November 23, 2004

Mr. Gregory M. Rueger
Senior Vice President, Generation and
Chief Nuclear Officer
Pacific Gas and Electric Company
Diablo Canyon Power Plant
P. O. Box 3
Avila Beach, CA 93424

SUBJECT: DIABLO CANYON POWER PLANT, UNIT NO. 2 - RELAXATION OF REQUIREMENTS ASSOCIATED WITH FIRST REVISED ORDER (EA-03-009) REGARDING ALTERNATE EXAMINATION COVERAGE FOR REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES (TAC NO. MC4932)

Dear Mr. Rueger:

By letter dated October 26, 2004, and its supplement dated November 12, 2004, 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 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 64 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 64 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 64 VHP nozzles at DCPP Unit 2, subject to the following condition:

> If the NRC staff finds that the crack-growth formula in industry report MRP-55 is unacceptable, PG&E shall 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the crack growth acceptance criteria are exceeded prior to the end of the current operating cycle, this relaxation is rescinded and PG&E shall, within 72 hours, submit to the NRC written justification for continued operation.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 shall, 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 shall, within 30 days submit a letter to the NRC confirming that its analyses 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 Girija Shukla at (301) 415-8439.

Sincerely,

/RA/

Herbert N. Berkow, Director
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-323

Enclosure: Safety Evaluation

cc w/encl: See next page

are not exceeded during either the current operating cycle or the subsequent operating cycle, PG&E shall, within 30 days submit a letter to the NRC confirming that its analyses 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 Girija Shukla at (301) 415-8439.

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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

DIABLO CANYON POWER PLANT, UNIT 2

DOCKET NO. 50-323

1.0 INTRODUCTION

By letter dated October 26, 2004, and its supplement dated November 12, 2004, Pacific Gas and Electric Company (PG&E or licensee) requested relaxation to implement an alternative to the requirements of Section IV.C.(5)(b) of the First Revised NRC Order EA-03-009, dated February 20, 2004, for reactor pressure vessel (RPV) head penetration nozzles at Diablo Canyon Power Plant, Unit 2 (DCPP Unit 2).

Specifically, PG&E requested relaxation from the First Revised NRC Order where inspection coverage is limited by inaccessible areas of 64 vessel head penetration (VHP) nozzles for DCPP Unit 2, with respect to nondestructive examination (NDE), including ultrasonic testing (UT), eddy current testing (ET), and dye penetrant testing (PT).

2.0 REGULATORY EVALUATION

The First Revised NRC Order EA-03-009 (Order), issued on February 20, 2004, requires specific examinations of the RPV head and VHP nozzles of all pressurized water reactor (PWR) plants. Section IV.F. of the Order states that requests for relaxation of the 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 (ASME) Code in accordance with 10 CFR 50.55a(a)(3). Section IV.F. of the 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 Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

For 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 Order, the following inspections are required to be performed every refueling outage in accordance with Sections IV.C.(5)(a) and (b) of the Order:

(a) Bare metal visual (BMV) examination of 100 percent of the RPV head surface (including 360E 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 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.

2.1 First Revised Order Requirements for Which Relaxation is Requested

Section IV.C. of the Order requires, in part, that inspections of Section IV.C.(5)(b) of the 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 Order. The specific relaxation requested is identified below.

3.0 TECHNICAL EVALUATION

3.1 Licensee's Proposed Alternative

The licensee seeks relaxation from the Order where inspection coverage is limited by inaccessible areas of 64 VHP penetration nozzles for DCPP Unit 2, with respect to NDE, including UT, ET, and PT.

The licensee proposes to achieve NDE coverage by means of UT to at least the coverage achieved at each of these nozzles as listed in Table 1 below:

3.2 Licensee's Basis for Proposed Alternative

NDE coverage to at least one (1) inch below the J-groove weld is unnecessary for the cited nozzles because UT examination to the lower limit physically achievable provides an acceptable level of quality and safety, as described below.

Table 1 below shows the extent of UT coverage achieved for 64 penetration nozzles that do not meet the inspection requirements of the Order during the DCPP Unit 2 refueling outage twelve (2R12) volumetric inspections. The inspection coverage above the J-groove weld satisfies the Order requirements for all penetrations. The coverage below the J-groove weld required by the Order was not achievable for penetrations 2-9, 14-17, 22-23, 25-61, 64, 66-74, and 76-78.

The Alloy 600 tubing base metal immediately adjacent to the weld area was completely inspected in all penetration tubes. In addition, the area above the weld was inspected to determine if there were leakage paths present in the interference fit between the tube and the carbon steel head. In all cases, there were no indications of detectable discontinuities noted.

The tube area below the weld is not part of the pressure boundary; however, if any flaws are present, they could potentially propagate into the weld material, eventually causing a leakage path through the reactor coolant pressure boundary.

Table 1 - DCPP Unit 2, Fall 2004 RPV Head Inspection Nozzles with UT Coverage Less than 1 Inch Below the Lowest Point of the Toe of the J-Groove Weld (i.e., Downhill Side)

Pen #	Time for Flaw Growth to Weld (EFPY)	Lower Exam Extent @0°	Lower Exam Extent @180°	Pen #	Time for Flaw Growth to Weld (EFPY)	Lower Exam Extent @0°	Lower Exam Extent @180°
2	> 5	0.79	1.59	43	> 5	0.55	3.83
3	> 5	0.75	1.55	44	> 5	0.75	3.71
4	> 5	0.91	1.47	45	> 5	0.67	3.91
5	> 5	0.87	1.72	46	> 5	0.75	3.55
6	> 5	0.87	2.20	47	2.2	0.43	3.59
7	> 5	0.87	2.23	48	3.5	0.47	3.47
8	> 5	0.71	2.07	49	> 5	0.55	3.75
9	> 5	0.67	1.95	50	> 5	0.63	3.71
14	1.8	0.39	2.59	51	4.5	0.51	3.47
15	> 5	0.67	2.63	52	3.5	0.47	3.79
16	> 5	0.63	2.47	53	2.2	0.43	3.63
17	> 5	0.59	2.51	54	4.5	0.51	3.58
22	> 5	0.63	2.87	55	1.44	0.31	3.99
23	> 5	0.55	2.75	56	> 5	0.67	3.87
25	> 5	0.71	2.88	57	> 5	0.67	4.07
26	> 5	0.63	2.91	58	> 5	0.59	4.03
27	> 5	0.63	2.99	59	2.0	0.40	3.79
28	> 5	0.67	2.79	60	2.2	0.43	3.91
29	2.2	0.43	2.83	61	4.5	0.51	4.23
30	> 5	0.71	3.16	64	> 3.2	0.68	5.12
31	> 5	0.43	3.07	66	> 3.5	0.59	4.67
32	> 5	0.43	3.23	67	> 3.5	0.47	4.95
33	> 5	0.67	3.35	68	> 3.5	0.35	4.91
34	4.5	0.51	3.27	69	> 3.5	0.46	4.91
35	1.44	0.31	2.91	70	> 3.5	0.55	5.15
36	3.5	0.47	2.95	71	> 3.5	0.35	4.87
37	> 5	0.55	3.07	72	> 3.5	0.43	4.83
38	2.2	0.43	3.63	73	> 3.5	0.35	4.87
39	4.5	0.51	3.83	74	> 4.5	0.76	5.92
40	4.5	0.51	3.51	76	> 4.5	0.92	6.04
41	> 5	0.59	3.63	77	> 4.5	0.48	6.00
42	2.2	0.43	3.83	78	> 4.5	0.76	6.16

To demonstrate the acceptability of the inspection coverage achieved, a through-wall flaw was postulated to exist immediately below the lowest extent covered on the downhill side of each penetration tube to a length for which the nozzle had no tensile stress applied. A measurement tolerance of ± 0.04 inches was included in all flaw evaluations. For the downhill side of the welds, the 0.04-inch tolerance was conservatively subtracted from the measured lower inspection coverage.

The growth of postulated flaws was provided in the flaw growth curves in WCAP-15429-P, previously provided in PG&E letter (DCL-04-146), "Relaxation Request for NRC Issuance of First Revised Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors," dated October 26, 2004.

This postulated flaw at the lower extent of coverage (accounting conservatively for the measurement tolerance) was located on the flaw growth curve associated with the penetration angle. For those penetrations that did not have a curve specific to the tube angle, a conservative curve (nearest lower angle), as demonstrated below, was used. The time it would take for the postulated flaws to grow to intersect the weld metal based on the minimum coverage achieved was then determined. The results are provided in Table 1 above.

While the flaw growth rate for 82/182 weld metal is greater than the alloy 600 base materials, there is a finite time associated with flaw growth through the weld to create a through-wall leakage path. Conservatively, no credit is taken for this time in this evaluation.

The measured coverage was sufficient to provide at least 1.44 effective full power years (EFPY) until the postulated flaws would reach the weld metal. Cycle 13 is designed for an 18-month cycle with a core design of 1.33 EFPY. Therefore, the next inspection will be conducted prior to the time that the postulated flaw would be expected to grow to intersect the weld. This demonstrates that DCPP Unit 2 can safely operate until the next inspection is performed in DCPP Unit 2 refueling outage thirteen (2R13). If there were a flaw as postulated above, it would be detected during the next inspection and corrective actions would be taken.

3.3 Evaluation

The NRC staff's review of this request was based on criterion (2) of Section IV.F of the 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 coverage is not achievable at DCPP Unit 2 for 64 nozzles, noted in Table 1 above, because of nozzle end geometry. Specifically, the bottom ends of these nozzles are externally threaded, or internally tapered, or both. Thus, the geometry of the nozzle ends makes inspection in accordance with the Order difficult and would involve a hardship including 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 Order despite this hardship.

The alternative inspection proposed by the licensee for these 64 nozzles is to volumetrically examine each nozzle to as far below the weld as can be achieved as identified in Table 1 above. In support of this request, the licensee documented that preliminary assessment of the inspection results from the current November 2004 inspections had disclosed no evidence of head material wastage or of leaking or cracked nozzles. There was no leakage or PWSCC in penetration nozzles in past inspections. 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 control rod drive mechanism (CRDM) penetrations at DCPP Unit 2, show that most residual stresses decrease significantly at distances identified in Table 1 above for minimum UT coverage achieved. The maximum operating stress level at the nozzle base material beyond the UT coverage, as determined by the licensee, is 32 ksi with most being below 20 ksi. The nominal yield strength of the CRDM penetration base material is from 35 to 57.5 ksi. 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.

An analysis provided by the licensee demonstrates that if an axial crack initiates from the minimum UT coverage achieved locations, it will take more than one operating cycle for this postulated crack to propagate to the point of contact with the J-groove weld. This analysis used the approach described in footnote 1 of the Order as the criteria to set the necessary height of the examination. As DCPP Unit 2 is categorized as a high susceptibility plant for Order-required inspection frequency, the licensee will be performing bare metal visual inspection and non-visual NDE of the RPV head each refueling outage until the RPV head is replaced. Therefore, the coverage addressed by this request provides reasonable assurance of structural integrity of the component. However, this analysis incorporates a crack growth formula as provided in the EPRI 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 October 26, 2004, letter to the NRC, and is as follows:

> The crack-growth rate formula used in the structural integrity evaluation for DCPP Unit 2 is the same as reported in industry report MRP-55. If the NRC staff finds that the crack-growth formula in industry report MRP-55 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.

The safety issues that are addressed by the inspections mandated by the Order 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 proposed alternative, as conditioned, provides reasonable assurance that these safety issues are addressed. Based on the above discussion, the alternative proposed by the licensee to inspect the 64 nozzles to the minimum UT coverage achievable below the J-groove weld, as documented in Table 1 above, will provide reasonable assurance of structural integrity.

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 six R/hour radiation fields. The NRC staff finds that performing these additional surface examinations would result in significant hardship through radiation exposure without a compensating increase in the level of 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 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 has demonstrated good cause for the requested relaxation in that the proposed alternative examination of the 64 VHP nozzles (identified above in Section 2.3, Table 1), 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 64 VHP nozzles (identified above in Section 2.3, Table 1), at DCPP Unit 2, subject to the following condition:

> If the NRC staff finds that the crack-growth formula in industry report MRP-55 is unacceptable, the licensee shall revise its analysis that justifies relaxation of the First Revised Order dated February 20, 2004, within 30 days after the NRC informs the licensee of an NRC-approved crack growth formula. If the licensee's revised analysis shows that the crack growth acceptance criteria are exceeded prior to the end of the current operating cycle, this relaxation is rescinded and the licensee shall, 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, the licensee shall, 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, the licensee shall, within 30 days submit a letter to the NRC confirming that its analyses 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: November 23, 2004