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PG&E Letter DCL-21-036

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

Docket No. 50-275, OL-DPR-80
Diablo Canyon Unit 1
<u>One Hundred Eighty Day Steam Generator Report for Diablo Canyon Power Plant Unit 1 Twenty-Second Refueling Outage</u>

Dear Commissioners and Staff:

Diablo Canyon Power Plant (DCPP) Technical Specification (TS) 5.6.10, "Steam Generator (SG) Tube Inspection Report," requires a report to be submitted within 180 days after initial entry into Mode 4 (Hot Shutdown) following completion of SG inspections performed in accordance with TS 5.5.9, "Steam Generator (SG) Tube Inspection Program." The enclosure provides the 180-day report for SG inspections performed during the DCPP Unit 1 Twenty-Second Refueling Outage.

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

If there are any questions or if additional information is needed, please contact Mr. John Arhar at 805-545-4629.

Sincerely,

Paula Gerfen

dqmg/50943041-2
Enclosure
cc: Diablo Distribution
cc/enc: Donald R. Krause, NRC Senior Resident Inspector
Samson S. Lee, NRC Project Manager
Scott A. Morris, NRC Region IV Administrator
State of California, Pressure Vessel Unit

ONE HUNDRED EIGHTY DAY STEAM GENERATOR REPORT
FOR
DIABLO CANYON POWER PLANT UNIT 1
TWENTY-SECOND REFUELING OUTAGE

ONE HUNDRED EIGHTY-DAY STEAM GENERATOR REPORT FOR DIABLO CANYON POWER PLANT UNIT 1 TWENTY SECOND REFUELING OUTAGE

Pacific Gas and Electric Company (PG&E) performed eddy current testing (ECT) inspections of the Diablo Canyon Power Plant (DCPP) Unit 1 steam generators (SGs) during the DCPP Unit 1 Twenty Second Refueling Outage (1R22) in October 2020. The inspections were conducted in accordance with DCPP Technical Specification (TS) 5.5.9. These were the third in-service inspections conducted on the Unit 1 SGs since they were replaced in the DCPP Unit 1 Fifteenth Refueling Outage (1R15).

The condition monitoring (CM) assessment concludes that, based on the results of the 1R22 inspections, none of the SG performance criteria were exceeded since the last ECT inspection in DCPP Unit 1 Nineteenth Refueling Outage (1R19), that is, the three-cycle operating period between the start of Unit 1 Cycle 20 and the end of Unit 1 Cycle 22. The operational assessment concludes that there is reasonable assurance that operation of the DCPP Unit 1 SGs until the planned shutdown following Unit 1 Cycle 25 (three operating cycles) will not cause any of the SG performance criteria to be exceeded.

A detailed description of the 1R22 SG inspection, CM, and operational assessment (OA) are documented in Westinghouse report SG-CDMP-20-22 (Reference 2). The inspections and CM are summarized in the 180-day report as required by TS 5.5.9.

- Section 1.0 provides background information including SG design features and SG operation summary.
- Section 2.0 provides the scope of inspections performed.
- Section 3.0 provides the results of primary side inspections and CM.
- Section 4.0 provides voluntary information on the OA and secondary side integrity assessment, in support of Reference 6. This information is not required by TS 5.5.9.

Pursuant to TS 5.6.10, a report shall be submitted within 180 days after initial entry into MODE 4 (Hot Shutdown) following completion of an inspection performed in accordance with TS 5.5.9. DCPP Unit 1 entered Mode 4 on October 30, 2020.

The report shall include:

a. The scope of inspections performed on each SG.

   See Section 2.0 for the scope of inspections performed.

b. Active degradation mechanisms found.

See Section 3.0 for discussion of tube support plate (TSP) wear and antivibration (AVB) wear, which were the only active degradation mechanisms identified.

c. Nondestructive examination techniques utilized for each degradation mechanism.

   See Section 3.0 for nondestructive examination techniques utilized.

d. Location, orientation (if linear), and measured sizes (if available) of service induced indications.

   See Table 4 and Table 6 for locations and measured sizes of the TSP and AVB wear indications, respectively.

e. Number of tubes plugged during the inspection outage for each active degradation mechanism.

   No tubes were plugged.

f. Total number and percentage of tubes plugged to date.

   SG 1-1: 1 tube plugged, 0.02%
   SG 1-2: 5 tubes plugged, 0.11%
   SG 1-3: 2 tubes plugged, 0.04%
   SG 1-4: no tubes plugged

g. The results of CM, including the results of tube pulls and in situ testing.

   Section 3.0 provides the results of primary side inspections and CM. No tubes required removal or in situ testing.

1.0 Background Information

1.1 SG Design

Diablo Canyon Unit 1 is a four-loop plant with Westinghouse Model Delta 54 steam generators. Each SG includes 4,444 tubes fabricated from Alloy 690 thermally treated (A690TT) material. The tubes have a nominal outer diameter of 0.75 inch with a 0.043 inch thickness, except for tubes in Row 1 and Row 2 which have a nominal tube thickness of 0.044 inch. The tubes are full-depth hydraulically expanded into the tubesheet. The end of each tube was tack expanded with a urethane plug expansion process prior to making the autogenous seal weld at the primary tubesheet. The tube bundle consists of 96 rows and 119 columns of tubes arranged in a triangular pattern with a pitch of 1.144 inches, which results in tube-to-tube centerline distances of 0.572 inch between adjacent rows and 0.9907 inch between adjacent columns. The tubes in Rows 1 through 16 were full-length stress relieved after the U-bends were bent.

The straight lengths of the tubes are supported by eight stainless steel TSPs, 1.125 inch thick, and have broached trefoil-shaped tube holes. The first TSP is located 20 inches above the secondary tubesheet and the span between subsequent TSPs is 44 inches (centerline-to-centerline). The tubes are supported in the U-bend by three sets of stainless steel V-shaped anti-vibration bars (AVB). The AVB width is 0.71 inch with a thickness of 0.2375 inch. The lowest tube row supported by AVBs is Row 8, except for Tube Columns 1-2 and 118-119 where all rows are supported.

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.

Figure 1 provides the Westinghouse Delta 54 SG tubesheet map depicting the row and column numbers. Figure 2 provides the Westinghouse Delta 54 SG sketch depicting the tube support plate naming convention.

1.2 SG Operation Summary

The original DCPP Unit 1 Westinghouse Model 51 SGs that contained mill-annealed Alloy 600 (A600MA) tubing were replaced with Westinghouse Model Delta 54 SGs during 1R15 in 2009.

Table 1 provides the SG inspections over time. DCPP TS 5.5.9.d defines the SG inspection periods. The DCPP TS, including inspection periods, are modeled after Reference 5. The 1R22 SG inspection was the third inspection, following inspections in 1R16 and 1R19. After the first inspection in 1R16, Unit 1 entered the first TS sequential period of 144 effective full power months (EFPM), and the SGs have operated for 109 EFPM since 1R16. Therefore, Unit 1 is still in the first period.

DCPP TS 5.5.9 allows SG operation without inspections up to 72 EFPM or three refueling outages, whichever is less. Because 55 EFPM have accumulated since the prior inspection in 1R19 (3 cycles ago), SG operation without inspections is limited to three refueling outages.

DCPP TS 5.5.9 requires that 100% of the tubes be inspected in each sequential period, and to inspect 50% of the tubes by the refueling outage nearest the midpoint of the period and the remaining 50% by the refueling outage nearest the end of the period. 1R22 is the refueling outage nearest the end of the 144 EFPM period. Therefore, at least 50% of the tubes were required to be inspected in 1R22; however, 100% of the tubes were inspected.

The operating interval between the 1R19 and 1R22 SG inspections was 4.57 effective full power year (EFPY). The planned 3 cycle operating interval from 1R22 to the end of Cycle 25 (EOC-25) is about 3.77 EFPY, at which time the plant is planned to be retired at the end of the operating license. Therefore, the 1R22 inspection is the last planned inspection of the DCPP Unit 1 SGs.

The DCPP Unit 1 SGs operate at a nominal primary hot leg temperature (Thot) of 601 degrees F. The SG primary side inlet pressure is 2,250 psia and the SG nominal secondary side pressure is 805 psia at the SG main steam exit nozzle, thus producing a 1,445 psi differential pressure across the tubes. The SG tube integrity structural performance criterion (SIPC) at 3 times normal operating pressure differential pressure (3dPNOP) is conservatively assessed at 4,350 psi.

The DCPP Model Delta 54 SGs have never exhibited primary-to-secondary leakage throughout their operating life.

2.0 Inspections Performed

The 1R22 Degradation Assessment evaluated the condition of the SGs in advance of the 1R22 SG inspections to satisfy TS 5.5.9. The Degradation Assessment identified the appropriate eddy current inspection scope, probes to be utilized, and appropriate detection and sizing information for potential degradation mechanisms for the proposed inspection scope. The potential degradation mechanisms were identified as TSP wear (existing), AVB wear (existing), and foreign object wear (potential). Foreign object wear was conservatively considered as a potential degradation mechanism even though no foreign object wear has ever been detected in the DCPP Model Delta 54 SGs.

In 1R22, the following tube ECT inspection criteria and primary side visual inspection criteria were implemented. Expanded ECT inspection was not required. No secondary side sludge lancing or secondary side visual inspections were performed in 1R22.

- Bobbin probe inspections:
  - A full-length (tube end to tube end) bobbin coil probe inspection on 100% of the in-service tubes in each SG. Note: SG 1-4 R1C39 short radius U-bend was inspected with +POINT from 8H to 8C, due to an obstruction at 8H +8.36" (tangent) which would not allow the bobbin probe to pass from either the hot leg or cold leg.
- +POINT rotating probe inspections:
  - Bobbin "I" codes.
  - AVB wear indications, including existing 1R19 indications.
  - TSP wear indications, including existing 1R19 indications
  - Potential Loose Part (PLP) indications. (No PLP were reported.)
  - Ding and dent indications ≥ 1.0 volt that were not previously examined with +POINT.
  - New ding and dent indications ≥ 1.0 volt. (One new ≥ 1.0 volt dent was reported.)
  - New proximity indications (PRO). (No new PRO were reported.)
  - 100% of region of interest locations where the measured tube noise exceeded pre-established threshold values.
- Visual inspections of sixteen mechanical roll plugs that were installed in eight tubes in 1R19.
- Visual inspection of each SG channel head in accordance with Westinghouse Nuclear Safety Advisory letter (NSAL 12-1) recommendations.

3.0 Results of Primary Side Inspections and Condition Monitoring

Table 2 summarizes the ECT indications detected during the 1R22 eddy current inspections. The tube degradation detected in 1R22 was tube wear at TSP intersections and tube wear at AVB intersections. The Table 2 indications that represent tube wear are a) distorted support indications (DSI) that were reported by bobbin coil and were confirmed by +POINT probe as support wear indications (WAR) and b) percent throughwall (PCT) indications reported by bobbin coil that were confirmed by +POINT probe as WAR. Potential tube degradation due to foreign object wear was not detected.

A CM evaluation of the steam generator tube bundles was performed to verify that the condition of the tubes, as reflected in the inspection results, complies with the SIPC and the accident induced leakage performance criteria (AILPC).

3.1 TSP Wear

Table 3 provides a summary of the TSP wear indications reported in 1R22. Table 4 provides a listing of the TSP wear indications reported in 1R22, including the SG number, tube row and column, TSP number, indication location (inches) relative to the TSP centerline, and +POINT probe voltage and depth.

TSP wear was detected with a bobbin probe (using EPRI Appendix I Examination Technique Specification Sheet (ETSS) 96043.4 technique) and reported as a distorted support indication (DSI). All DSIs were then inspected with a +POINT probe (using EPRI Appendix H ETSS 96910.1 technique) to confirm if the bobbin DSI was tube wear, to depth size the wear, to determine if the wear was at multiple TSP lands, and to allow structural profiling (length and depth) for any new TSP indications. In addition, all existing TSP wear from 1R19 was +Point inspected.

There were 75 DSIs reported by the bobbin coil probe, of which 74 were confirmed with the +POINT probe as TSP wear. A total of 87 TSP wear (WAR) indications (at 76 TSP intersections) were confirmed by +POINT, of which 12 were newly reported indications. Most TSP wear indications were at a single land contact of the broached trefoil support plates. Some TSP locations had wear at multiple TSP lands: 5 had wear at 2 land contacts, and 3 had wear at 3 land contacts. Bobbin cannot resolve these flaws separately, which results in a single DSI call. Multiple indications do not reduce the burst strength of the tubing.

The +POINT probe sizing reported maximum depths ranging from 2% through-wall (TW) to 15%TW, and total axial lengths ranging from 0.11 inch to 1.31 inch. The TSP thickness is 1.125 inches and reported wear lengths larger than 1.125 inches are a result of the +POINT probe look-ahead and look-behind fields of view. Most of the shallow TSP wear exhibits a tapered profile. The limiting flaw (15%TW new wear indication at SG 1-3 R2C84 at 7C) exhibits a flat profile.

A CM assessment was performed using the +POINT probe results and conservatively assumes a flat TSP wear profile.

The CM limit for broached TSP flat wear over the entire TSP thickness is 42.4%TW using the +POINT probe ETSS 96910.1 sizing technique. The CM limit is probabilistically determined, using Monte Carlo simulations to apply tube material, burst relation, and ETSS sizing uncertainties at 0.95 probability and 50% confidence level (95/50). The measured flaw sizes can be compared directly to the CM limit.

The largest TSP wear depth measured by the +POINT probe was 15%TW and was well below the CM limit. Therefore, the SIPC for tube burst is satisfied at a 3dPNO loading condition, with significant margin. For volumetric wear flaws with pressure-only loading condition, as is the condition for TSP wear, tube burst and ligament tearing (i.e., pop-through) are coincident, therefore, satisfaction of the tube burst criteria at 3dPNO also satisfies the AILPC at steam line break differential pressure. Therefore, for TSP wear, the SIPC and AILPC are satisfied for CM.

All TSP wear indications were left in service because the TW depths are less than the 40%TW plugging criteria defined in TS 5.5.9.c, and because SG tube integrity will be maintained for the next 3 cycles based on performance of an operational assessment.

3.2 AVB Wear

Table 5 provides a summary of the AVB wear indications reported in 1R22. Table 6 provides a listing of the AVB wear indications reported in 1R22, including the SG number, tube row and column, AVB number, indication location (inches) relative to the AVB centerline, bobbin probe voltage and depth, and +POINT probe voltage and depth.

AVB wear was detected with a bobbin probe (using EPRI Appendix I ETSS 96041.1 technique), reported as a percent indication (PCT), and depth sized. All PCT were then inspected with a +POINT probe (using EPRI Appendix I ETSS 10908.5 technique) to confirm if the bobbin PCT was tube wear, to depth size the wear, and to determine if the wear was double sided. In addition, all existing AVB wear from 1R19 was +Point inspected.

There were 11 PCTs reported by the bobbin probe, of which 10 were confirmed by the +POINT probe as AVB wear (WAR). There were a total of 18 AVB indications confirmed by +POINT, of which 4 were newly reported indications. This includes the 10 indications detected by bobbin plus 8 indications that were not detectable (NDD) by bobbin. None of the AVB wear was double-sided wear.

The +POINT probe sizing reported maximum depths range from 4%TW to 26%TW and total axial lengths range from 0.10 inch to 1.11 inch. The bobbin probe sizing reported maximum depths range from 5%TW to 15%TW.

The AVB support thickness is nominally 0.71 inch. For tube Rows 39 and higher, AVB wear lengths are bounded by 0.8 inch, because this is the bounding physical contact length between the tubes and the AVBs. Therefore, a conservative AVB wear length of 0.8 inch was considered in the development of the CM limits. All of the 1R22 AVB wear is located between Rows 79 and 96, and therefore the CM limits are applicable. AVB wear reported lengths exceed 0.8 inches because of the +POINT probe look-ahead and look-behind field of views.

The CM assessment evaluated both the bobbin and the +POINT probe results. For a uniformly deep, 0.80-inch wear scar at an AVB intersection, the CM limit using the bobbin probe is 49.6%TW, and the CM limit using the +POINT probe is 53.0%TW (applying the ETSS 96041.1 bobbin technique and ETSS 10908.5 +POINT technique, respectively.) The CM limits are probabilistically determined, using Monte Carlo simulations to apply tube material, burst relation, and ETSS sizing uncertainties at 0.95 probability and 50% confidence level (95/50). The measured flaw sizes can be compared directly to the CM limits.

The largest depths measured by the bobbin probe (15%TW) and the +POINT probe (26%TW) are well below their respective CM limits of 49.6%TW and 53.0%TW. Therefore, the SIPC for tube burst is satisfied at a 3dPNO loading condition, with significant margin. For volumetric wear flaws with pressure-only loading condition, as is the condition for TSP wear, tube burst and ligament tearing (i.e., pop-through) are coincident, therefore, satisfaction of the tube burst criteria at 3dPNO also satisfies the AILPC at steam line break differential pressure. Therefore, for TSP wear, the SIPC and AILPC are satisfied for CM.

All AVB wear indications were left in service because the TW depths are less than the 40%TW plugging criteria defined in TS 5.5.9.c, and because SG tube integrity will be maintained for the next 3 cycles based on performance of an operational assessment.

3.3 Tube Noise Inspections

Eddy current noise monitoring was implemented for the collected bobbin data. The bobbin probe data was monitored for noise and the potential for noise to mask degradation in various regions of interest, including AVB, TSP and top of tubesheet locations. Locations where the noise measurements exceeded the amplitude thresholds established in the Degradation Assessment were reviewed by the eddy current data analysis team for the need to perform further analysis or ECT inspection. There was one top of tubesheet location that exceeded the pre-established threshold values, was assigned a distorted tubesheet indication (DTI) code, and was inspected by +POINT probe with no detectable degradation found. There were 10 TSP locations and 2 AVB locations that exceeded the pre-established threshold values. These signals were reviewed by the Lead Level III data analyst and confirmed that none of the noise signals could mask a flaw. Therefore, diagnostic +POINT probe inspection was not required for these TSP and AVB locations.

3.5 Tube Plug Visual Inspections

All previously installed hot leg and cold leg tube plugs were visually examined. The DCPP Unit 1 SGs have eight (8) plugged tubes with sixteen (16) tube plugs installed (one plug per tube end). All tube plugs are AREVA SB-166 Alloy 690 rolled plugs and were installed during 1R19. No evidence of plug degradation, excessive boron deposits, or wetness was noted during the plug visual examination.

3.6 Channel Head Visual Inspections

A visual inspection of the SG channel head bowl internal surfaces (including the cladding, tubesheet, divider plate, and all associated welds) was performed for all SGs based on Westinghouse Nuclear Safety Advisory Letter NSAL-12-1. Satisfactory results were observed in all channel heads with no areas of defects or unusual discolorations noted.

4.0 Additional Information

The following additional information is not required by existing TS 5.5.9, but is being voluntarily provided in support of Reference 6.

4.1 1R22 CM Results Compared to 1R19 OA Predictions

Reference 6 proposed the following new reporting requirement: “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.” The forward-looking tube integrity assessment is another name for the operational assessment (OA).

Section 3 provided the 1R22 condition monitoring assessment results for TSP wear and AVB wear, and the results are summarized in Table 7. The as-found depths are well below the CM limits, demonstrating significant margin.

The previous OA was performed in 1R19. Table 8 provides the limiting tube wear depths from the 1R19 OA projections versus the 1R22 CM as-found. The as-found depths are well below the projected depths, demonstrating significant margin.

4.2 1R22 OA Summary and Methodology

Reference 6 proposed the following new reporting requirement: “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.”

The 1R22 OA is documented in Reference 2.

The OA for existing degradation mechanisms was performed to justify three cycles of operation until the end of the plant operating license. The next three-cycle operating length estimate is 3.77 EFPY. However, a three-cycle operating length of 3.9 EFPY is used in the OA to provide additional margin.

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 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 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 3dPNOP, which is 4,350 psi. The worst-case degraded tube Monte Carlo calculations are performed using the WEC Single Flaw Model (SFM) 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 1R22 inspection. The size of the undetected flaw is determined by the largest of 1) a site-specific noise-based probability of detection (POD) curve, 2) an NDE analysis reporting threshold, or 3) the largest +POINT depth indication that was not reported by bobbin.

TSP wear growth rate distributions were developed from all available data from the current and prior SG inspections at 1R22, 1R19, and 1R16. For 1R16-1R19 and 1R19-1R22, the +POINT probe 95th percentile growth rates were 3.1%TW/EFPY (86 growth rate points) and 1.6%TW/EFPY (87 growth rate points), respectively. The OA is based on the 95th percentile growth rate of 2.8%TW/EFPY, using the combined +POINT data set from 1R16-1R19 and 1R19-1R22 (173 growth rate data points).

AVB wear growth rate distributions were developed from all available data from the current and prior SG inspections at 1R22, 1R19, and 1R16. For 1R16-1R19 and 1R19-1R22, the +POINT probe 95th percentile growth rates were 8.8%TW/EFPY (62 growth rate points) and 4.3%TW/EFPY (18 growth rate points), respectively. For the higher AVB wear growth rates observed at 1R19, a causal analysis concluded that the most likely cause was localized AVB-to-tube gap variations due to AVB assembly fabrication coupled with localized tube excitation in the region of the tube wear. These high growth rate tubes were plugged in 1R19. Tubes with observed AVB wear that are still in service at 1R22 have been operating for 10.6 EFPY with well-established, relatively low growth rates. Therefore, this OA applies the 95th percentile growth rate of 4.3%TW/EFPY for existing AVB wear flaws. However, the maximum growth rate observed from 1R16-1R19 (9.3%TW/EFPY based on bobbin data) was conservatively applied in the OA for undetected flaws.

Tables 9, 10, 11, and 2 provide a summary of the deterministic and Monte Carlo OA calculations for TSP and AVB wear.

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

4.3 Secondary Side Integrity Assessment

Reference 6 proposed the following new reporting requirement: “The results of any SG secondary side inspections.” The following provides this information as well as a summary of the SG secondary side integrity assessment.

4.3.1 1R22 Secondary Side Inspections and Cleaning – None Performed

As stated earlier, no secondary side sludge lancing or secondary side visual inspections were performed in 1R22. Foreign object search and retrieval (FOSAR) visual inspections at the top of tubesheet was only planned as an emergent activity if a PLP was confirmed by +POINT probe examination.

The 1R22 ECT found no PLP indications based on the bobbin analysis. Designated analysts performed a separate in-depth PLP analysis in the outer peripheral tubes, which are subject to high secondary water fluid velocity and are typically the most susceptible to flow induced foreign object wear.

The 1R22 ECT found no foreign object wear based on the bobbin analysis. A bobbin coil 3-frequency mix (“turbo” mix) was used for the detection of potential foreign object wear at the top of the tubesheet expansion transition up to 0.5 inch above the tubesheet. A site validation demonstration was performed that provided high assurance that significant flaws caused by foreign object wear could be detected.

Therefore, because the 1R22 ECT did not detect PLP indications or foreign object wear, no FOSAR was performed.

4.3.2 Historical Sludge Lancing and Chemistry Evaluation

Sludge lancing at the top of tubesheet has been previously performed in 1R16, 1R17, and 1R19, and the amount of sludge removed was 12, 11, and 23 pounds, respectively. Sludge lancing has effectively removed soft deposits located at the top of tubesheet, such that the post-lance tubesheet condition is generally clean.

Foreign material that was collected in the sludge lance filter strainer was assessed after each sludge lancing. All foreign material was of small dimension and insignificant mass, and judged unlikely to cause SG tube wear.

In each outage in which lancing was performed, sludge samples were taken from each SG for chemical analysis. The chemical analysis showed no irregularities in metals. Iron is the major elemental constituent in the samples.

4.3.3 Historical FOSAR Tubesheet Visual Inspections

Top of tubesheet FOSAR visual inspections have been previously performed after every sludge lancing in 1R16, 1R17, and 1R19. The video probe inspections included the no tube lane and selected in-bundle locations. Tube bundle periphery inspections were done using a crawler with integrated camera. Because the FOSAR inspections were performed on a cleaned tubesheet, only minor foreign objects have been encountered, and some objects were removed by FOSAR. Any foreign material that was found was of small dimension and insignificant mass, and judged unlikely to cause SG tube wear.

4.3.4 Historical Steam Drum Visual Inspections

Steam generator steam drum visual inspections were previously performed in 1R17. No abnormal conditions were noted on steam drum components, including sludge collectors, primary separators, swirl vanes, baffle plates, feedrings, secondary moisture separators and outlet nozzle.

4.4.5 Tube Deposit Trending

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

In 1R16 and 1R19, SG tube deposit mapping was previously performed as part of the bobbin ECT data collection. The 1R19 deposit mapping indicates that about 2,000 lbs of deposits are on the tubing, about 500 lbs per each SG. The heaviest deposits are on the hot leg side of the steam generator between the second and eighth tube support plates.

Through Unit 1 Cycle 22 (7 cycles of RSG operation), about 3,000 lbs of feedwater iron has been transported to the SGs, about 750 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 on the tubes as confirmed by ECT deposit mapping.

The amount of tube deposits is well below any thresholds for bundle cleaning, and no cleanings are needed through the end of plant life.

4.4.6 Future Secondary Side Inspections and Cleanings – None Planned

With no history of foreign object wear at DCPP Unit 1, and no PLPs reported in the 1R22 ECT, and based on the analysis in Reference 3, the remaining 3.9 EFPY operating interval is acceptable with respect to not performing FOSAR through the end of plant life. Reference 3 evaluated potential DCPP Unit 2 SG tube wear from feed water heater (FWH) tube support/baffle plate fragments that could exist in the SGs in all areas of the top of the tubesheet. The analysis concluded that the fragments would be acceptable to remain in the SGs for future operating cycles. The analysis also applies for similar size objects that could exist in the Unit 1 steam generators, and the evaluated length of time bounds the remaining life of the Unit 1 SGs.

Reference 4 provides a secondary side integrity assessment for the DCPP Unit 1 SGs through the end of the plant life. This assessment concludes that future secondary side inspection activities, including steam drum inspections, sludge lancing, and bundle cleaning, are not recommended through the end of plant life at EOC-25. These recommendations are supported by 1R22 SG ECT inspection findings.

5.0 Conclusions

SG tube ECT inspections, SG tube plug visual inspections, and channel head visual inspections were conducted in 1R22. The CM assessment concludes that, based on the results of the 1R22 inspections, none of the SG performance criteria were exceeded since the last SG inspection in 1R19. The operational assessment concludes that there is reasonable assurance that operation of the DCPP Unit 1 SGs for the next three operating cycles, through the end of plant life, will not cause any of the SG performance criteria to be exceeded.

No secondary side inspections or cleaning were performed in 1R22, and none are planned through the end of plant life.

6.0 References

1. PG&E Diablo Canyon Unit 1 1R22 Steam Generator Degradation Assessment, Revision 1, October 14, 2020

2. Westinghouse Report SG-CDMP-20-22, “Diablo Canyon Unit 1 1R22 Condition Monitoring and Operational Assessment,” Revision 0, October 2020 (Westinghouse Non-Proprietary Class 3)

3. Westinghouse letter LTR-CECO-19-064, Revision 0, “Evaluation of Foreign Object in the Secondary Side of Diablo Canyon Unit 2 Replacement Steam Generators – Fall 2019 2R21 Outage,” October 18, 2019.

4. Westinghouse Report SG-CCOE-17-2, Revision 0, “Diablo Canyon Unit 1 Steam Generator Secondary Side Maintenance Optimization Evaluation for Fuel Cycle 20,” June 2017.

5. Technical Specification Task Force TSTF-449 Revision 4, "Steam Generator Tube Integrity"

6. Technical Specification Task Force TSTF-577 Revision 1, "Revised Frequencies for Steam Generator Tube Inspections," letter TSTF-20-07 to NRC dated March 1, 2021

Table 1
Unit 1 SG First ECT Inspection Period
ECT Examinations Completed

Year	2010	2012	2014	2015	2017	2019	2020	2022
Outage	1R16	1R17	1R18	1R19	1R20	1R21	1R22	1R23
SG EFPY per cycle	1.49	1.42	1.60	1.50	1.44	1.60	1.53	1.36
SG EFPM cumulative	18	35	54	72	89	108	127	143
Tech Spec ECT Period EFPM		144						
SG EFPM for ECT period		17	36	54	71	91	109	125
SG EFPM between ECT				54			55	
ECT	Yes			Yes			Yes	
% Bobbin	100			100			100	

Table 2
Summary of 1R22 Eddy Current Indications

Code	Description	SG 1-1	SG 1-2	SG 1-3	SG 1-4	Total
ADS	Absolute Drift Signal	3	9	2	3	17
DNG	Ding	10	13	9	7	39
DNH	Ding with History	9	16	19	6	50
DNT	Dent	1	9	4	2	16
DSI	Distorted Support Indication	4	14	39	18	75
DTI	Distorted Tubesheet Indication		1		2	3
INF	Indication Not Found	1				1
INR	Indication Not Reportable	15	17	11	24	67
MBM	Manufacturing Burnish Mark		1	1	2	4
NDD	No Degradation Detected	4409	4375	4373	4378	17535
NDF	No Degradation Found		4	2	3	9
PCT	Percent Through Wall	8	3			11
NQS	Non-Quantifiable Signal			1		1
PDS	Pilger Drift Signal		2	3	11	16
PRO	Tube-to-Tube Proximity				2	2
RBD	Re-Test Bad Data		6	1	9	16
RND	Re-Test No Data			5		5
ROB	Retest Obstructed Tube				1	1
WAR	Support Wear Indication	22	19	46	18	105

Table 3
1R22 TSP Wear Summary

1R22 TSP Summary	SG 1-1	SG 1-2	SG 1-3	SG 1-4	Total
Bobbin Distorted Support Indications (DSI)	4	14	39	18	75
TSP wear DSI confirmed by +Point	4	14	38	18	74
TSP wear by +POINT, NDD by bobbin	3	0	0	0	3
Total TSP wear indications +Point	9	14	46	18	87
New TSP wear	4	2	5	1	12
TSP Wear Tubes Affected	6	13	34	16	69
Tubes to be plugged	0	0	0	0	0

Table 4
1R22 TSP Wear Indications

No.	SG ID	Row	Col	TSP	Inch	+POINT Volts	+POINT Depth (%TW)
1	11	29	5	7C	-0.65	0.14	7
2	11	51	11	7C	-0.65	0.17	8
3	11	74	22	6C	-0.66	0.07	4
4	11	74	22	6C	0.16	0.13	6
5	11	74	22	6C	0.34	0.06	3
6	11	78	66	8C	-0.01	0.15	7
7	11	78	66	8C	0.37	0.1	5
8	11	83	57	8C	-0.28	0.08	4
9	11	95	73	6H	-0.64	0.11	6
10	12	5	27	6C	-0.58	0.2	10
11	12	23	25	6C	-0.65	0.17	8
12	12	54	12	7C	-0.67	0.22	11
13	12	54	12	8C	-0.63	0.09	5
14	12	60	18	6H	-0.71	0.1	5
15	12	66	18	6H	-0.55	0.16	8
16	12	75	23	6H	-0.54	0.14	7
17	12	79	79	5C	-0.64	0.09	4
18	12	82	52	4H	0.4	0.16	8
19	12	84	82	6H	-0.55	0.13	6
20	12	85	57	6C	-0.56	0.28	13
21	12	88	38	5H	-0.55	0.12	6
22	12	92	44	5H	-0.48	0.18	9
23	12	92	62	5C	-0.58	0.07	4
24	13	2	84	7C	0	0.33	15
25	13	3	3	7C	-0.4	0.12	6
26	13	8	118	5C	0.38	0.26	12
27	13	8	118	6C	-0.61	0.16	8

Table 4
1R22 TSP Wear Indications

No.	SG ID	Row	Col	TSP	Inch	+POINT Volts	+POINT Depth (%TW)
28	13	8	118	6C	0.39	0.13	6
29	13	38	12	6H	-0.66	0.17	8
30	13	49	23	6H	-0.66	0.1	5
31	13	52	12	6H	-0.73	0.1	5
32	13	55	15	6C	-0.68	0.07	4
33	13	56	16	6C	-0.65	0.07	4
34	13	56	100	6H	-0.66	0.13	7
35	13	56	104	6H	-0.67	0.2	10
36	13	57	107	6C	-0.61	0.14	7
37	13	57	107	6C	0.49	0.11	6
38	13	58	22	6C	-0.58	0.09	5
39	13	60	26	6H	-0.67	0.14	7
40	13	63	23	6C	0.36	0.14	7
41	13	63	29	7C	-0.58	0.13	7
42	13	66	20	6C	-0.62	0.15	7
43	13	66	64	7C	-0.67	0.07	3
44	13	69	19	6H	-0.68	0.1	5
45	13	71	27	6H	-0.63	0.21	10
46	13	74	38	8C	-0.6	0.07	3
47	13	76	30	6C	-0.58	0.15	7
48	13	76	96	8H	0.24	0.22	10
49	13	79	93	6C	-0.72	0.07	4
50	13	86	34	3H	-0.62	0.08	4
51	13	86	34	6H	0.49	0.23	11
52	13	87	39	6C	-0.64	0.08	4
53	13	87	55	6H	-0.68	0.08	4
54	13	87	67	6C	-0.52	0.04	2
55	13	88	38	6C	-0.6	0.13	6
56	13	89	51	6C	-0.63	0.06	3
57	13	89	51	6C	-0.61	0.04	2
58	13	89	51	6C	0.45	0.07	4
59	13	89	53	6C	-0.58	0.17	8
60	13	89	67	6C	-0.58	0.14	7
61	13	95	67	6C	-0.59	0.17	8
62	13	95	67	6C	-0.56	0.1	5
63	13	95	67	7C	-0.56	0.1	5
64	13	96	52	6C	-0.61	0.1	5
65	13	96	52	6C	-0.56	0.08	4

Table 4
1R22 TSP Wear Indications

No.	SG ID	Row	Col	TSP	Inch	+POINT Volts	+POINT Depth (%TW)
66	13	96	52	6C	0.36	0.07	4
67	13	96	56	6C	-0.65	0.08	4
68	13	96	56	6C	0.35	0.1	5
69	13	96	56	7H	-0.74	0.07	4
70	14	4	14	6H	-0.72	0.11	5
71	14	5	1	6H	-0.61	0.11	6
72	14	12	8	4H	-0.6	0.1	5
73	14	25	11	5C	-0.58	0.12	6
74	14	28	102	5C	-0.61	0.1	5
75	14	32	22	5C	-0.54	0.08	4
76	14	52	12	5C	-0.65	0.13	6
77	14	67	99	5C	-0.65	0.08	4
78	14	68	20	7C	-0.63	0.12	6
79	14	72	58	6H	-0.69	0.15	8
80	14	73	25	5H	-0.65	0.1	5
81	14	74	24	5C	-0.64	0.08	4
82	14	77	25	5H	-0.64	0.13	6
83	14	81	29	4H	-0.6	0.15	8
84	14	81	29	6H	-0.65	0.18	9
85	14	95	67	5H	-0.66	0.15	7
86	14	95	67	6H	0.3	0.16	8
87	14	96	50	6C	-0.62	0.14	7

Table 5
1R22 AVB Wear Summary

1R22 AVB Summary	SG 1-1	SG 1-2	SG 1-3	SG 1-4	Total
AVB wear PCT by bobbin	8	3	0	0	11
AVB wear PCT by bobbin confirmed by +Point	8	2	0	0	10
AVB wear by +POINT, NDD by bobbin	5	3	0	0	8
Total AVB wear indications +Point	13	5	0	0	18
New AVB wear indications	4	0	0	0	4
AVB Wear Tubes Affected	6	3	0	0	9
Tubes plugged	0	0	0	0	0

Table 6
1R22 AVB Wear Indications

No.	SGID	Row	Col	AVB Number	Inch	Bobbin Volts	+POINT Volts	Bobbin Depth (%TW)	+POINT Depth (%TW)
1	11	78	66	AV4	-0.02	0.33	0.54	12	22
2*	11	78	66	AV5	-0.02	0.25	0.44	10	18
3*	11	78	66	AV6	-0.09	--	0.13	NDD	6
4	11	83	57	AV2	-0.02	--	0.2	NDD	9
5	11	83	57	AV5	-0.02	0.29	0.2	11	21
6*	11	83	57	AV6	-0.09	--	0.51	NDD	5
7	11	86	56	AV4	0.0	0.44	0.09	15	26
8	11	86	56	AV5	0.0	--	0.68	NDD	8
9	11	87	45	AV3	0.0	0.14	0.16	6	13
10*	11	91	59	AV5	0.0	0.25	0.28	10	20
11	11	95	53	AV3	0.0	--	0.5	NDD	8
12	11	95	53	AV4	-0.32	0.21	0.17	9	18
13	11	95	53	AV5	-0.25	0.21	0.44	9	17
14	12	69	21	AV4	-0.51	0.09	--	5	NDF
15	12	72	64	AV2	-0.21	0.18	0.16	9	8
16	12	89	79	AV2	0.12	--	0.1	NDD	5
17	12	89	79	AV3	-0.08	--	0.08	NDD	4
18	12	89	79	AV4	0.39	0.2	0.25	10	12
19	12	89	79	AV6	0.18	--	0.23	NDD	11

Notes:
NDD: Indication not reported by bobbin probe at this AVB intersection
NDF: No degradation found by +Point probe of a bobbin indication
*Newly reported at 1R22

Table 7
1R22 CM Limiting Depths Versus CM Limits

Degradation Mechanism	Probe	1R22 CM As-Found Limiting Depth	1R22 CM Limit
TSP Wear	+POINT	15%	42.4%
AVB Wear	Bobbin	15%	49.6%
AVB Wear	+POINT	26%	53.0%

Table 8
1R19 OA Projected Depths Versus 1R22 CM As-Found Depths

Degradation Mechanism	1R19 OA Projected Limiting Depth at EOC 22	1R22 CM Limiting As-Found Depth
TSP Wear	41%	15%
AVB Wear	54%	26%

Table 9
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	15%	2.8%	40.7%	51.5%
N/A		Undetected	9%	2.8%	Bounded by existing flaw OA	

Table 10
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	15%	2.8%	5555	4350
N/A		Undetected	9%	2.8%	Bounded by existing flaw OA	

Table 11
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	Existing	15%	4.3%	38.3%	53%
I10908.5	+POINT	Existing	26%	4.3%	45.3%	53%
I96041.1	Bobbin	Undetected	11%	9.3%	47.3%	53%

Table 12
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)
96910.1	Bobbin	Existing	15%	4.3%	5760	4350
I10908.5	+POINT	Existing	26%	4.3%	5130	4350
I96041.1	Bobbin	Undetected	11%	9.3%	4795	4350

Figure 1
DCPP Unit 1 and 2 Westinghouse Delta 54 Steam Generator Tubesheet Map

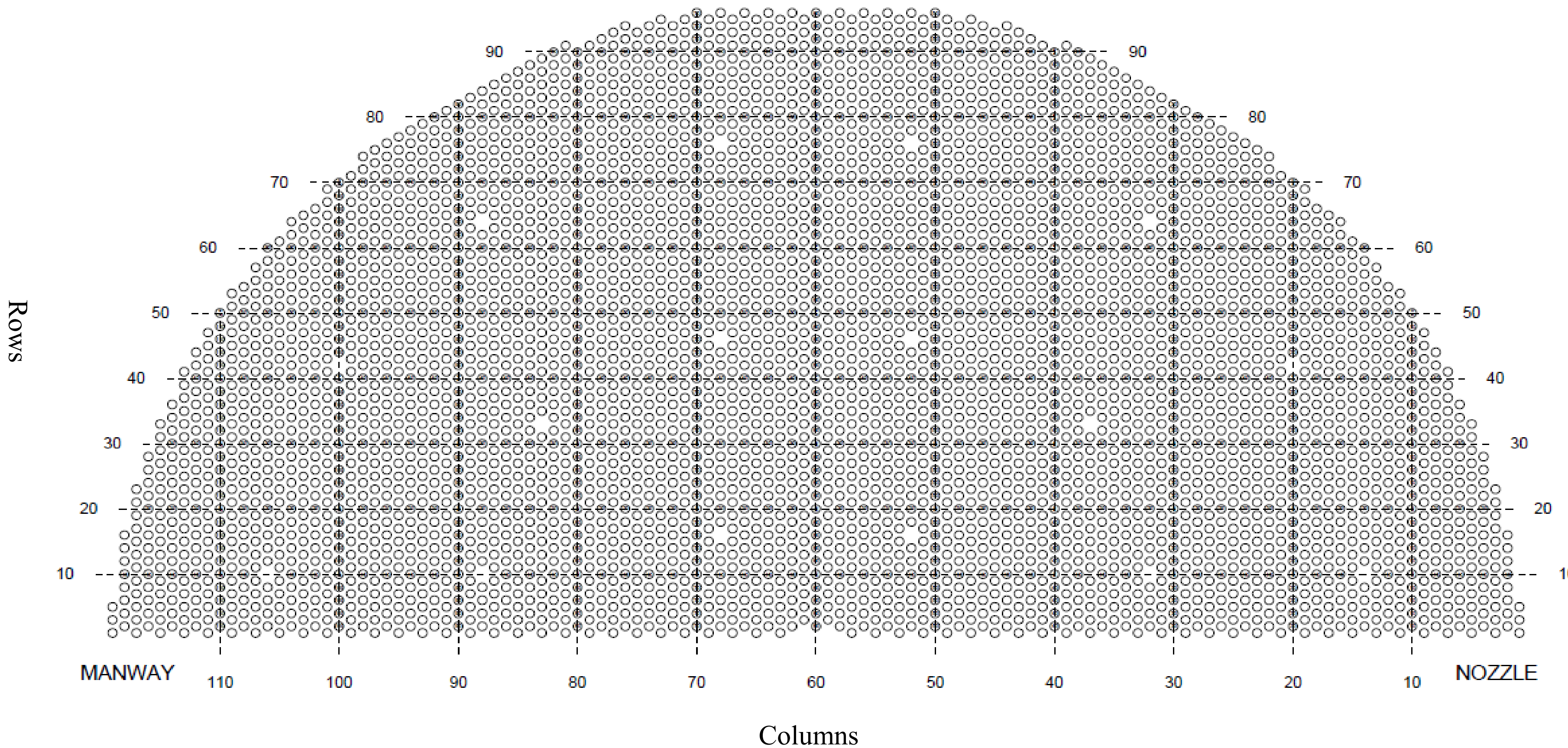
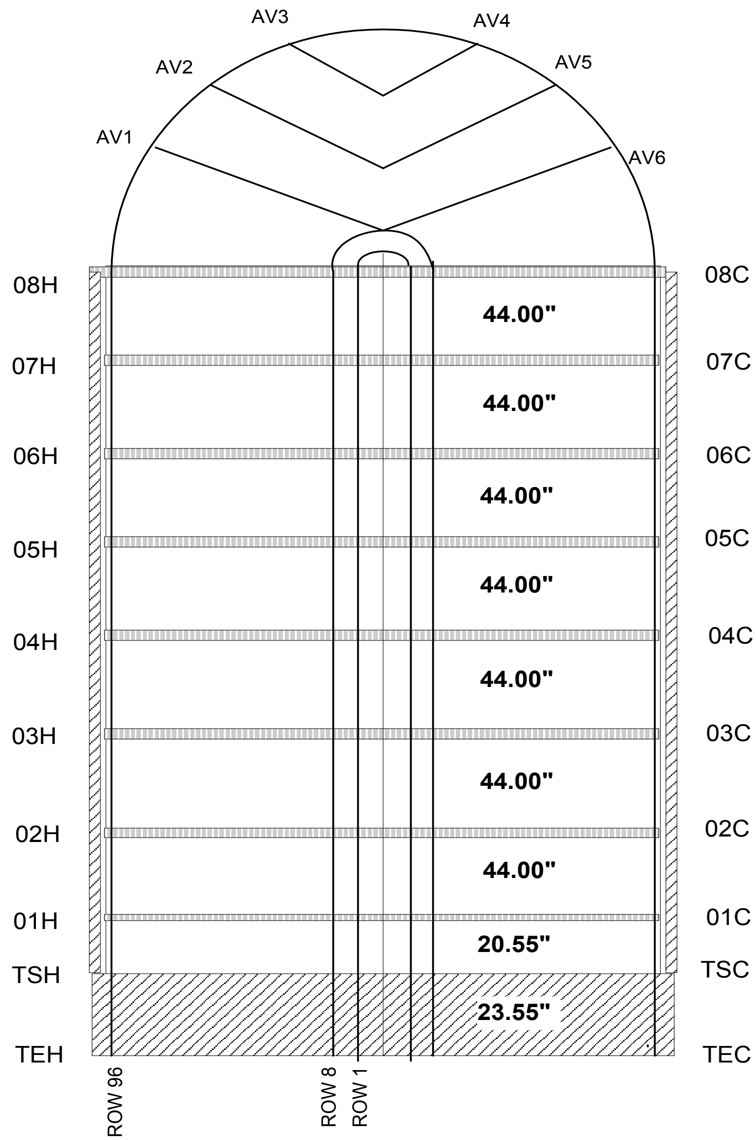


Figure 2
Sketch of DCPP Unit 1 and 2 Westinghouse Delta 54 Steam Generator



Westinghouse Delta 54 RSG

Support thickness is 1.125"

TSP Spacing values are center to center