Pacific Gas and Electric Company®

Paula Gerfen
Site Vice President

Diablo Canyon Power Plant
Mail code 104/6/605
P.O. Box 56
Avila Beach, CA 93424

805.545.4596
Internal: 691.4596
Fax: 805.545.4234

April 15, 2021

PG&E Letter DCL-21-034

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

10 CFR 50.54(f)

Docket No. 50-275, OL-DPR-80
Docket No. 50-323, OL-DPR-82
Diablo Canyon Units 1 and 2
Response to Request for Additional Information on Final Supplemental Response to Generic Letter 2004-02

Reference:
1. PG&E Letter DCL-20-031, "Final Supplemental Response to Generic Letter 2004-02," dated April 30, 2020 [ML20121A095]
2. NRC email, "Request for additional information for Diablo Canyon Generic Letter 2004-02 Submittal (L-2017-LRC-0000)," dated March 2, 2021

Dear Commissioners and Staff:

In Reference 1, Pacific Gas and Electric Company (PG&E) submitted the final supplemental response for Diablo Canyon Units 1 and 2 to Generic Letter 2004-02, dated September 13, 2004, "Potential Impact of Debris Blockage on Emergency Recirculation Design Basis Accidents at Pressurized-Water Reactors". In Reference 2, the NRC Staff provided a request for additional information (RAI) via an e-mail, dated March 2, 2021. The Enclosure to this letter provides PG&E responses to the RAI.

This letter does not include any new or revised regulatory commitment (as defined by NEI 99-04).

If you have any questions or require additional information, please contact Mr. James Morris, Regulatory Services Manager, at (805) 545-4609.

I state under penalty of perjury that the foregoing is true and correct.

Executed on April 15, 2021.

Sincerely,

Paula Gerfen
Site Vice President

kjse/51105667
Enclosure
cc: Diablo Distribution
cc/enc: Donald R. Krause, NRC Senior Resident Inspector
Samson S. Lee, NRR Senior Project Manager
Scott A. Morris, NRC Region IV Administrator
Gonzalo L. Perez, Branch Chief, California Department of Public Health

Response to Request for Additional Information on Final Supplemental Response to Generic Letter 2004-02

NRC Question 1

By letter dated April 30, 2020 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML20121A095), Pacific Gas and Electric Company (PG&E or the licensee) submitted a final response to close Generic Letter (GL) 2004-02, dated September 13, 2004 (ADAMS Accession No. ML042360586), "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," for the Diablo Canyon Power Plant, Units 1 and 2. 10 CFR 50.46 requires that plants are able to maintain adequate long-term core cooling (LTCC) to ensure that the fuel in the core can be cooled and maintained in a safe and stable configuration following a postulated accident. GL 2004-02 requested that licensees provide information confirming that their plants are in compliance with the regulation. During its review of the licensee's submittal, the NRC staff identified that it required additional information to confirm the licensee's evaluation.

Please provide the following information:

Table 3.b.1-1 of the April 30, 2020 submittal states that WCAP-17561 was used to determine the zone of influence (ZOI) for Temp-Mat. The ZOI credited is 3.7D. The NRC staff reviewed WCAP-17561 and found that the methods and results in the WCAP were generally acceptable. However, the NRC staff determined that some of the test geometries for the Temp-Mat tests may not have been representative or conservative with respect to those installed in plants. The text in Section 3.b.1 states that the amount of debris included in the testing exceeded the debris quantity that would result if a ZOI of 11.7D (NRC generically approved ZOI for Temp-Mat) were applied. As used in the current debris generation and head loss analysis, this is a conservative assumption and is acceptable. This issue regarding the test geometry for the WCAP-17561 testing is not relevant to Diablo Canyon's current submittal but could be relevant to future modifications or operability determinations. If future actions assume the reduced ZOI based on WCAP-17561, and the use of this ZOI is not appropriate for the plant specific geometry, the amount of fibrous debris generated could exceed that included in the plant specific testing. Please justify that the WCAP-17561 ZOI is representative of the plant geometry or explain how the potential discrepancy will be managed.

PG&E Response

As noted in the question, applicability of the test geometry for the WCAP-17561 testing to the current Diablo Canyon Power Plant (DCPP) configuration is not in question. To ensure that WCAP-17561 will continue to be representative to potential future design configurations at DCPP, two scenarios are considered: insulation changes due to planned modifications and unexpected discovery of new debris sources that have not been included in previous analyses. The potential for each of these scenarios to impact the applicability of WCAP-17561 to DCPP is discussed below.

Insulation changes due to planned modifications are evaluated according to the DCPP design change procedure. This procedure discourages the use of fibrous thermal insulation inside containment and requires the review of the debris generation and transport calculations by design engineering personnel if the use of fibrous insulation is desired. Additionally, DCPP controls the fabrication and installation requirements for encapsulated Temp-Mat insulation that complies with the WCAP-17561-P tested configuration. This includes the encapsulation foil material, thickness, stitching composition, seam orientation, and seam coverage.

Discovery of new Temp-Mat debris sources in quantities significant enough to challenge existing margins is considered unlikely given the insulation reduction and controls implemented over the past years, as described in Section 2 in PG&E's Letter DCL-20-031 providing the final response to close GL 2004-02 [ML20121A095]. Any future discovery of new Temp-Mat debris would constitute a non-conforming condition which is within the scope of the DCPP operability determination procedure. It is expected that, for an operability determination, any newly-discovered Temp-Mat condition would follow the procedural guidance and be initially evaluated by assuming that its full quantity would count against the existing containment debris margins. Should a more detailed analysis be required, the existing containment debris margin calculation provides a roadmap back to the debris generation calculation, where the 3.7D ZOI is referred to the WCAP-17561-P testing configuration (Temp-Mat encapsulated in stainless steel) and results. The calculation also states that non-encapsulated Temp-Mat has a ZOI of 11.7D per the NRC safety evaluation of NEI 04-07, Volume 2, Revision 0, “Pressurized Water Reactor Sump Performance Evaluation Methodology – Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Generic Letter 2004-02” [ML050550156].

NRC Question 2

Provide an overview of the analysis method for the Temp-Mat ZOI “length” for the hot and cold-leg nozzle breaks. Also, describe how the break geometries and sizes were determined and how these geometries relate to the assigned ZOI volumes.

PG&E Response

Due to the presence of pipe whip restraints, the maximum allowable axial and radial separations are less than the pipe wall thicknesses for both the hot and cold legs. The analysis of Temp-Mat ZOI for the reactor nozzle breaks used the American National Standards Institute/American Nuclear Society (ANSI/ANS) standard

ANSI/ANS-58.2-1988 laterally restrained double-ended guillotine break (DEGB) jet model. This approach is reasonable because the shape of the jet resulting from this configuration will not be significantly affected by the slight radial offset. The flow from one end of the ruptured pipe will not escape in the axial direction past the outside surface of the opposite pipe, and the jet will continue to form radially. The jet configuration is illustrated in Figure 2-1.

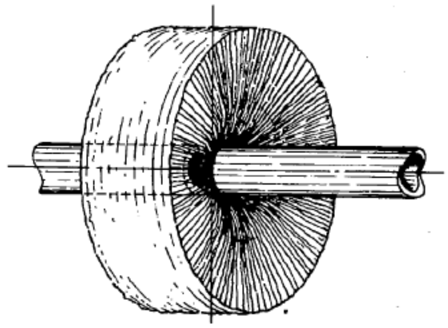

Figure 2-1: Illustration of a laterally restrained DEGB jet

The Temp-Mat ZOI length was determined according to the ANSI 58.2-1988 standard, as well as Appendix I in the NRC safety evaluation of NEI 04-07, Volume 2, Revision 0, where appropriate since the NRC safety evaluation focused on the evaluation of a fully separated break.

The first step of the analysis is to determine the mass flux from the break, which depends on the temperature and pressure conditions upstream of the break. As recommended in the NRC safety evaluation for subcooled conditions, the Henry-Fauske model was used for the hot and cold leg nozzle breaks. The initial condition necessary for the calculation of mass flux requires the determination of thermodynamic parameters for different regions within the break jet. ANSI 58.2-1988 defines three jet regions that characterize an expanding jet. Figure 2-2 illustrates the break jet regions for a partially separated circumferential break. Region 1 is the jet core which is characterized by the upstream stagnation pressure and temperature, and the length of the core defines the boundary between Region 1 and Region 2. Region 2 occurs between the jet core and the asymptotic plane. It was assumed that the jet can only interact with the environment after crossing the asymptotic plane to maintain the maximum jet force. Region 3 occurs after the asymptotic plane and is the low pressure region of the jet.

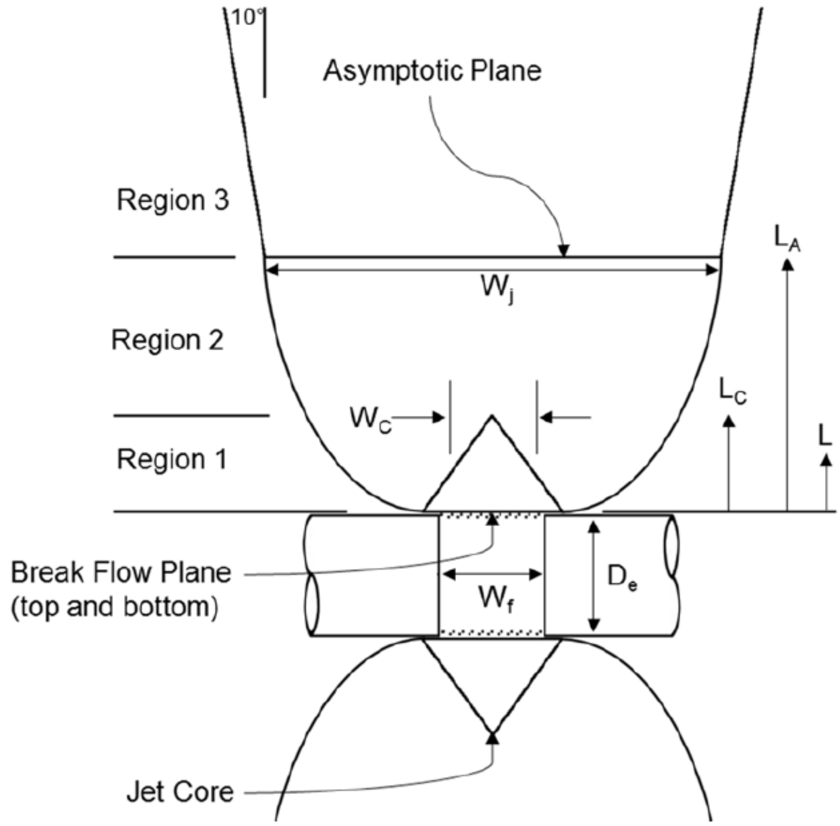

Figure 2-2: Partially separated circumferential break

The next step in the analysis is to evaluate the lengths and diameters of the jet at different intervals using Appendix D of standard ANSI 58.2-1988, which determines the jet pressure as a function of radius from the centerline of the pipe and the distance from the break plane. This allows for calculation of the pressure isobars for contour mapping of a jet emission from the pipe break including pressure of the core and localized pressure inside the expanding jet. The conversion of the jet pressure to isobars was performed using the methodology in Appendix I of the NRC safety evaluation of NEI 04-07, Volume 2, Revision 0. The pressure isobars for the hot leg break are illustrated in Figure 2-3. The ZOI for the reactor nozzle breaks with restricted separation results from the revolution of the isobars around the circumference of the pipe, which resembles the ZOI shape shown in Figure 2-1.

The final step of the analysis is to determine the points at which the isobar corresponding to the destruction pressure of Temp-Mat insulation (10.2 pounds per square inch gage) crosses the centerline of the jet pressure volume.

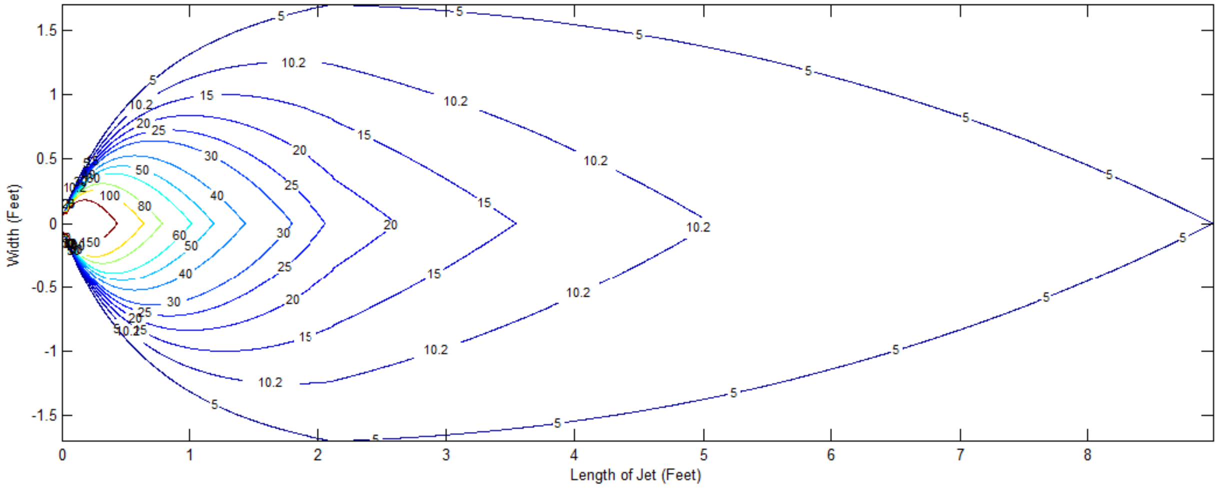

Figure 2-3: Hot leg break pressure isobars

This point represents the farthest radial reach of the ZOI from the reactor nozzle break location. The ZOI lengths for hot leg and cold leg breaks were overlayed onto a model of the reactor coolant system (RCS) piping to demonstrate that the ZOI for any RCS nozzle break would not reach the primary shield penetrations of the adjacent legs, as shown in Figure 2-4. Therefore, the debris generation analysis assumed that 100 percent of the Temp-Mat in the primary shield penetration of the broken leg becomes fines while the Temp-Mat in the adjacent legs become intact pieces. Equivalent spherical ZOIs were calculated based on the volume within the pressure isobar. However, the spherical ZOIs were not used in the debris generation analysis since the radius of an equivalent volume sphere is smaller than the calculated jet length.

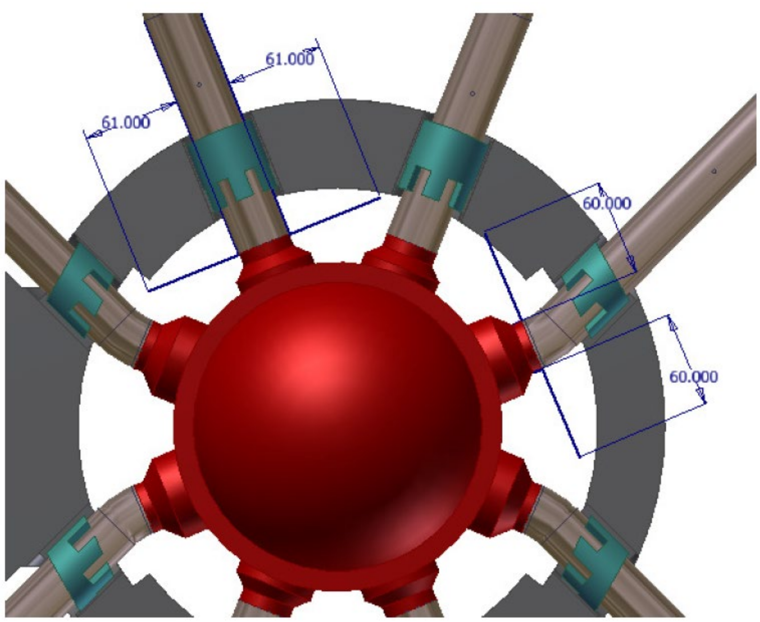

Figure 2-4: Hot leg and cold leg nozzle break ZOI lengths

NRC Question 3

Please provide additional details regarding the submergence of the strainer for the Small Break Loss-of-Coolant Accident (SBLOCA) scenario. Section 3.f.11 of the submittal states that the submerged height of the strainer is 1.01 ft. for the front and 1.79 ft. for the rear sections. It also states that the headloss is 0.758 ft. This is less than half of the rear section submergence, but greater than half of the front section submergence. Considering Regulatory Guide (RG) 1.82 guidance, please explain why this condition is acceptable? Also, please provide details of the timing of additional submergence for this case. For example, how long does it take the height of the pool to increase such that the strainer is fully submerged? If this occurs relatively quickly, it may be demonstrated that headloss will not increase quickly enough to cause partially submerged strainer failure.

PG&E Response

Section 3.f.11 of PG&E's Letter DCL-20-031 providing the final response to close GL 2004-02 (hereafter referred to as "the submittal") states that <u>half of the strainer submerged depth</u> is 1.01 ft for the front and 1.79 ft for the rear sections. These values have already been halved from the full strainer submergence depths at those locations. Therefore, the head loss is required by RG 1.82 to be less than 1.01 ft. The maximum strainer head loss is 0.758 ft, which meets the requirement of RG 1.82 independent of the timing of the submergence for the evaluated limiting SBLOCA scenario.

NRC Question 4

Related to question 3 above, Section 3.g.5 of the submittal states that the Containment Spray (CS) pumps may not be actuated. Table 3.g.12-1 implies that the volume injected from the Refueling Water Storage Tank (RWST) for the SBLOCA assumes CS flow. Please describe how the status of CS affects strainer submergence for the SBLOCA case. The submittal demonstrates that there is adequate margin to account for the sump level reduction that may occur due to reduced injection from the RWST. Please confirm that future changes to net positive suction head (NPSH) calculations will account for the actual minimum sump level that may occur. The potential for a reduction in sump level of 1.3 ft. may be evaluated against increased NPSH available from other sources. For example, if CS does not actuate, there is additional inventory available because CS piping is not filled. In addition, debris headloss is very low at start of recirculation. Other aspects of the scenario may be considered.

PG&E Response

DCPP analyzed the minimum containment water level using the injection volume associated with the RWST low level trip setpoint and recirculation switchover timing.

The additional contribution from CS for those cases when it is actuated is the result of its operation during the time between RWST low level trip and the beginning of recirculation, for which a conservative time of three minutes was assumed. As a result, the injection volume is not significantly affected by CS actuation.

Minimum containment water levels for break sizes between 1.5 inches and 6 inches were analyzed both with and without operation of CS under minimum and maximum safeguard conditions. Break sizes below 3 inches do not automatically actuate CS; however, due to conservative inputs affecting the selected water level case (described below), the minimum water level of 93.17 ft presented in Section 3.g.1 of the submittal results from a 4-inch break with CS and minimum safeguards.

In Table 4-1, the credited volumes from Table 3.g.12-1 of the submittal are shown alongside the volumes from another case evaluated in the water level calculation. The additional case is for a 2-inch break with minimum safeguards but no CS. For the 4-inch break case, a conservatively small volume from the accumulators was used due to lack of break-specific accumulator injection time curve. This led to a water level lower than that determined for smaller breaks without CS. Therefore, the case resulting in the minimum water level is bounding for all other breaks of 6 inches and smaller, including those which do not actuate CS.

In summary, the minimum sump pool water level shown in Section 3.g.1 of the submittal for the breaks of 6 inches and smaller was 93.17 ft, resulting from a 4-inch break with CS and minimum safeguards flow. Table 3.g.12-1 in the submittal shows the source water volumes used for the analysis of this 4-inch break (see Table 4-1 below). The 4-inch break minimum water level bounds (i.e., is smaller than) the cases for breaks down to 1.5 inches without CS. Therefore, it is conservative to use this minimum water level in Section 3.f.11 to evaluate the strainer head loss and NPSH for SBLOCAs against the RG 1.82 acceptance criterion for a partially submerged strainer. The current NPSH calculation already uses a sump minimum level value of 93.17 feet, the lowest level for breaks less than six inches, and therefore a future revision to the NPSH calculation to account for the actual minimum sump level that may occur is not required.

Table 4-1: Source water volumes and resulting water level

Source	4-inch break with containment spray	2-inch break without containment spray
RWST (gallons)	283,388	274,850
Accumulators (gallons)	6,927	24,358
RCS (gallons)	2,164	825
Spray Additive Tank (gallons)	2,279	0
Water level (feet)	93.17	93.35

NRC Question 5

In Section 3.f.14 of the submittal, it was determined that the maximum amount of entrained gases that can reach the pump suction is 0.17 percent. Was the NPSH required value used in the NPSH margin calculation adjusted per the guidance in Regulatory Guide 1.82, Appendix A-3, to account for the entrained gases? If not, please describe how the effect of entrained gases on pump performance was evaluated.

PG&E Response

The NPSH required value used in the NPSH margin calculation was not adjusted per the guidance in RG 1.82, Appendix A-3 As stated in Section 3.f.14 of the submittal, the void fraction is 0.17 percent at the pump suction, which is much lower than the 2 percent limit from NEI 09-10, Guidelines for Effective Prevention and Management of System Gas, Revision 1, December 2010, to prevent mechanical damage and significant impact on the pump head. Various conservativisms were built into the void fraction analysis, as summarized below.

Void fraction immediately downstream of the strainer was maximized by:

- Using the maximum strainer head loss at 60°F.
- Using the smaller minimum strainer submergence between the front and rear sections of the strainer.

The 0.17 percent void fraction was based on the assumption that the voids formed at the strainer will transport intact to the pump suction. When crediting compression of the voids at the pump suction using the ideal gas law, the pressure ratio between the strainer and pump suction was maximized by:

- Neglecting strainer head loss when calculating the strainer pressure but including the maximum strainer head loss when calculating the pump suction pressure.

- Using the greater strainer submergence between the front and rear strainer disks for the strainer pressure term

When the voids formed at the strainer are transported to the pump, the increased elevation head generated in moving the fluid down to the pump suction overcomes the head loss associated with the piping, strainer, and debris bed, resulting in a net pressure increase. For DCPP, the increase in pressure is over 10 pounds per square inch. Although not credited in the DCPP analysis, the increasing pressure tends to compress and collapse the bubbles formed at the strainer as they transport to the pump suction. This is similar to cavitation, where bubbles form when water near its saturation point experiences a rapid pressure drop and collapse as the pressure recovers.

In summary, PG&E calculated the void fraction using a conservative method and showed that the resulting void fraction is well below the NEI 09-10 acceptance criterion. Although not credited in the analysis, the voids formed at the strainer are expected to collapse as they transport to the pump suction and experience higher pressures. As a result, the voids will not degrade pump performance.

NRC Question 6

For the in-vessel evaluation, please provide the WCAP-17788 chemical effects test group number that was applied to the Diablo Canyon in-vessel analysis and confirm it is representative of projected post-LOCA plant conditions.

PG&E Response

WCAP-17788 autoclave Test Group 45, including Test 45-01 and Test IBOB 45-01, is applied as representative of the DCPP post-LOCA plant conditions for the in-vessel analysis. This test group demonstrates that the minimum chemical precipitation time is greater than 24 hours as stated in Table 3.n.1-3 of the submittal.

Table 6-1 shows the critical projected post-LOCA conditions and debris loads at plant scale.

Table 6-1: Critical Projected Diablo Canyon Post-LOCA Plant Conditions (plant scale)

Parameter	Diablo Canyon Unit 1 (Plant Scale)	Diablo Canyon Unit 2 (Plant Scale)
Buffer	Sodium Hydroxide	Sodium Hydroxide
Sump pH (Long-term)	8.0 - 9.5	8.0 - 9.5
Minimum Sump Volume	68,925 ft^3	68,925 ft^3
Maximum Sump Pool Temperature	261°F	261°F
Maximum Calcium Silicate	34,800 g	52,300 g
Maximum E-Glass	119,100 g	72,500 g
Maximum Silica	0 g	0 g
Maximum Mineral Wool	0 g	0 g
Maximum Aluminum Silicate	30,800 g	37,900 g
Maximum Concrete	Not Determined	Not Determined
Maximum Interam™	0 g	0 g
Aluminum	4,039 ft^2	4,039 ft^2
Galvanized Steel	Not Determined	Not Determined

Table 6-2 shows the above parameters scaled by volume to the WCAP-17788 autoclave test scale for comparison with Test Group 45.

Table 6-2: Critical Projected Diablo Canyon Post-LOCA Plant Conditions (test scale)

Parameter	Diablo Canyon Unit 1 (Test Scale)	Diablo Canyon Unit 2 (Test Scale)
Buffer	Sodium Hydroxide	Sodium Hydroxide
Sump pH (Long-term)	8.0 - 9.5	8.0 - 9.5
Minimum Sump Volume	1.76 ft^3 (50 L*)	1.76 ft^3 (50 L)
Maximum Sump Pool Temperature	261°F	261°F
Maximum Calcium Silicate	0.889 g	1.335 g
Maximum E-Glass	3.04 g	1.85 g
Maximum Silica	0 g	0 g
Maximum Mineral Wool	0 g	0 g
Maximum Aluminum Silicate	0.786 g	0.968 g
Maximum Concrete	Not Determined	Not Determined
Maximum Interam™	0 g	0 g
Maximum Aluminum	0.1031 ft^2	0.1031 ft^2
Galvanized Steel	Not Determined	Not Determined

* Refer to Page 3-2 of WCAP-17788-NP, Volume 5 for this volume of test solution.

Test 45-01 and Test IBOB 45-01 used sodium hydroxide as the buffer. The test pH values fall within the representative range for DCPP. The maximum test temperatures are greater than the maximum DCPP sump temperatures. Finally, the maximum test debris and aluminum amounts exceed the projected DCPP post-LOCA plant amounts.

The maximum post-LOCA exposed concrete surface area was not determined for DCPP. As stated in the response in part 3.o.2.3 of the submittal, exposed concrete does not significantly impact chemical product generation.

The maximum post-LOCA galvanized steel surface area was not determined for DCPP. The presence of zinc from galvanized steel is postulated to impact the release of aluminum from aluminum metal. Despite the variability in the galvanized steel surface area included in Test 45-01 versus Test IBOB 45-01, the aluminum concentrations measured in Test 45-01 and IBOB 45-01 were not significantly different relative to the aluminum precipitation boundary.

Filtration tests did not detect precipitates for Test 45-01 or Test IBOB 45-01 down to a temperature of 120°F for the 24-hour duration. A DCPP containment sump temperature of 120°F after only 24 hours is indicative of a significantly less severe accident than simulated within the autoclaves. Therefore, the WCAP-17788 autoclave Test Group 45 results demonstrate that the minimum post-LOCA precipitation time for DCPP is greater than 24 hours.