April 21, 2006

Mr. John S. Keenan
Senior Vice President and Chief Nuclear Officer
Pacific Gas and Electric Company
Diablo Canyon Power Plant
P.O. Box 770000
San Francisco, CA 94177-0001

SUBJECT: DIABLO CANYON POWER PLANT, UNIT NO. 2 - RELAXATION OF REQUIREMENTS ASSOCIATED WITH FIRST REVISED ORDER (EA-03-009) DATED FEBRUARY 20, 2004, REGARDING ALTERNATE EXAMINATION COVERAGE FOR REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES (TAC NO. MD0024)

Dear Mr. Keenan:

By letter dated February 7, 2006, Pacific Gas and Electric Company (PG&E) requested relaxation to implement an alternative to the requirements of Section IV.C.(5)(b) of the First Revised Nuclear Regulatory Commission (NRC) Order EA-03-009 (Order) dated February 20, 2004, for reactor pressure vessel (RPV) head penetration nozzles at Diablo Canyon Power Plant, Unit 2 (DCPP Unit 2).

PG&E requested relaxation from the Order where inspection coverage is limited by inaccessible areas of 78 vessel head penetration (VHP) nozzles for DCPP Unit 2, with respect to nondestructive examination, including ultrasonic testing, eddy current testing, and dye penetrant testing.

The NRC staff has reviewed and evaluated the information provided by PG&E in support of this request and concludes that PG&E's proposed alternative examination of the 78 VHP nozzles provides reasonable assurance of the structural integrity of the RPV head, VHP nozzles, and welds. Further inspections of these VHP nozzles in accordance with Section IV.C.(5)(b) of the Order would result in hardship without a compensating increase in the level of quality and safety. Therefore, pursuant to Section IV.F. of the Order, the NRC staff authorizes the proposed alternative inspection for the 78 VHP nozzles at DCPP Unit 2, subject to the understanding, as included in your relaxation request that:

> If the NRC staff finds that the crack-growth formula in industry report MRP-55, "Materials Reliability Program (MRP) Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick Wall Alloy 600 Material," is unacceptable, then PG&E will revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs PG&E of an NRC-approved crack-growth formula. If PG&E's revised analysis shows that the crack-growth acceptance criteria are exceeded prior to the end of the current operating cycle, this relaxation request will be rescinded and PG&E will, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack-growth acceptance criteria are exceeded during the subsequent operating cycle, PG&E will, within 30 days, submit the revised

analysis for NRC review. If the revised analysis shows that the crack-growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, PG&E will, within 30 days, submit a letter to the NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for this and future cycles for RPV head penetrations must be based on an acceptable crack-growth rate formula.

The NRC staff's review is provided in the enclosed safety evaluation. If you have any questions, please contact Alan B. Wang at (301) 415-1445.

Sincerely,

/RA/

David Terao, Chief
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-323

Enclosure: Safety Evaluation

cc w/encl: See next page

analysis for NRC review. If the revised analysis shows that the crack-growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, PG&E will, within 30 days, submit a letter to the NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for this and future cycles for RPV head penetrations must be based on an acceptable crack-growth rate formula.

The NRC staff's review is provided in the enclosed safety evaluation. If you have any questions, please contact Alan B. Wang at (301) 415-1445.

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ACCESSION NO.: ML061000417 ***SE Dated** 4/3/06 **NRR-058**

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

FIRST REVISED ORDER EA-03-009 RELAXATION REQUEST

ALTERNATE EXAMINATION COVERAGE

FOR REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES

PACIFIC GAS AND ELECTRIC COMPANY, INC.

DIABLO CANYON POWER PLANT, UNIT 2

DOCKET NUMBER 50-323

1.0 INTRODUCTION

The First Revised Nuclear Regulatory Commission (NRC) Order EA-03-009 (First Revised Order), issued on February 20, 2004, requires specific examinations of the reactor pressure vessel (RPV) head and vessel head penetration (VHP) nozzles of all pressurized-water reactor plants. Section IV.F of the First Revised Order states that requests for relaxation of the First Revised Order associated with specific penetration nozzles will be evaluated by the NRC staff using the procedure for evaluating proposed alternatives to the American Society of Mechanical Engineers Boiler and Pressure Code in accordance with paragraph 50.55a(a)(3) of Title 10 of the *Code of Federal Regulations* (10 CFR). Section IV.F of the First Revised Order states that a request for relaxation regarding inspection of specific nozzles shall address the following criteria: (1) the proposed alternative(s) for inspection of specific nozzles will provide an acceptable level of quality and safety, or (2) compliance with this First Revised Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

For Diablo Canyon Power Plant, Unit 2 (DCPP Unit 2), and similar plants determined to have a high susceptibility to primary water stress corrosion cracking (PWSCC) in accordance with Sections IV.A and IV.B of the First Revised Order, the following inspections are required to be performed every refueling outage in accordance with Sections IV.C.(5)(a) and IV.C.(5)(b) of the First Revised Order:

(a) Bare metal visual examination of 100 percent of the RPV head surface (including 360° around each RPV head penetration nozzle). For RPV heads with the surface obscured by support structure interferences which are located at RPV head elevations downslope from the outermost RPV head penetration, a bare metal visual inspection of no less than 95 percent of the RPV head surface may be performed provided that the examination shall include those areas of the RPV head upslope and downslope from the support structure interference to identify any evidence of boron or corrosive product. Should any evidence of boron or corrosive product be identified, the licensee shall examine the RPV head surface under the support structure to ensure that the RPV head is not degraded.

(b) For each penetration, perform a nonvisual nondestructive examination (NDE) in accordance with either (i), (ii), or (iii):

(i) Ultrasonic testing of the RPV head penetration nozzle volume (i.e., nozzle base material) from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches [see Figure IV-1]); OR from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0-inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operation stresses) of 20 ksi tension and greater (see Figure IV-2). In addition, an assessment shall be made to determine if leakage has occurred into the annulus between the RPV head penetration nozzle and the RPV head low-alloy steel.

(ii) Eddy current testing or dye penetrant testing of the entire wetted surface of the J-groove weld and the wetted surface of the RPV head penetration nozzle base material from at least 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches [see Figure IV-3]); OR from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0-inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld have an operating stress level (including all residual and normal operation stresses) of 20 ksi tension and greater (see Figure IV-4).

(iii) A combination of (i) and (ii) to cover equivalent volumes, surfaces, and leak paths of the RPV head penetration nozzle base material and J-groove weld as described in (i) and (ii). Substitution of a portion of a volumetric exam on a nozzle with a surface examination may be performed with the following requirements:

1. On nozzle material below the J-groove weld, both the outside diameter and inside diameter surfaces of the nozzle must be examined.

2. On nozzle material above the J-groove weld, surface examination of the inside diameter surface of the nozzle is permitted provided a surface examination of the J-groove weld is also performed.

By letter dated February 7, 2006, Pacific Gas and Electric Company, Inc. (PG&E/the licensee), requested relaxation to implement an alternative to the requirements of Section IV.C.(5)(b) of the First Revised Order for RPV head penetration nozzles at DCPP Unit 2. The licensee referenced supporting information previously provided in letters dated October 24 and November 12, 2004, and May 27, 2005.

2.0 RELAXATION REQUEST

2.1 First Revised Order Requirements for which Relaxation is Requested

Section IV.C of the First Revised Order EA-03-009 dated February 20, 2004, requires, in part, that inspections of Section IV.C.(5)(b) of the First Revised Order be performed every refueling outage for high susceptibility plants similar to DCPP Unit 2.

The licensee has requested relaxation from Section IV.C.(5)(b) of the First Revised NRC Order EA-03-009. The specific relaxation requested is identified below.

2.2 Licensee's Proposed Alternative

The licensee seeks relaxation from the First Revised Order EA-03-009, dated February 20, 2004, to revise the minimum inspection coverage requirement below the J-groove weld for DCPP Unit 2, be to the maximum extent possible with a minimum inspection distance of 0.3-inches below the J-groove weld. The licensee also requests this relaxation be granted until the First Revised Order EA-03-009 is replaced or rescinded.

2.3 Licensee's Basis for Proposed Alternative

It is the licensee's intent to perform the ultrasonic testing (UT) examination to the maximum extent possible. The licensee will utilize inspection option (b)(i) and will achieve UT coverage 2 inches above the J-groove weld down to the lowest elevation that can be practically inspected on each nozzle with the UT probe being used with a minimum required inspection distance of 0.3-inches below the J-groove weld.

The licensee states that testing of portions of the nozzle significantly below the J-groove weld is not significant to the phenomena of concern. The phenomena that are of concern are leakage through the J-groove weld and circumferential cracking in the nozzle above the J-groove weld. The nozzle is essentially an open-ended tube, and the nozzle wall below the J-groove weld is not part of the reactor coolant system (RCS) pressure boundary. The licensee believes the proposed inspection coverage does not preclude full UT examination coverage of the portions of these nozzles that are of primary interest.

A structural integrity evaluation has been performed for DCPP Units 1 and 2 reactor vessel head penetrations. A series of crack-growth calculations were performed presuming a flaw where the lower extremity of this initial through-wall flaw is conservatively postulated to be located on the penetration nozzle where either the inside or outside surface hoop stress drops below 0 ksi. The calculation demonstrated that more than one operating cycle would elapse before a postulated flaw in the unexamined area of the penetration nozzle would propagate into the pressure boundary formed by the J-groove weld. DCPP Unit 2 is in the high susceptibility

category, therefore, nonvisual NDE will be performed during each refueling outage, until the reactor head is replaced.

The methodology and the technical basis of the crack-growth calculation, which was based on the hoop stress distribution and the PWSCC crack-growth rate recommended in MRP-55, Revision 1, were provided in WCAP-15429-P.

The calculation demonstrates that the minimum time for a flaw to propagate from 0.3-inches below the weld to the bottom of the J-groove weld would be at least one operating cycle. The results of the flaw propagation calculation indicate that, even if a flaw were to occur in the region of the penetration nozzle not being inspected, there would be adequate opportunity for detection prior to the crack reaching the RCS pressure boundary. The results demonstrate that the extent of the proposed inspection coverage would provide reasonable assurance of the structural integrity of DCPP Unit 2 RPV head penetration nozzles and the J-groove welds. These flaw propagation calculations were verified to be conservative to the as-built weld dimension, through a series of calculations performed by Westinghouse to evaluate the impact of larger fillet weld sizes found in the as-built configurations of penetration numbers 35 and 55. The evaluation concluded that the as-designed crack-growth charts were conservative if the as-built weld sizes are larger than the as-designed weld sizes.

In summation of the results which led to the conclusions above, the licensee provided figures of the crack-growth predictions for six nozzle angles. The licensee also provided figures detailing hoop stresses for six nozzle angles. As the crack-growth rate formula used in the structural integrity evaluation for Unit 1 is the same as the PWSCC crack-growth rate recommended in MRP-55, Revision 1, the licensee states the following:

> If the NRC staff finds that the crack-growth formula in industry report MRP-55, "Materials Reliability Program (MRP) Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick Wall Alloy 600 Material," is unacceptable, then PG&E will revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs PG&E of an NRC-approved crack-growth formula. If PG&E's revised analysis shows that the crack-growth acceptance criteria are exceeded prior to the end of the current operating cycle, this relaxation request will be rescinded and PG&E will, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack-growth acceptance criteria are exceeded during the subsequent operating cycle, PG&E will, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack-growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, PG&E will, within 30 days, submit a letter to the NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for this and future cycles for RPV head penetrations must be based on an acceptable crack-growth rate formula.

The licensee requests approval of the proposed alternative through the period in which the First Revised Order EA-03-009 is in effect, or until inspection technology is developed to a state that the examination volume can be extended to full compliance with the First Revised Order, or information is received from the NRC regarding nonacceptance of the crack-growth formula in MRP-55.

3.0 STAFF EVALUATION

The NRC staff's review of this request was based on criterion (2) of Section IV.F of the First Revised Order, which states:

> Compliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Full inspection coverage is not achievable at DCPP Unit 2 for all vessel head penetration (VHP) nozzles, because of nozzle end geometry. Specifically, the bottom end of these nozzles are externally threaded, or internally tapered, or both. Thus, the geometry of the nozzle ends makes inspection in accordance with the First Revised Order difficult and would involve a hardship including an increased personnel radiation dose due to possible surface examination options. This evaluation focuses on the issue of whether there is a compensating increase in the level of quality and safety such that these nozzles should be inspected in accordance with the First Revised Order despite this hardship.

The alternative inspection proposed by the licensee for the VHP nozzles is to volumetrically examine each nozzle from 2 inches above the weld down to the maximum extent possible with a minimum required inspection distance of 0.3-inches below the J-groove weld. DCPP Unit 2's previous inspection results indicate no evidence of head material wastage or of leaking VHP nozzles. The NRC staff reviewed evaluations and analyses performed by the licensee in support of this request, as described below.

Stress profiles, based on the licensee's finite element analysis of VHP at DCPP Unit 2 show that most residual stresses decrease significantly at distances greater than 0.3-inches below the J-groove weld. Since the stress level at the unexamined area is low, initiation of a crack is very unlikely. Operating experience also indicates that locations with this low stress level have been much less susceptible to cracking. In addition, if examination of the high stress locations of these nozzles (i.e., nozzle locations adjacent to the J-groove weld and associated heat affected zone areas) finds no cracks, then cracking at the low stress locations is unlikely.

The licensee's analysis used the methodology described in footnote 1 of the First Revised Order and conservative criteria to set the necessary height of the examination. The analysis postulated a through-wall crack in the unexamined area and showed that it would take the crack more than one operating cycle to reach the J-groove weld. The NRC staff's assessment of the licensee's conclusion is based on data analysis of the supporting figures of the crack-growth predictions for various nozzle angles, as provided in the licensee's first relaxation request letter to the NRC dated October 26, 2004, and as supplemented by letter dated November 12, 2004. In addition, as documented in the letter dated February 7, 2006, the staff notes that the licensee verified these flaw propagation calculations using as-designed weld dimensions are conservative, through a series of calculations performed by Westinghouse to evaluate the impact of larger fillet weld sizes found in the as-built configurations of penetration numbers 35 and 55. Therefore, NRC staff concurs with the licensee's conclusion, that a crack located beyond a minimum distance of 0.3-inches below the J-groove weld would take more than one operating cycle to reach the J-groove weld.

As DCPP Unit 2 is in the high susceptibility category, nonvisual NDE will be performed during each refueling outage, until the reactor head is replaced. Therefore, an inspection frequency based on the licensee's crack-growth assessment above provides a reasonable basis for the proposed alternative inspection, to perform the UT examination below the J-groove weld to the

maximum extent possible with a minimum inspection distance of 0.3-inches below the J-groove weld.

However, this analysis incorporates a crack-growth formula as provided in the Electric Power Research Institute Report, "Material Reliability Program (MRP) Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick Wall Alloy 600 Material" (MRP-55) Revision 1. The NRC staff has completed a preliminary review of the crack-growth formula, but has not yet made a final assessment regarding the acceptability of the report. Therefore, a condition has been included regarding the approval of the proposed relaxations. The condition was agreed to by the licensee in their February 7, 2006, letter to the NRC, and is as follows:

> If the NRC staff finds that the crack-growth formula in industry report MRP-55, "Materials Reliability Program (MRP) Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick Wall Alloy 600 Material," is unacceptable, then PG&E will revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs PG&E of an NRC-approved crack-growth formula. If PG&E's revised analysis shows that the crack-growth acceptance criteria are exceeded prior to the end of the current operating cycle, this relaxation request will be rescinded and PG&E will, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack-growth acceptance criteria are exceeded during the subsequent operating cycle, PG&E will, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack-growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, PG&E will, within 30 days, submit a letter to the NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for this and future cycles for RPV head penetrations must be based on an acceptable crack-growth rate formula.

The safety issues that are addressed by the First Revised Order EA-03-009 are degradation (corrosion) of the low-alloy steel RPV head, reactor coolant pressure boundary integrity and ejection of the VHP nozzle due to circumferential cracking of the nozzle above the J-groove weld. The licensee's proposed alternative inspection, to perform the UT examination below the J-groove weld to the maximum extent possible with a minimum inspection distance of 0.3-inches below the J-groove weld, as conditioned, provides reasonable assurance that these safety issues are addressed.

The licensee has noted that surface examination could be performed to increase the inspection coverage for each nozzle, however, these additional inspections would require extensive work in approximately 6 R/hour radiation fields. The staff finds that performing these additional surface examinations would result in significant hardship through radiation exposure without a compensating increase in the level or quality or safety.

Based upon the information above, the NRC staff finds that the licensee's proposed alternative examination is acceptable as it provides reasonable assurance of the structural integrity of the RPV head, VHP nozzles and welds. Further inspections to comply with the First Revised Order requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

4.0 CONCLUSION

The NRC staff concludes that the licensee's proposed alternative inspection of DCPP Unit 2's VHP nozzles, to perform the UT examination below the J-groove weld to the maximum extent possible with a minimum inspection distance of 0.3-inches below the J-groove weld, as conditioned, provides reasonable assurance of the structural integrity of the RPV head, VHP nozzles and welds. Further inspections of these VHP nozzles in accordance with Section IV.C.(5)(b), of the First Revised Order EA-03-009 dated February 20, 2004, would result in hardship without a compensating increase in the level of quality and safety. Therefore, pursuant to Section IV. F, of the First Revised Order EA-03-009 dated February 20, 2004, the NRC staff authorizes the proposed alternative inspection as stated above at DCPP Unit 2 until the First Revised Order EA-03-009 is replaced or rescinded, subject to the following condition:

> If the NRC staff finds that the crack-growth formula in industry report MRP-55, "Materials Reliability Program (MRP) Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick Wall Alloy 600 Material," is unacceptable, then PG&E will revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs PG&E of an NRC-approved crack-growth formula. If PG&E's revised analysis shows that the crack-growth acceptance criteria are exceeded prior to the end of the current operating cycle, this relaxation request will be rescinded and PG&E will, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack-growth acceptance criteria are exceeded during the subsequent operating cycle, PG&E will, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack-growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, PG&E will, within 30 days, submit a letter to the NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for this and future cycles for RPV head penetrations must be based on an acceptable crack-growth rate formula.

Principal Contributor: J. Collins

Date: April 21, 2006

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