedring contains 38 spray nozzles to distribute the feedwater into the SG. The spray nozzles have small 0.27-inch diameter holes to help prevent the introduction of foreign material of significant size.
Tube sub-populations with increased degradation susceptibility (e.g., tubes with potential high residual stress ("- two sigma"), other areas based on growth rates or design features)	None. (Note: Bobbin turbo mix used at the top of the tubesheet expansion region to detect potential foreign object wear.)
A list of any deviations taken from Mandatory and/or Needed (Shall) requirements important to tube integrity from the EPRI Guidelines referenced by NEI 97-06 since the last inspection.	None
SG schematic without dimensions	See PG&E letter DCL-20-039 Figure 2

Table 2
2R21 CM Limiting Depth Compared to CM Limit and Projected Depth

Degradation Mechanism	Probe	2R21 CM As-Found Limiting Depth	2R21 CM Limit	2R18 OA Projected Limiting Depth at 2R21
TSP Wear	+POINT	14%	42.4%	47.7%

Table 3
Deterministic Worst-Case Degraded Tube OA Results for TSP Wear

ETSS	Probe	BOC Flaw Type	BOC Depth	Depth Growth Per EFPY	EOC 25 Project Depth	EOC 25 Structural Limit
96910.1	+POINT	Existing	14%	2%	39.8%	51.5%
I96043.4	Bobbin	Existing	18%	2%	35.1%	51.5%
96910.1	+POINT	Existing	14%	4%	50.8%	51.5%
I96043.4	Bobbin	Existing	18%	4%	46.1%	51.5%

Table 4
Monte Carlo Worst-Case Degraded Tube OA Results for TSP Wear

ETSS	Probe	BOC Flaw Type	BOC Depth	Depth Growth Per EFPY	EOC 25 Burst Pressure (psi)	3dPNO Criteria (psi)
96910.1	+POINT	Existing	14%	2%	5625	4350
I96043.4	Bobbin	Existing	18%	2%	5888	4350
96910.1	+POINT	Existing	14%	4%	4740	4350
I96043.4	Bobbin	Existing	18%	4%	5007	4350

Table 5
Deterministic Worst-Case Degraded Tube OA Results for AVB Wear

ETSS	Probe	BOC Flaw Type	BOC Depth	Depth Growth Per EFPY	EOC 25 Project Depth	EOC 25 Structural Limit
I96041.1	Bobbin	Undetected	10%	5%	44.0%	53%

Table 6
Monte Carlo Worst-Case Degraded Tube OA Results for AVB Wear

ETSS	Probe	BOC Flaw Type	BOC Depth	Depth Growth Per EFPY	EOC 25 Burst Pressure (psi)	3dPNO Criteria (psi)
I96041.1	Bobbin	Undetected	10%	5%	5314	4350

END OF REPORT