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

October 15, 2009

Mr. John T. Conway
Senior Vice President – Energy Supply
and Chief Nuclear Officer
Pacific Gas and Electric Company
Diablo Canyon Power Plant
P.O. Box 3, Mail Code 104/6/601
Avila Beach, CA 93424

SUBJECT: DIABLO CANYON POWER PLANT, UNIT NOS. 1 AND 2 - REQUEST FOR ADDITIONAL INFORMATION (RAI) REGARDING SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02, "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS" (TAC NOS. MD4682 AND MD4683)

Dear Mr. Conway:

By letter dated February 1, and July 10, 2008 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML080420438 and ML081980104, respectively), Pacific Gas and Electric Company (PG&E, the licensee) for the Diablo Canyon Power Plant, Unit Nos. 1 and 2 (DCPP) submitted supplemental responses to Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors." By letter dated August 1, 2008 (ADAMS Accession No. ML082050608), the Nuclear Regulatory Commission (NRC) staff requested additional information on the above supplemental responses. By letter dated November 3, 2008 (ADAMS Accession No. ML083190020), PG&E provided a response to that request for additional information (RAI).

The NRC staff has determined that further information is needed for the NRC staff to conclude there is reasonable assurance that GL 2004-02 has been satisfactorily addressed for DCPP. This information is identified in the enclosed RAI. On August 17, 2009, the NRC staff discussed this RAI with the licensee. The NRC staff and the licensee agreed that further interactions are needed before a due date for the response to this RAI is established.

If you or your staff has any questions concerning the resolution of this matter, please contact me at (301) 415-1445.

Sincerely,

Alan Wang

Alan B. Wang, Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-275 and 50-323

Enclosure:
Request for Additional Information

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OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR ADDITIONAL INFORMATION (RAI)

REGARDING SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02

DIABLO CANYON POWER PLANT, UNIT NOS. 1 AND 2

DOCKET NOS. 50-275 AND 50-323

By letters dated February 1, and July 10, 2008 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML080420438 and ML081980104, respectively), Pacific Gas and Electric Company (PG&E) the licensee for the Diablo Canyon Power Plant, Unit Nos. 1 and 2 (DCPP), submitted supplemental responses to Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors." The Nuclear Regulatory Commission (NRC) staff has reviewed the supplemental responses and has determined that we require the following additional information to complete our review:

For continuity, the NRC staff has linked the issues below to the question numbers in the staff's previous RAI package for DCPP, dated August 1, 2008 (ADAMS Accession No. ML082050608).

RAI 2 This RAI questioned the basis for comparability/use of jet impingement testing resulting in zones of influence (ZOIs) with a 3.5 inch jet when much larger jets could be experienced in a loss-of-coolant accident (LOCA). The NRC staff had noted that the licensee had deviated from the Nuclear Energy Institute 04-07 Guidance Report (GR) by assuming plant-specific ZOI radii based on jet impingement testing conducted by Westinghouse at a Wyle Laboratories facility, as documented in WCAP-16720-P. In its review of the licensee's RAI response, the NRC staff noted that the licensee provided additional information on the testing conducted by Westinghouse as reported in WCAP-16720-P. This additional information on the testing conducted to define the ZOIs for the site-specific insulation system installations did not address the intent of the question. Also, since the original RAI No. 2 was developed for DCPP, the NRC staff has performed additional evaluations of the methodology utilized by Westinghouse during the debris generation testing for licensees. This evaluation resulted in a more detailed set of questions regarding the debris generation testing listed below. The licensee's RAI 2 response indicates that similar methodology was used for the DCPP testing. Although, the list of questions was based on, and specifically references, different WCAPs than were used by DCPP in its evaluation, it is expected that similar concerns exist with WCAP-16720-P since the NRC staff understands the methods were similar.

RAI 2 has been replaced with the following RAIs 14-23, which are numbered sequentially after the questions in the NRC staff's August 1, 2008, letter. This RAI includes the staff's follow-up questions on previous RAIs 5, 7 and 12. One new question (RAI 24) has been identified as a result of the NRC staff's review of other licensee's submittals for GL 2004-02.

14. Although the American National Standards Institute/American Nuclear Society (ANSI/ANS) standard predicts higher jet centerline stagnation pressures associated with higher levels of subcooling, it is not apparent that this would necessarily correspond to a

generally conservative debris generation result. Please justify the initial debris generation test temperature and pressure with respect to the plant-specific reactor coolant system (RCS) conditions, specifically the plant hot and cold leg operating conditions. If ZOI reductions are also being applied to lines connecting to the pressurizer, then please also discuss the temperature and pressure conditions in these lines. Please discuss whether any tests were conducted at alternate temperatures and pressures to assess the variance in the destructiveness of the test jet to the initial test condition specifications, and if so, provide that assessment.

15. Please describe the jacketing/insulation systems used in the plant for which the testing was conducted and compare those systems to the jacketing/insulation systems tested. Demonstrate that the tested jacketing/insulation system is adequately representative of the plant jacketing/insulation system. The description should include differences in the jacketing and banding systems used for piping and other components for which the test results are applied, potentially including steam generators, pressurizers, reactor coolant pumps, valves, etc. At a minimum, the following areas should be addressed:

    a. How did the characteristic failure dimensions of the tested jacketing/insulation compare with the effective diameter of the jet at the axial placement of the target? The characteristic failure dimensions are based on the primary failure mechanisms of the jacketing system, e.g., for a stainless steel jacket held in place by three latches where all three latches must fail for the jacket to fail, then all three latches must be effectively impacted by the pressure for which the ZOI is calculated. Applying test results to a ZOI based on a centerline pressure for relatively low length to diameter (L/D) nozzle to target spacing would be non-conservative with respect to impacting the entire target with the calculated pressure.
    b. Was the insulation and jacketing system used in the testing of the same general manufacture and manufacturing process as the insulation used in the plant? If not, what steps were taken to ensure that the general strength of the insulation system tested was conservative with respect to the plant insulation? For example, it is known that there were generally two very different processes used to manufacture calcium silicate whereby one type readily dissolved in water but the other type dissolves much more slowly. Such manufacturing differences could also become apparent in debris generation testing, as well.
    c. The information provided should also include an evaluation of scaling the strength of the jacketing or encapsulation systems to the tests. For example, a latching system on a 30-inch pipe within a ZOI could be stressed much more than a latching system on a 10-inch pipe in a scaled ZOI test. If the latches used in the testing and the plants are the same, the latches in the testing could be significantly under-stressed. If a prototypically sized target were impacted by an undersized jet it would similarly be under-stressed. Evaluations of banding, jacketing, rivets, screws, etc., should be made. For example, scaling the strength of the jacketing was discussed in the Ontario Power Generation report on calcium silicate debris generation testing.

16. There are relatively large uncertainties associated with calculating jet stagnation pressures and ZOIs for both the test and the plant conditions based on the models used

in the WCAP reports. Please describe what steps were taken to ensure that the calculations resulted in conservative estimates of these values. Please provide the inputs for these calculations and the sources of the inputs.

17. Please describe the procedure and assumptions for using the ANSI/ANS-58-2-1988 standard to calculate the test jet stagnation pressures at specific locations downrange from the test nozzle.

    a. Please discuss why the analysis was based on the initial condition of 530 °F whereas the initial test temperature was specified as 550 °F (if applicable to WCAP-16720-P).
    b. Describe whether the water subcooling used in the analysis was that of the initial tank temperature or was it the temperature of the water in the pipe next to the rupture disk. Test data indicated that the water in the piping had cooled below that of the test tank.
    c. The break mass flow rate is a key input to the ANSI/ANS-58-2-1988 standard. Describe how the associated debris generation test mass flow rate was determined. If the experimental volumetric flow was used, then explain how the mass flow was calculated from the volumetric flow given the considerations of potential two-phase flow and temperature dependent water and vapor densities. If the mass flow was analytically determined, then describe the analytical method used to calculate the mass flow rate.
    d. Noting the extremely rapid decrease in nozzle pressure and flow rate illustrated in the test plots in the first tenths of a second; discuss how the transient behavior was considered in the application of the ANSI/ANS-58-2-1988 standard. Specifically, address whether the inputs to the standard represent the initial conditions or the conditions after the first extremely rapid transient, e.g., say at one tenth of a second.
    e. Given the extreme initial transient behavior of the jet, justify the use of the steady state ANSI/ANS-58-2-1988 standard jet expansion model to determine the jet centerline stagnation pressures rather than experimentally measuring the pressures.

18. Please describe the procedure used to calculate the isobar volumes used in determining the equivalent spherical ZOI radii using the ANSI/ANS-58-2-1988 standard by addressing the following questions.

    a. What were the assumed plant-specific RCS temperatures and pressures and break sizes used in the calculation? Note that the isobar volumes would be different for a hot leg break than for a cold leg break since the degrees of subcooling is a direct input to the ANSI/ANS-58-2-1988 standard and which affects the diameter of the jet. Note that an under calculated isobar volume would result in an under calculated ZOI radius.
    b. What was the calculational method used to estimate the plant-specific and break-specific mass flow rate for the postulated plant LOCA, which was used as input to the standard for calculating isobar volumes?
    c. Given that the degree of subcooling is an input parameter to the ANSI/ANS-58-2-1988 standard and that this parameter affects the pressure isobar volumes, what

steps were taken to ensure that the isobar volumes conservatively match the plant-specific postulated LOCA degree of subcooling for the plant debris generation break selections? Were multiple break conditions calculated to ensure a conservative specification of the ZOI radii?

19. Please provide a detailed description of the test apparatus specifically including the piping from the pressurized test tank to the exit nozzle including the rupture disk system.

    a. Based on the temperature traces in the test reports it is apparent that the fluid near the nozzle was colder than the bulk test temperature. How was the fact that the fluid near the nozzle was colder than the bulk fluid accounted for in the evaluations?
    b. How was the hydraulic resistance of the test piping which affected the test flow characteristics evaluated with respect to a postulated plant-specific LOCA break flow where such piping flow resistance would not be present?
    c. What was the specified rupture differential pressure of the rupture disks?

20. Please address the following questions relating to the testing:

    a. Was any analysis or parametric testing conducted to get an idea of the sensitivity of the potential to form a shock wave at different thermal-hydraulic conditions? Were temperatures and pressures prototypical of pressurized-water reactor hot legs considered?
    b. Was the initial lower temperature of the fluid near the test nozzle taken into consideration in the evaluation? Specifically, was the damage potential assessed as a function of the degree of subcooling in the test initial conditions?
    c. What is the basis for scaling a shock wave from the reduced-scale nozzle opening area tested to the break opening area for a limiting rupture in the actual plant piping?
    d. How is the effect of a shock wave scaled with distance for both the test nozzle and plant condition?

21. Please provide the basis for concluding that a jet impact on piping insulation with a 45° seam orientation is a limiting condition for the destruction of insulation installed on steam generators, pressurizers, reactor coolant pumps, and other non-piping components in the containment, if the testing was applied to these components. For instance, considering a break near the steam generator nozzle, once insulation panels on the steam generator directly adjacent to the break are destroyed, the LOCA jet could impact additional insulation panels on the generator from an exposed end, potentially causing damage at significantly larger distances than for the insulation configuration on piping that was tested. Furthermore, it is not clear that the banding and latching mechanisms of the insulation panels on a steam generator or other RCS components provide the same measure of protection against a LOCA jet as those of the piping insulation that was tested. Although WCAP-16710-P asserts that a jet at Wolf Creek or Callaway cannot directly impact the steam generator, but will flow parallel to it, it seems that some damage to the steam generator insulation could occur near the break, with the parallel flow then jetting under the surviving insulation, perhaps to a much greater extent than predicted by the testing. Similar damage could occur to other component insulation. Please provide

a technical basis to demonstrate that the test results for piping insulation are prototypical or conservative of the degree of damage that would occur to insulation on steam generators and other non-piping components in the containment. If the testing was not applied to other components or addressed other components in some manner, please provide these details.

22. Some piping oriented axially with respect to the break location (including the ruptured pipe itself) could have insulation stripped off near the break. Once this insulation is stripped away, succeeding segments of insulation will have one open end exposed directly to the LOCA jet, which appears to be a more vulnerable configuration than the configuration tested by Westinghouse. As a result, damage would seemingly be capable of propagating along an axially oriented pipe significantly beyond the distances calculated by Westinghouse. Please provide a technical basis to demonstrate that the reduced ZOIs calculated for the piping configuration tested are prototypical or conservative of the degree of damage that would occur to insulation on piping lines oriented axially with respect to the break location.

23. WCAP-16710-P noted damage to the cloth blankets that cover the fiberglass insulation in some cases resulting in the release of fiberglass. The tears in the cloth covering were attributed to the steel jacket or the test fixture and not the steam jet. It seems that any damage that occurs to the target during the test would be likely to occur in the plant. Discuss whether the potential for damage to plant insulation from similar conditions was considered. For example, the test fixture could represent a piping component or support, or other nearby structural member. The insulation jacketing is obviously representative of itself. Describe the basis for the statement in the WCAP that damage similar to that which occurred to the end pieces in not expected to occur in the plant. It is likely that a break in the plant will result in a much more chaotic condition than that which occurred in testing. Therefore, it would be more likely for the insulation to be damaged by either the jacketing or other objects nearby. If the testing referenced by the plant noted similar damage mechanisms and did not account for debris created by such, please provide a basis for the determination that the debris generation would not occur in the plant.

RAI 5 The NRC staff requested that the licensee state whether unjacketed debris and fire stops would be exposed to runoff from spray drainage and describe whether this effect was accounted for in the spray erosion testing. The licensee's response, dated November 3, 2008, described erosion testing performed for both unjacketed insulation and for fire stops in cable trays. Regarding the unjacketed insulation tests, the runoff flow was modeled as impacting the insulation with a velocity of 0.4 ft/s, while the spray nozzle exit velocity was modeled as being greater than or equal to 15.75 ft/s. Although a basis was provided for the spray nozzle exit velocity, the response did not adequately demonstrate that 0.4 ft/s is a conservative or prototypical velocity for drainage runoff to impact unjacketed insulation. Furthermore, since the test results of the unjacketed insulation subjected to runoff were used as a justification not to conduct testing of vertical cable tray fire stops exposed to runoff drainage, the choice of 0.4 ft/s as a velocity for runoff drainage also affects the vertical cable tray fire stop testing. Therefore, please provide a technical basis to demonstrate that 0.4 ft/s is a conservative or prototypical velocity for drainage runoff that could impact unjacketed insulation and vertical cable tray fire stops in order to show that the erosion testing and assumptions made for these materials are justified.

RAI 7 The NRC staff requested additional information regarding how stirring affected the results of the head loss test. The licensee provided information that justified that excessive debris settlement did not occur. However, it is also possible that the stirring affected the debris bed non-prototypically such that debris did not accumulate uniformly over the strainer surface as would occur if added turbulence was not present. Post-test photographs and inspection of the strainer showed that an unexpected non-uniform distribution of debris on the strainer occurred. It was particularly unusual that photographs showed less debris accumulation near the bottom of the strainer than elsewhere. Additionally, the test resulted in a significantly increased deposition of paint chips on the strainer compared to what would be expected in the plant. The licensee should provide information that justifies that the debris bed formed during testing is a realistic or conservative representation of what would occur in the plant.

RAI 12 The NRC staff requested that the licensee provide a revised table showing the results of the net positive suction head margin calculation without including the head loss from accumulated debris. The table provided by the licensee on page 29 of the November 3, 2008, supplemental response showed the individual contributions from the increased containment water level assumed by the licensee, as well as the impact of the strainer and debris bed head losses. The licensee indicated that the previous net positive suction head calculations conservatively did not take credit for minimum sump water levels. The NRC staff questions this response because a 5-ft level increase was credited for cold-leg recirculation, whereas only a 2-ft level increase was credited for hot-leg recirculation. The NRC staff expected that the minimum water level available for hot-leg recirculation would be greater than or equal to the minimum cold-leg recirculation water level. Furthermore, the licensee's response, dated July 10, 2008, indicates that the minimum pool depth is 1.8 ft for a small-break LOCA and 2.6 ft for a large-break LOCA. Even at the point when the containment spray pumps are secured, this supplemental response states that the calculated minimum pool level could be a minimum of 3.5 ft. Therefore, the basis for crediting a 5 ft increase in water level for the cold-leg recirculation case to account for the minimum containment water level was not clear to the NRC staff, since it appeared that a minimum level of 5 ft could not be assured post-LOCA. In light of the discussion above, please provide a technical basis to demonstrate that the increased water levels credited for cold-leg and hot-leg recirculation are justified in light of the minimum containment water levels for Diablo Canyon, or provide a different level with justification.

24. The potential for deaeration of the coolant as it passes through the debris bed should be considered. Please provide an evaluation of the potential for deaeration of the fluid as it passes through the debris bed and strainer and whether any entrained gasses could reach the pump suction. If detrained gasses can reach the pump suction, please evaluate whether pump performance could be affected as described in Appendix A of Regulatory Guide 1.82, Revision 3.

If you or your staff has any questions concerning the resolution of this matter, please contact me at (301) 415-1445.

Sincerely,

/RA/

Alan B. Wang, Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-275 and 50-323

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