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PG&E Letter DCL-15-054

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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Docket No. 50-323, OL-DPR-82
Diablo Canyon Unit 2
<u>One Hundred Eighty-Day Steam Generator Report for Diablo Canyon Power Plant Unit 2 Eighteenth Refueling Outage</u>

Dear Commissioners and Staff:

Diablo Canyon Power Plant (DCPP) Technical Specification (TS) 5.6.10, requires a report to be submitted within 180 days after initial entry into Mode 4 (Hot Shutdown) following completion of steam generator (SG) inspections performed in accordance with TS 5.5.9. The enclosure provides the 180-day report for SG inspections performed during the DCPP Unit 2 Eighteenth Refueling Outage.

PG&E 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 John Arhar at 805-545-4629.

Sincerely,

Barry S. Allen

Barry S. Allen

bnsm/4540/64050853

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ONE HUNDRED EIGHTY-DAY STEAM GENERATOR REPORT FOR DIABLO CANYON POWER PLANT UNIT 2 EIGHTEENTH REFUELING OUTAGE

ONE HUNDRED EIGHTY-DAY STEAM GENERATOR REPORT FOR DIABLO CANYON POWER PLANT UNIT 2 EIGHTEENTH 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 Eighteenth Refueling Outage (2R18) in October 2014. The inspections were conducted in accordance with DCPP Technical Specification (TS) 5.5.9. These were the second inservice inspections conducted on the Unit 2 SGs since they were replaced in the DCPP Unit 2 Fourteenth Refueling Outage. The first inservice inspection was conducted in the DCPP Unit 2 Fifteenth Refueling Outage (2R15).

The condition monitoring (CM) assessment concludes that, based on the results of the 2R18 inspections, none of the SG performance criteria were exceeded since the last ECT inspection in 2R15, that is, the three cycle operating period between the start of Unit 2 Cycle 16 and the end of Unit 2 Cycle 18. The operational assessment (OA), not included in this report, concludes that there is reasonable assurance that operation of the DCPP Unit 2 SGs until the next scheduled ECT inspection in DCPP Unit 2 Twenty First Refueling Outage (2R21) (three operating cycles) will not cause any of the SG performance criteria to be exceeded.

- Section 1.0 provides background information including SG design features, Electric Power Research Institute (EPRI) guidelines, DCPP TS periods, and cycle lengths.
- Section 2.0 provides the SG tube integrity performance criteria.
- Section 3.0 provides the scope of inspections performed.
- Section 4.0 provides the results of condition monitoring.
- Section 5.0 provides an assessment of relevant non-degradation mechanisms.
- Section 6.0 provides an assessment of SG secondary side integrity.

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 2 entered Mode 4 on November 1, 2014.

The report shall include:

a. The scope of inspections performed on each SG.

   See Section 3.0 for the scope of inspections performed.

b. Active degradation mechanisms found.

   See Section 4.0 for active degradation mechanisms identified.

c. Nondestructive examination (NDE) techniques utilized for each degradation mechanism.

   See Section 4.0 for NDE techniques utilized.

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

   See Table 3 for location and measured sizes of the indications.

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

   See Section 4.0. No tubes were plugged.

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

   Three tubes in SG 2-4 were plugged in the factory using weld plugs in both ends of the tubing. The percentage plugging in SG 2-4 is 0.07 percent. No tubes are plugged in SG 2-1, SG 2-2, and SG 2-3.

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

   Section 4.0 provides the results of condition monitoring for tube degradation that was detected. No tubes required removal or in situ testing.

1.0 Background Information

1.1 SG Description

Table 1 provides a description of pertinent DCPP SG design features. 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 EPRI Steam Generator Integrity Assessment Guidelines

The EPRI Steam Generator Integrity Assessment Guidelines (SGIAGL), Revision 3, contains the following requirements:

- A CM report shall be completed prior to MODE 4 after a SG inspection.
- When SGs pass CM, an operational assessment shall be completed for the next inspection interval within 90 days after MODE 4.

Consistent with the requirements of the SGIAGL, PG&E developed a report prior to MODE 4 to document the 2R18 DCPP Unit 2 SG as-found CM assessment and the anticipated condition during the next operating period operational assessment (OA), thus satisfying the MODE 4 requirements for CM and the 90 day OA requirements. The 180-day TS 5.5.9 report requires the results of the CM assessment, but not the OA assessment. As such, only the CM assessment is provided in this report.

1.4 DCPP TS Periods and Cycle Lengths

The DCPP Unit 2 cycle lengths are nominally 20 months, ranging from 19 to 21 months.

Following the first ECT inspections in 2R15, Unit 2 Cycle 16 initiated the first ECT sequential period as defined in TS 5.5.9.d.2. The first sequential period is 144 effective full power months (EFPM). TS 5.5.9 allows SG operation without inspections up to 72 EFPM or three refueling outages, whichever is less.

Per Table 6, 54 EFPM (4.51 effective full power year, EFPY) have occurred since the last ECT inspection in 2R15, three cycles ago. 54 EFPM is much less than 72 EFPM and, therefore, 3 cycles establishes the period between ECT inspections.

A conservative projection for operational run time for the next three cycles between 2R18 and 2R21 is 4.75 EFPY (1.51, 1.70, 1.54 EFPY for cycles 19, 20, and 21, respectively). The next inservice inspection may be conducted after three cycles (at 2R21), based on the satisfactory OA. 2R18 and 2R21 are the only outages in the first 144 EFPM period.

DCPP TS 5.5.9 requires that 100 percent of the tubes be inspected in each sequential period, and to inspect 50 percent of the tubes by the refueling outage nearest the midpoint of the period, and the remaining 50 percent by the refueling outage nearest the end of the period. 2R18 is the refueling outage nearest the

midpoint of the period. Therefore, at least 50 percent of the tubes were required to be inspected in 2R18. However, 100 percent of the tubes were inspected as a conservative measure.

Note: TSTF-510 Revision 2 (NRC Notice of Availability dated October 27, 2011) changes the sequential periods to 144, 120, 96, and 72 EFPM, and deletes the midpoint specification. PG&E has not yet filed for a license amendment to incorporate TSTF-510 Revision 2.

2.0 SG Performance Criteria

Structural Integrity Performance Criteria (SIPC) and Accident Induced Leakage Performance Criterion (AILPC) were developed in accordance with the SGIAGL and DCPP TS 5.5.9.b for SG tube integrity. The probability for satisfying the limit requirements shall be at least 0.95 at 50 percent confidence level (95/50).

2.1 DCPP SIPC Limits

For development of the CM limit, burst pressure relationship and tube material property uncertainties were applied, plus ECT sizing uncertainties, as discussed below. The uncertainties were combined via a Monte Carlo process. The Monte Carlo process involves randomly selecting uncertainties for the applicable parameters to remove excessive conservatism as allowed by the EPRI SGIAGL.

- A burst model is used based on regression analysis of tube failure data, including uncertainty in the prediction of burst pressure, for a given extent of degradation. A burst model of axial-oriented thinning (as a function of length) with limited circumferential extent (less than 135 degrees) is used because the design of the antivibration bar (AVB) and tube support plate (TSP) limits the width of the area of contact between the tube and support to less than 135 degrees. Three times normal operating pressure differential (3dPNO) loading of 4335 pounds per square inch differential was applied, based on the nominal SG exit pressure of 805 pounds per square inch absolute (psia) and reactor coolant system pressure of 2250 psia.

- Tube material strength information is used, including uncertainty in mechanical strength behavior due to material heat variability. Actual DCPP SG tubing material properties measured at the tubing mill are applied (yield and ultimate strengths) to develop a material property distribution. Adjustments to operating temperature properties at 650 degree F were made using ASME code factors.

- Depth measurement uncertainty of the ECT sizing technique, including sizing uncertainty due to the technique and analyst variability. For AVB wear, bobbin coil and +Point coil ECT depth sizing technique uncertainties are taken from EPRI examination technique specification sheet (ETSS) 96004.1

and EPRI ETSS 10908.4, respectively. For TSP wear, +Point NDE depth sizing technique uncertainties are taken from EPRI ETSS 96910.1. The ETSS defines the slope, intercept, and standard deviation of the regression between the relationship of the actual flaw depth and the ECT depth. No uncertainties are applied to the ECT length sizing because tube integrity evaluations apply bounding length values, not ECT length measurements. Analyst variability is conservatively assumed to be 50 percent of the technique uncertainty.

The following 95/50 CM limits for AVB wear and TSP wear were calculated based on the inputs defined above, and are also shown in Table 4.

AVB Wear:

- The CM limits for AVB wear are 53.5 percent through-wall (TW) and 50.6 percent TW for rows 39-96 and rows 8-38, respectively, applying bobbin ETSS 96004.1.
- The CM limits for AVB wear are 52.4 percent TW and 49.9 percent TW for rows 39-96 and rows 8-38, respectively, applying +Point ETSS 10908.4.

TSP Wear:

- The CM limit for TSP wear is 44.6 percent TW, applying +Point ETSS 96910.1.

2.2 DCPP AILPC Limits

The accident-induced leak rate for indications in an individual SG, combined with operational primary-to-secondary leakage in an individual SG, cannot exceed 0.05 gallons per minute (gpm) (room temperature condition) at main steam line break differential pressure.

The total accident-induced leak rate from indications in all SGs, combined with operational primary-to-secondary leakage in all SGs, cannot exceed 0.2 gpm (room temperature condition) at main steam line break differential pressure.

3.0 2R18 Inspections

The 2R18 Degradation Assessment (DA) evaluated the condition of the SGs in advance of the 2R18 SG inspections. Per TS 5.5.9, "an assessment of degradation shall be performed to determine the type and location of flaws to which the tubes may be susceptible and, based on this assessment, to determine which inspection methods need to be employed and at what locations." The DA 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.

In 2R18, the following inspections and maintenance were performed on the DCPP SGs:

- A full-length (tube end to tube end) bobbin coil probe inspection was performed on 100 percent of the in-service tubes in each SG.
- +Point rotating probe inspection was performed on:
  - 100 percent of bobbin "I" codes, which included absolute drift indication (ADI),distorted support indication (DSI), and non-quantifiable indication (NQI).
  - 100 percent of bobbin possible loose part (PLP) codes, including bounding tubes.
  - 100 percent of 2R15 and 2R18 bobbin ding (DNG) and dent (DNT) indications greater than or equal to 1.0 volt that were not examined with +Point in 2R15.
  - 100 percent of tube U-bend regions with proximity (PRO) indications
  - 100 percent of tube U-bend regions that were impacted during manufacturing
- Visual inspections were performed on all six tube plugs in the SGs, which are welded plugs that were installed in three tubes in SG 2-4 in the factory prior to SG replacement.
- Pre-lancing visual inspection of the top-of-tubesheet (TTS) to determine the as-found condition.
- Sludge lancing of the TTS
- Post-lancing Foreign Object Search and Retrieval (FOSAR) visual inspections to determine effect of lancing, and retrieval of foreign objects.
- Visual inspection of each SG channel head in accordance of Westinghouse Nuclear Safety Advisory letter (NSAL 12-1) recommendations.
  - Areas of inspection included the channel head cladding, and divider plate to channel head weld.
- No inspections were performed on the upper SG internals during 2R18.

The only tube degradation that was detected was wear at TSP intersections in SGs 22, 23, and 24. The largest wear flaw detected was 12 percent TW.

Table 2 provides the number of 2R18 bobbin indications, and the number of +Point inspections conducted as part of special interest examinations. Table 5 provides the relevant data analysis codes and their definitions.

4.0 Condition Monitoring

A CM evaluation of the SG tube bundles is performed to verify that the condition of the tubes, as reflected in the inspection results, is in compliance with the structural and leakage integrity requirements.

During 2R18, tube degradation was detected at TSPs in SGs 22, 23, and 24. Twenty two tubes were reported with a bobbin DSI. A special TSP wear standard was then used to acquire +Point inspection data of these 22 DSI indications. The +Point inspection confirmed 15 of the 22 DSI indications as wear (WAR). Table 3 provides a list of the wear indications, and associated sizing information. Of the 15 wear indications, one was a repeat indication from 2R15, and 14 were new. All tube wear indications were left in service because the TW depths are less than the 40 percent TW plugging criteria defined in TS 5.5.9.c, and because SG tube integrity will be maintained until the next planned SG inspection in 2R21 (3 cycles) based on performance of an OA.

Detection of wear at TSP structures using the bobbin probe is qualified in accordance with ETSS 96004.1. Detection and depth sizing of wear at TSP structures using the +Point probe is qualified in accordance with EPRI ETSS 96910.1.

4.1 Evaluation of SIPC Using the Flaw Handbook CM Limits

+Point line by line sizing of each indication was performed to assess the maximum depth and total NDE length. The line by line information was then input to the EPRI Flaw Handbook calculator to determine structural length and structural depth (average depth) for assessment against the CM limit.

The indications were very shallow, with maximum depths ranging from 3 percent TW to 12 percent TW. The total length of all the indications, with the exception of SG 24 R4C68, did not extend the full width of the TSP.

The most structurally significant wear indication is SG 24 R4C68 6C. There are two indications at this location, located on two separate TSP contact lands of the tre-foil broach. Indication number 1 has a maximum depth of 12 percent TW with a length of 1.22 inch. The length spans the full width of the 1.125 inch TSP, and is slightly longer than the TSP width due to the look ahead of the +Point probe. The wear depth is fairly constant over the TSP length. The structural length and depth that contributes to burst is 0.8 inch and 10.4 percent TW. Indication number 2 is very shallow (3 percent TW maximum depth) and does not reduce the burst strength of the tubing because the indications are at different TSP lands are thus are not interacting.

There is one repeat wear indication in SG 24 R49C15 5C. The indication was 5 percent TW in 2R15, and is 6 percent TW in 2R18, showing little change. The total length increased from 0.17 inch to 0.66 inch, showing some growth in length.

Tubes with 2R18 +Point confirmed TSP wear indications were looked up in 2R15 inspection data to determine if the indication existed at that time or has

developed since that time. 7 of the 14 new indications were traced to 2R15 bobbin data, as shown on Table 3.

The 95/50 CM limit for a 1.125 inch long TSP wear scar is 44.6 percent TW. For a quick screening, the TSP maximum wear depth (12 percent TW) is well below the CM limit (44.6 percent TW), thereby demonstrating significant margin to the SIPC. Using the profiling information, the structural length and depth of this bounding indication is 0.8 inch and 10.4 percent TW, demonstrating even more margin the SIPC. All wear indications are plotted on Figure 3 showing their structural length and depth, and margin to the CM limit.

For volumetric degradation such as tube wear, a defect that satisfies the SIPC will also satisfy the AILPC. For pressure loading of volumetric degradation that is predominantly axial in character with a circumferential extent that is less than 135 degrees (which is the case for TSP wear), the onset of pop-through and burst is coincident. Therefore, since the TSP wear passes SIPC at 3NOdP differential pressure, leakage integrity at a lower differential pressure during a main steam line break is also demonstrated. Therefore, CM is satisfied for both structural and leakage integrity.

4.2 Evaluation of AILPC

There was no operational leakage in the prior cycles (Cycle 16, 17 and 18), and none is postulated in the upcoming cycles. Six tube plugs that were previously installed in the DCPP SGs (all in SG 2-4) were visually inspected at 2R18 and showed no signs of leakage. Therefore, there is no operational leakage or plug leakage component needed in the DCPP AILPC for condition monitoring.

4.3 Screening for In Situ Leak and Proof Testing

The EPRI In Situ Pressure Test Guidelines, Revision 4, provides NDE screening value thresholds for leak and proof testing. When CM cannot be satisfied by calculation methods, In Situ testing can be performed to demonstrate satisfaction of CM. Since CM has been satisfied by calculation methods, application of the EPRI In Situ Pressure Test Guidelines is not needed.

4.4 Channel Head Inspection Results

Visual exams of each channel head were conducted and recorded in support of Westinghouse Nuclear Safety Advisory Letter NSAL-12-1 recommendations to perform a channel head bowl scan in a dry condition (during plant shutdown) of the low lying areas (e.g., areas where a pool of primary water with concentrated boric acid could remain in the drained SGs) of both the hot and cold legs of the inside surface of the channel head. Areas of the inspection included the channel head cladding and the divider plate-to-channel head weld. (Note: There is no

drain tube in the channel head in these replacement SGs.) No areas of defects or unusual discolorations were noted.

5.0 Assessment of Relevant Non-Degradation Indications

This section discusses assessments performed of inspection results of non-degradation indications that are of relevance.

5.1 Proximity Indications

During the preservice inspection (PSI) of the DCPP Unit 2 replacement SGs, 12 tubes with tube proximity signals were reported during the bobbin coil inspection. +Point examination was conducted in the PSI on the two largest signals. These signals in the U-bend were attributed to the proximity of a given tube to another tube. Signals were reported in pairs of adjacent tubes in the same column at nearly the same axial location along the tube and are several inches in length. The locations were in the U-bend region of the tube bundle. This confirms that the signal pairs were related to each other in that each tube contributed to the signal in the other.

During 2R15, these 12 tubes were examined with bobbin coil and the proximity signals (PRO) were again identified. Single coil +Point inspections were conducted on these 12 PRO locations and no degradation was detected.

As discussed in PG&E response to NRC RAI in PG&E letter DCL-10-149, dated November 24, 2010, the logical cause of the proximity indications is a reduced tube-to-tube gap condition. A proximity signal can be generated on the bobbin coil if two tubes experience such a condition. A potential cause of a reduced tube-to-tube gap condition is manufacturing tolerances on a tube-to-tube basis, such as tolerances on U-bend profile and tube overall height. A tolerance stack-up indicates that a reduced gap may occur but tube-to-tube contact is not possible. Manufacturing tolerances on the U-bend profile are slightly larger in higher radius U-bend tubes.

During 2R18, the existing PRO indications in 12 tubes were examined with bobbin coil and the PRO signals were again identified. In addition, four new PRO indications were reported by bobbin that had not been reported in 2R15. These are all in SG 23. Three locations were traced to 2R15 bobbin data and PSI data. One location was not traceable to 2R15.

Single coil +Point inspections were conducted on these 16 PRO locations in 2R18 and no degradation was detected. Because no degradation was detected by +Point probe, and since there is no active degradation mechanism in tubes that have the proximity condition based on the above assessment, condition monitoring is inherently met.

5.2 Factory Impacted Tubes

During SG fabrication at the factory, AVB retainer bars in SG 2-4 were removed and relocated. During the removal process, 12 tubes in SG 2-4 were visibly damaged in the periphery of the U-bend by a grinding tool. In order to assess the condition of the tubes resulting from the event, eddy current inspection (both bobbin and +Point) of the 12 tubes was performed at the factory, prior to the PSI inspection. Of these, 3 tubes were repaired by plugging at the factory, thus leaving 9 tubes inservice that had no indication of degradation. 8 tubes had ding signals and one tube had no detectable degradation (NDD) by ECT.

In 2R15 and again in 2R18, these 9 inservice tubes were inspected by both bobbin and single coil +Point in the region of interest. Because no degradation was detected by +Point probe, CM was successfully met for these tubes.

6.0 Assessment of SG Secondary Side Integrity

The EPRI SGIAGL, Revision 3, contains the following requirements with respect to secondary side integrity:

- CM shall include aspects of the secondary side inspection that affect tube integrity such as secondary side inspections performed, foreign material removed, and foreign material remaining in the SGs.

- OAs shall include a justification for operating the planned interval between secondary side inspections as well as primary side inspections.

The following describes the 2R18 SG top of tubesheet secondary side cleaning, top of tubesheet visual inspections including FOSAR, and results achieved. The handhole covers (4) on each SG were removed to facilitate this maintenance. The secondary manways were not removed and no upper internals inspections were conducted.

6.1 Pre-Lance Visual Inspection

In all SGs, a pre sludge lance visual inspection was performed to determine the as-found conditions at the TTS. There was an inch of water at the TTS. An in-bundle inspection tool with a 5 mm video probe was inserted into the no tube lane and in-bundle inspections were conducted in the center 10 columns of the hot leg and cold leg TTS region (where sludge pile can exist and tube collars can originate), and columns 20, 40, 80, and 100 in both legs. A 5 mm video probe was also inserted into the peripheral trough region to look for foreign material in the trough.

With regard to the as-found conditions, all SGs had buildup of accumulated debris piles approximately one inch high that were blocking several tube columns

in the hot leg sludge pile region. The debris consisted of sludge mixed with moisture separator reheater (MSR) gasket graphite material and minor loose particulate. The debris piles were located in each SG in nearly the same tubesheet locations, bounded by about columns 63 to 68 and rows 35 to 39. The in-bundle probe was able to go over the debris piles to the periphery. The areas of these debris piles were communicated to the sludge lance crew for a focused lancing. Only minor, scattered debris such as MSR gasket graphite (some floating) was observed in the cold legs of the SGs. No retrievals were attempted.

6.2 Sludge Lancing

Sludge lancing was performed in each SG, in the order of SG 2-1, 2-2, 2-3, and 2-4. The weight in pounds of sludge removed was 4, 3, 3, and 3, respectively, for a total of 13 pounds. This amount is slightly greater than the amounts removed in the previous sludge lancing in 2R15 (12 pounds) and 2R16 (9 pounds).

6.3 FOSAR Exam

After sludge lancing in each SG, a FOSAR exam was performed. The inspection consisted of the following elements:

- Insertion of an in-bundle guide tube inspection system through the no tubelane handholes. A 5 mm video probe was inserted into a guide tube to perform in-bundle inspections. The in-bundle inspection scope was the same as the pre-lance scope: center 10 columns of the hot leg and cold leg TTS region, and columns 20, 40, 60, 80, and 100 in both legs.

- Insertion of a wheeled cart with integrated camera through a handhole and into the trough, inspecting 100 percent of the trough region and 100 percent of the outer periphery tubes. The camera is capable of inspecting several rows into the peripheral tube region.

The examination determined that the debris piles observed in the pre-lance inspections were removed, such that the columns were no longer blocked. However, a small hardened deposit was visually observed on the tubes and tubesheet, which can be attributed to tube collaring residual which remained after the softer debris piles were removed by lancing. Subsequent eddy current examinations noted SLG (sludge) signals in the same areas, confirming that these deposits were adhered to the tubing. SG 2-1, 2-2, and 2-3 had 3, 1, and 3 SLG indications reported by bobbin, respectively, all located within 1 inch from the hot leg top of tubesheet. In addition, SG 2-3 had a PLP signal detected in the hot leg sludge pile at R35C65. The PLP indication was likely a sludge deposit. Nonetheless, this location was conservatively inspected by +Point, along with 10 bounding tube locations (6 of which were in the sludge pile region), and no tube

degradation nor loose parts were detected, validating the results of the post lance visual examination.

Three minor foreign objects in SG 2-1 and SG 2-3 were retrieved from in-bundle inspections, and were determined to be pieces of graphite from the MSR gasket, which is discussed in more detail in Section 6.4. Other identical minor graphite material was observed in-bundle in SG 2-1 and SG 2-4 and was not retrieved per DCPP Engineering approval because the graphite has no impact to tube integrity because the mass and dimension is bounded by larger foreign material previously assessed by Westinghouse for weld drop-through that was identified in the preservice inspection of the SGs.

6.4 Loose Parts in Sludge Lance Filter Strainer

Loose parts that were collected in the sludge lance filter strainer were assessed. The strainer contents were emptied after completion of each SG lancing operation.

Each strainer contents had minor debris including MSR gasket backing material (graphite), along with some small pieces of perforated MSR gasket metal (stainless steel), and a small number of machining remnants/curls and weld slag. All foreign material was of small dimension and insignificant mass. It is not uncommon for portions of MSR partition plate gaskets to get blown out due to the high flow velocities in the MSR channel head. The perforated gasket metal is capable of being broken into smaller pieces and then entering the FW heater tubing and being transported into the SG feedring, where the material can exit if smaller than the 0.27 inch diameter SG feedring nozzle holes.

None of the foreign material was greater than 0.27 inch diameter, and thus the origin of the material is from components upstream of the SG. The 0.27 inch diameter feedring nozzle holes act as a barrier by preventing large material from entering the SG tube bundle.

The sludge lancing that was performed in advance of the eddy current inspections and which removed foreign material at the top of tubesheet streamlined the eddy current review of potential loose parts. With the exception of the PLP indication (likely a sludge deposit signal) that was reported in the SG 2-3 sludge pile (after lancing was completed) and which was inspected with +Point inspection to confirm no tube degradation, there were no loose parts detected by bobbin probe inspection (low frequency) of 100 percent of the tubes. Designated analysts also 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.

No tube degradation by loose parts was detected in 2R18 (as well as 2R15) based on 100 percent bobbin coil exam, which supports the conclusions that the

loose parts observed are small and not capable of causing tube wear. The standard bobbin exam was augmented by a bobbin "turbo-mix" (three frequency) evaluation at the top of tubesheet in order to detect potential tube degradation that could be missed by the normal analysis process.

6.5 Conclusions of SG Secondary Side Integrity Assessment

In conclusion, CM for secondary side integrity was satisfied because no loose part wear was detected by eddy current inspections in 2R18, and the loose parts removed from the SGs had insignificant mass. All foreign material observed at the top of tubesheet and in the sludge lance filters is of small mass and dimension, which is bounded by larger foreign material previously assessed by Westinghouse for weld drop-through that was identified in the PSI of the SGs.

7.0 Conclusions

SG tube ECT, tubesheet cleaning and inspections, and channel head visual inspections were conducted in 2R18. The CM assessment concludes that, based on the results of the 2R18 inspections, none of the SG performance criteria were exceeded since the last SG inspection in 2R15, that is, the three cycle operating period between the start of Unit 2 Cycle 16 and the end of Unit 2 Cycle 18. The OA, not included in this report, concludes that there is reasonable assurance that operation of the DCPP Unit 2 SGs until the next scheduled ECT inspection in 2R21 (three operating cycles) will not cause any of the SG performance criteria to be exceeded.

Table 1
Pertinent DCPP SG Design Features

SG Designer	Westinghouse
SG Model Number	Westinghouse Delta 54 (W-D54)
SG Fabricator	ENSA
SG Tube Manufacturer	Sandvik
Tube Material	Alloy I-690 Thermally Treated
Number of Tubes per SG	4444
Tube Outside Diameter (in)	0.75
Tube Nominal Wall Thickness (in)	0.043
Tube Pattern	Triangular / 96 Rows, 119 Columns
Tube Pitch	1.144 / Triangular
Number of Tube Support Plates (TSPs)	8
TSP Material	Type 405 SS
TSP Thickness (in)	1.125
TSP Design	Trefoil broached holes
TSP Flow Design Characteristics	In the no tube lane, TSPs 1 through 7 have flow slots and TSP 8 has flow holes.
U-bend Support Design	"V" Shaped Anti-Vibration Bars (AVBs)
Number of AVBs	3 sets
Tube Rows Supported by AVBs	Rows 8 through 96 (one AVB set) Rows 22 through 96 (two AVB sets) Rows 43 through 96 (three AVB sets)
AVB Material	Type 405 SS
Tubesheet Thickness (in)	23.55 (includes 0.30 inch cladding)
Tube Expansion Process	Full depth hydraulically expanded. Tube end tack expanded using urethane plug expansion process. Tube ends are sealed with a flush autogenous weld which is analyzed for pressure boundary in accordance with ASME Code Section III NB-3000 stress analysis.
U-bend minimum radius (in)	3.25 (Row 1)
Stress Relieved Tubes	Rows 1 through 16 were full-length stress relieved following bending.

Table 2
2R18 Bobbin Indications and +Point Inspections

	SG21	SG22	SG23	SG24	TOTAL	Total Inspected by +Point	
ADI	0	0	1	3	4	4	
ADS	35	16	16	13	80	0	
BLG	2	8	1	1	12	0	
DNG	84	30	7	61	182	54	Note 1
DNH	101	30	9	58	198	0	
DNI	0	0	0	0	0	0	
DNT	13	5	1	5	24	21	Note 1
DSI	1	4	6	11	22	22	
MBM	3	0	7	5	15	0	
NQI	1	1	1	0	3	3	
NQS	4	1	0	1	6	0	
PDS	42	74	15	9	140	0	
PRO	2	4	6	4	16	16	
PLP	0	0	1	0	1	11	Note 2
TOTAL	288	173	71	171	703	131	Note 3

General: Eddy current data analysis codes are defined in Table 5.

Note 1: Dents and dings >=1 volt without prior +Point inspection were inspected by +Point.
Note 2: The PLP plus 10 additional bounding tubes were inspected by +Point, for a total of 11 inspections.
Note 3: In addition to the 131 +Point inspections, 9 tubes were inspected by +Point for factory damaged tubes (no bobbin code).

Table 3
Summary of DCPP Unit 2 Tube Wear from 2R18

Outage	SG	Row	Col	Elev	Bobbin Call	Bobbin volts	PP Ind	Flaw	PP volts from depth sizing	%TW	Length inch	Structural Length inch	Structural Depth %TW	2R15 Lookup %TW
2R18	22	2	116	7C	DSI	0.2	WAR	1	0.3	9	0.53	0.32	7.3	NDD
2R18	22	9	3	5C	DSI	0.18	WAR	1	0.21	6	0.43	0.22	5.1	5
2R18	23	61	15	6H	DSI	0.16	WAR	1	0.18	5	0.36	0.27	4.6	6
2R18	23	86	86	6H	DSI	0.16	WAR	1	0.22	7	0.36	0.24	5.4	2
2R18	23	88	36	7H	DSI	0.16	WAR	1	0.28	8	0.45	0.3	7	NDD
2R18	24	1	7	6C	DSI	0.12	WAR	1	0.27	7	0.62	0.35	5.5	NDD
2R18	24	1	9	6C	DSI	0.16	WAR	1	0.26	7	0.62	0.4	5.4	NDD
2R18	24	1	11	6C	DSI	0.17	WAR	1	0.35	9	0.75	0.32	7.6	NDD
2R18	24	4	68	6C	DSI	0.26	WAR	1	0.47	12	1.22	0.8	10.4	3
							WAR	2	0.11	3	1.15	1.09	2.1	
2R18	24	10	2	5C	DSI	0.29	WAR	1	0.39	10	0.48	0.27	8.5	4
2R18	24	55	15	5C	DSI	0.18	WAR	1	0.21	6	0.3	0.18	4.2	5
2R18	24	77	25	5C	DSI	0.15	WAR	1	0.28	8	0.39	0.18	5.8	NDD
2R18	24	84	88	6H	DSI	0.19	WAR	1	0.3	10	0.59	0.29	8.2	NDD
2R18	24	85	47	5C	DSI	0.16	WAR	1	0.23	6	0.87	0.24	5.3	NDD
2R18	24	49	15	5C	DSI	0.1	WAR	1	0.23	6	0.66	0.21	5.3	5

Notes: 2R15 lookup depths are from bobbin, except for SG 24 R49C15 which is a repeat indication from 2R15.

Table 4
CM Limits for DCPP Unit 2 SGs as Applied in 2R18
Axially Oriented Thinning with Limited Circumferential Extent

		CM Limit		
Flaw Length	Applicability	ETSS 96004.1 (Bobbin)	ETSS 96910.1 (+Point)	ETSS 10908.4 (+Point)
0.8"	AVB Rows 39 Thru 96	53.5%TW	N/A	52.4% TW
1.125"	Tube Support Plates	not applied	44.6%TW	N/A
1.5"	AVB Rows 8 Thru 38	50.6%TW	N/A	49.9% TW

Notes:

- For 2R18 depth sizing of TSP wear, +Point (96910.1) was applied and bobbin (96004.1) was not applied.
- Regarding depth sizing of AVB wear, bobbin can be applied for single sided wear, and +Point can be applied for double sided wear.
- CM Limit reflects material strength, burst relation, and NDE sizing uncertainties

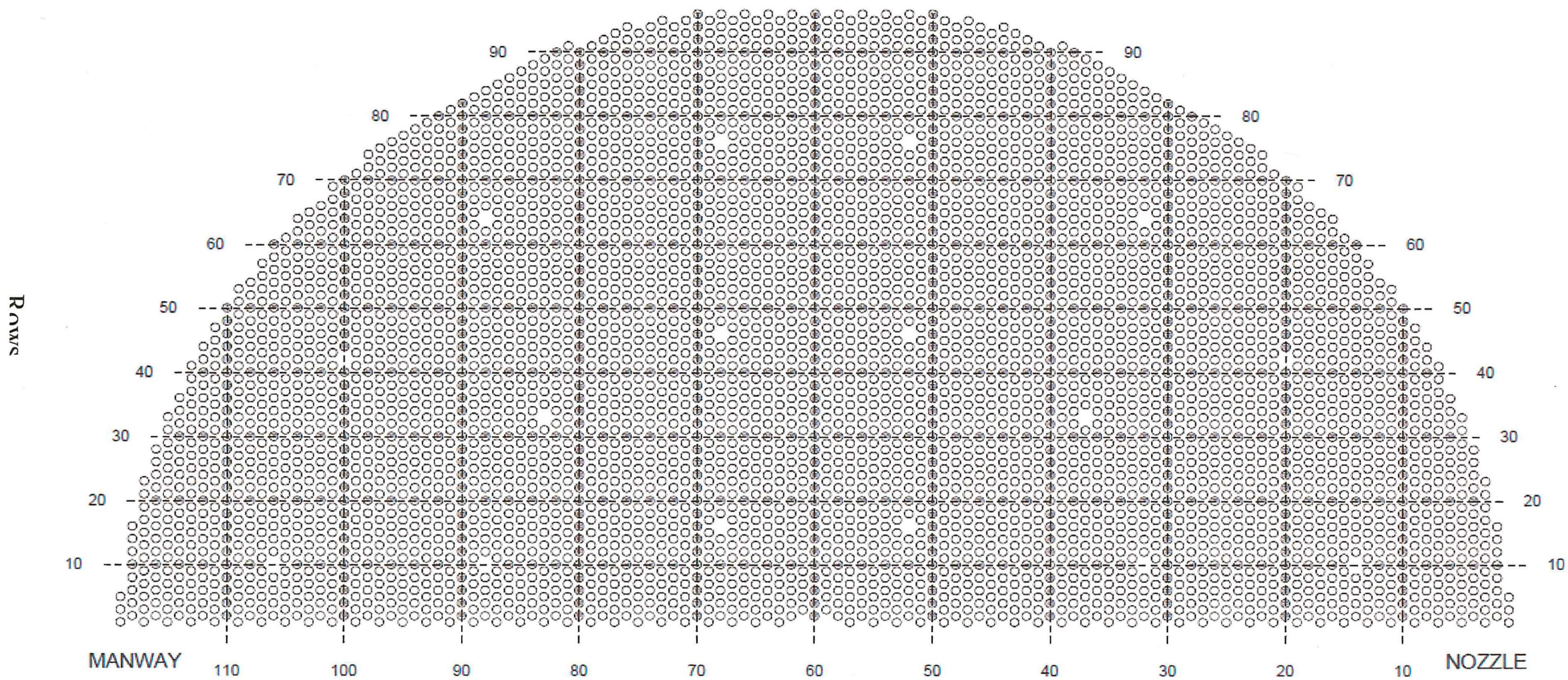
Table 5
Relevant Eddy Current Data Analysis Codes

%TW	Percent Thru-wall
ADS	ADI unchanged from history and NDF on previous +Point data.
ADI	Absolute Drift Indication
BLG	Bulge
DNH	DNI unchanged from history
DNI	Dent/ding with Indication
DNT	Dent at structure
DNG	Ding in freespan
DSI	Distorted Support Indication
DSS	DSI Unchanged from history and NDF on previous +Point data.
DTI	Distorted Tubesheet Indication
INF	Indication Not Found
INR	Indication Not Reportable
MBI	MBM changed from baseline
MBM	Manufacturing Buff Mark
NDF	No Degradation Found
NDD	No Detectable Degradation
NQS	NQI unchanged from history and NDF on previous +Point data.
NQI	Non-Quantifiable Indication
PDS	Pilgered Drift Signal
PLP	Possible Loose Part
PRO	Proximity
PUD	Previously Unreported DNT/DNG
PVN	Permeability Variation
SLG	Sludge
WAR	Confirmed Wear at TSP by +Point

Table 6
SG Inservice Inspection
First ECT Inspection Period
Examinations Completed and Scheduled

Year	2009	2011	2013	2014	2016	2018	2019	2021
Outage	2R15	2R16	2R17	2R18	2R19	2R20	2R21	2R22
Nominal Cycle Length		19	21	20	19	21	20	19
SG EFPY	1.35	1.43	1.61	1.47	1.49	1.64	1.54	1.49
SG EFPM per cycle	16.2	17.2	19.4	17.7	17.9	19.7	18.5	17.9
SG EFPM cumulative	16	33	53	70	88	108	127	144
Tech Spec ECT Periods EFPM		144						
SG EFPM cumulative for ECT inspection period		17	37	54	72	92	110	128
SG EFPM between ECT inspections				54			56	
ECT	Yes			Yes			Sch	
% Bobbin	100			100				

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



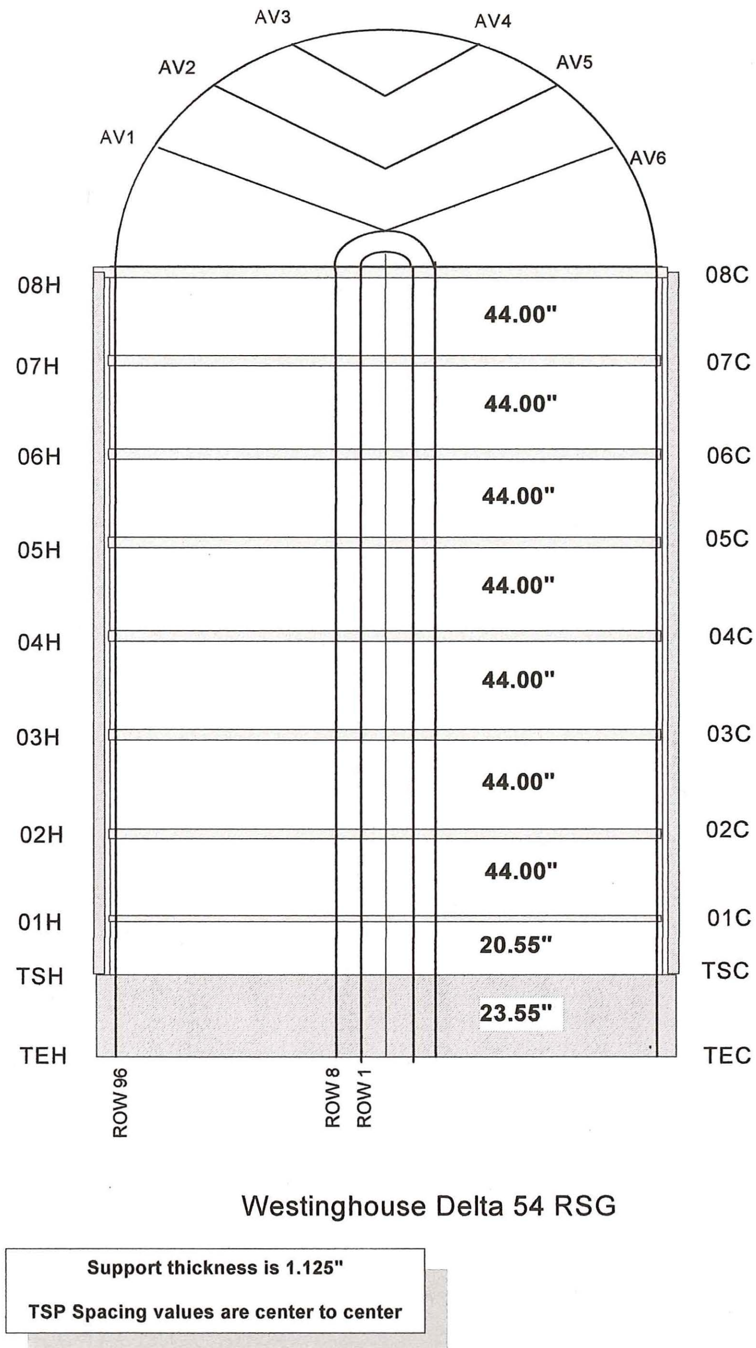


Figure 2
Sketch of DCPP Unit 1 and 2 Westinghouse Delta 54 Steam Generator

Figure 3
Comparison of 2R18 TSP Wear Indications to the CM Limit