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PG&E Letter DCL-10-065

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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Docket No. 50-275, OL-DPR-80
Docket No. 50-323, OL-DPR-82
Diablo Canyon Units 1 and 2
Supplement to Response to NRC Request for Additional Information Regarding License Amendment Request 09-06, "Critical Damping Value for Structural Dynamic Qualification of the Control Rod Drive Mechanism Pressure Housings" (TAC Nos. ME2995 and ME2996)

Reference:
1. PG&E Letter DCL-09-86, "License Amendment Request 09-06, 'Critical Damping Value for Structural Dynamic Qualification of the Control Rod Drive Mechanism Pressure Housings,'" dated December 14, 2009. (ADAMS Accession No. ML093580092)
2. PG&E Letter DCL-10-045, "License Amendment Request 09-06, 'Critical Damping Value for Structural Dynamic Qualification of the Control Rod Drive Mechanism Pressure Housings,'" dated April 23, 2010. (ADAMS Accession No. ML10125046)

Dear Commissioners and Staff:

By letter dated December 14, 2009 (Reference 1), Pacific Gas and Electric Company (PG&E) submitted a license amendment request to revise the licensing basis and the Final Safety Analysis Report Update (FSARU) to allow use of a damping value of 5 percent of critical damping for the structural dynamic qualification of the control rod drive mechanism pressure housings on the replacement reactor vessel head for the design earthquake, double design earthquake, Hosgri earthquake, and loss-of-coolant accident (LOCA) loading conditions.

On April 15, 2010 (ADAMS Accession No. ML101050521), the NRC staff requested additional information required to complete the review of LAR 09-06. PG&E's responses to the staff's questions are provided in Reference 2.

Subsequent to the submittal of Reference 2, PG&E performed a reanalysis of the Control Rod Drive Mechanisms for the Hosgri earthquake horizontal direction loads. The reanalysis was performed in response to an analysis methodology issue. The reanalysis affected PG&E's response to NRC Question 1. A revised response to NRC Question 1 is provided in the enclosure to this letter. This response supersedes the same numbered response provided in Reference 2.

This information does not affect the results of the technical evaluation or the no significant hazards consideration determination previously transmitted in Reference 1.

PG&E makes no regulatory commitments (as defined by NEI 99-04) in this letter. This letter includes no revisions to existing regulatory commitments.

If you have any questions, or require additional information, please contact Tom Baldwin at (805) 545-4720.

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

Executed on June 11, 2010.

Sincerely,

James R. Becker
Site Vice President

tcg4231 50276288
Enclosure
cc: Diablo Distribution
cc/enc: Gary W. Butner, Acting Branch Chief, California Department of Public Health
Elmo E. Collins, NRC Region IV
Michael S. Peck, NRC, Senior Resident Inspector
Alan B. Wang, Project Manager, Office of Nuclear Reactor Regulation

Supplement to PG&E Response to NRC Request for Additional Information Regarding License Amendment Request (LAR) 09-06, "Critical Damping Value for Structural Dynamic Qualification of the Control Rod Drive Mechanism Pressure Housings"

NRC Question 1:

Please provide the following information:

(a) Provide a summary of the recent analysis results for the new CRDM pressure housing based on a 5% critical damping value for all load combinations that contain DE, DDE, HE, and LOCA loadings, showing the respective margins.

(b) Provide a brief description of the structural dynamic analysis methodology used in the qualification of the CRDM pressure housings on the replacement reactor vessel head.

(c) Provide, for comparison, a summary of lower damping values used in the original CRDM analysis and a summary of the design basis analysis results, with the respective margins.

(d) Clarify that the higher 5% critical damping value will only be applied to the CRDMs, and will not be applied to the reactor coolant piping or reactor internals analyses.

PG&E Response:

(a) The following tables summarize the recent analysis results for the new control rod drive mechanism (CRDM) pressure housing based on a 5 percent critical damping value for all load combinations that contain design earthquake (DE), double design earthquake (DDE), Hosgri earthquake (HE), and loss-of-coolant accident (LOCA) loadings. The interaction ratio is the calculated value divided by the allowable value. Interaction ratios below 1.0 represent margin. The values are bounding for both units.

Table 1: Rod Travel Housing Stresses

ASME Classification	Calculated Value	Allowable Value	Interaction Ratio
Local Primary Membrane + Primary Bending Stress (DE Load Combination)	13.06 ksi	24.3 ksi	0.54
Local Primary Membrane + Primary Bending + Secondary Stress (DE Load Combination)	39.74 ksi	48.6 ksi	0.82
Fatigue Usage Factor (DE Load Combination)	.004	1.0	0.004
Local Primary Membrane + Primary Bending Stress (DDE + LOCA Load Combination)	36.91 ksi	58.3 ksi	0.63
Local Primary Membrane + Primary Bending Stress (DDE Load Combination)	17.32 ksi	58.3 ksi	0.30
Local Primary Membrane + Primary Bending Stress (HE Load Combination)	28.76 ksi	58.3 ksi	0.49

Table 2: Latch Housing Stresses

ASME Classification	Calculated Value	Allowable Value	Interaction Ratio
Local Primary Membrane + Primary Bending Stress (DE Load Combination)	22.01 ksi	24.3 ksi	0.91
Local Primary Membrane + Primary Bending + Secondary Stress (DE Load Combination) Note: Secondary Stress Excludes Thermal Bending Stress per ASME Simplified Elastic-Plastic Analysis Rules	18.71 ksi	48.6 ksi	0.38
Fatigue Usage Factor (DE Load Combination)	0.033	1.0	0.033
Local Primary Membrane + Primary Bending Stress (DDE + LOCA Load Combination)	54.74 ksi	58.3 ksi	0.94
Local Primary Membrane + Primary Bending Stress (DDE Load Combination)	39.29 ksi	58.3 ksi	0.67
Local Primary Membrane + Primary Bending Stress (HE Load Combination)	49.37 ksi	58.3 ksi	0.85

Table 3: CRDM Nozzle between Top of Head and Dissimilar Metal Weld

ASME Classification	Calculated Value	Allowable Value	Interaction Ratio
Local Primary Membrane + Primary Bending Stress (DE Load Combination)	26.64 ksi	34.9 ksi	0.76
Local Primary Membrane + Primary Bending + Secondary Stress (DE Load Combination)	66.77 ksi	69.9 ksi	0.96
Fatigue Usage Factor (DE Load Combination)	0.003	1.0	0.003
Local Primary Membrane + Primary Bending Stress (DDE + LOCA Load Combination)	71.43 ksi	83.8 ksi	0.85

Note: The DDE + LOCA load combination loads are larger than the HE load combination loads.

Table 4: CRDM Nozzle at J-Groove Weld

ASME Classification	Calculated Value	Allowable Value	Interaction Ratio
Local Primary Membrane + Primary Bending Stress (DE Load Combination)	25.88 ksi	35.0 ksi	0.74
Local Primary Membrane + Primary Bending + Secondary Stress (DE Load Combination)	66.77 ksi	69.9 ksi	0.96
Fatigue Usage Factor (DE Load Combination)	0.282	1.0	0.282
Local Primary Membrane + Primary Bending Stress (DDE + LOCA Load Combination)	67.47 ksi	83.9 ksi	0.80

Note: The DDE + LOCA load combination loads are larger than the HE load combination loads.

(b) The following provides a brief description of the structural dynamic analysis methodology used in the qualification of the CRDM pressure housings on the replacement reactor vessel head:

The DE and DDE horizontal direction seismic loads, acting on the CRDMs, were determined using finite element models and nonlinear seismic time history methods. For Unit 2, a center row of five CRDMs was modeled to include the effects of different CRDM lengths due to the curvature of the reactor head. For Unit 1, a center row of seven CRDMs was modeled. This approach is conceptually consistent with the approach used to determine seismic loads in the original CRDM seismic analysis.

The finite element models included nonlinear spring elements to represent the gaps and contact between the seismic plates (near the tops of the CRDM rod travel housings) and to represent the contact between the outer seismic plates and the seismic stop plates. A linear spring was also included to represent the combined tie-rod and Integrated Head Assembly (IHA) stiffness connection to the wall. The IHA was included in the models as a vertical beam connecting the Reactor Vessel Closure Head (RVCH) to the tie-rod spring. An IHA horizontal beam was included to connect the IHA vertical beam to the seismic stop plates.

Time history input motions for the CRDM DE and DDE horizontal earthquake analyses were developed at the RVCH elevation and at the elevation corresponding to the tie-rod/IHA connection to the wall. The time history input motions at the tie-rod/IHA connection elevation were used to generate acceleration response spectra for comparison to existing response spectra at this same elevation. The generated response spectra enveloped the existing response spectra at all frequencies within the CRDM response frequency range. Time history input motions at the RVCH were developed by Westinghouse for use by AREVA who supplied and qualified the replacement RVCH, IHA, and CRDMs.

The time history inputs and CRDM models were used with the ANSYS structural analysis program to determine seismic forces acting on the CRDMs along their lengths due to DE and DDE horizontal direction earthquakes. The analyses used ANSYS Beta damping corresponding to 5 percent of the critical damping ratio for the CRDMs. Analyses show the CRDM fundamental frequency range is 5 to 8 Hz and the dominant frequencies of response are below 10 Hz. Therefore, a conservative value of 10 Hz was used to determine the CRDM Beta damping value used in the analyses.

The HE horizontal direction seismic forces and the vertical direction seismic forces for DE, DDE, and HE were determined using linear elastic response spectra methods. The response spectra analyses included the center CRDM (the shortest) and a peripheral CRDM (the longest) to envelope the results for all CRDMs. Vertical direction 5 percent damping response spectra at the RVCH elevation were used for the vertical direction seismic analyses since the CRDMs are supported vertically only at the RVCH elevation. The HE horizontal direction seismic analysis used 5 percent damping response spectra at the RVCH elevation and the elevation of the seismic plates. To account for gaps between the seismic plates, a static analysis was also performed using a forced horizontal direction displacement at the CRDM seismic plate elevation that corresponds to the maximum cumulative gap.

The resulting seismic forces acting on the CRDMs due to both vertical and horizontal DE, DDE, and HE earthquakes were used with CRDM physical properties to determine seismic stresses acting on the CRDM. The seismic stresses were combined with other applicable stresses such as pressure and thermal to determine the total combined stress for each applicable load combination. The combined stresses were determined at each critical location along the length of the CRDM assembly including locations along the rod travel housing, latch housing, and CRDM penetration into the RVCH. These stresses were then evaluated for acceptance per Section NB-3200 of the ASME Boiler and Pressure Vessel Code 2001 Edition through 2003 Addendum. This Code was satisfactorily reconciled to the original CRDM code of record.

(c) The original CRDM analysis was performed for the DDE by Westinghouse using the nonlinear time history analysis method with stiffness damping corresponding to 3 percent of the critical damping. DDE loads were determined to be larger than the HE loads and therefore the DDE results bound the HE results. The DDE analysis was also used to qualify the CRDMs for the DE loads. A separate DE or HE analysis was not performed.

The following tables provide the original and replacement CRDM seismic analysis methods and damping values and summarize the results from the original CRDM analysis along with allowable values and interaction ratios. The interaction ratio is the calculated value divided by the allowable value. Interaction ratios below 1.0 represent margin.

Table 5: Original and Replacement CRDM Seismic Analysis Method and Damping Values (% Critical Damping)

		DE		DDE		HE	
		Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical
Original CRDM	Analysis Method	Non-linear Time History (Note 1)	Static Equivalent	Non-linear Time History	Static Equivalent	(Note 2)	Static Equivalent
	Damping	3%	(Note 3)	3%	(Note 3)	4%	(Note 3)
Replacement CRDM	Analysis Method	Non-linear Time History	USM[4] Response spectra	Non-linear Time History	USM[4] Response spectra	USM[4] Response spectra	USM[4] Response spectra
	Damping	5%	5%	5%	5%	5%	5%

1 The DDE analysis was used to qualify the CRDMs for DE (Used DE allowables).

2 The DDE input response spectra envelopes the HE input response spectra as described in DCPP FSARU Section 3.7.3.15.3.

3 The CRDM fundamental frequency in the vertical direction is approximately 100 Hz (ie: rigid). A static equivalent method vertical load per DCPP FSARU Section 3.7.2.1.5 was used to evaluate the CRDM nozzle between the top of the head and the dissimilar metal weld. Damping is not applicable to this analysis methodology.

4 USM refers to the use of Uniform Support Motion (Enveloped Spectra) as input to the response spectra analysis.

Table 6: Rod Travel Housing and Latch Housing Loads

Location and Load	Calculated Value	Allowable Value	Interaction Ratio
Rod Travel Housing DDE Moment	64 in-kip	73 in-kip	0.88
CRDM Latch Housing DDE Moment	140 in-kip	670 in-kip	0.21

Table 7: CRDM Nozzle between Top of Head and Dissimilar Metal Weld

ASME Classification	Calculated Value	Allowable Value	Interaction Ratio
Primary Membrane + Primary Bending Stress (DE Load Combination)	23.67 ksi	23.98 ksi	0.99
Primary Membrane + Primary Bending + Secondary Stress (DE Load Combination)	68.40 ksi	69.9 ksi	0.98
Fatigue Usage Factor (DE Load Combination)	0.002	1.0	0.002
Local Primary Membrane + Primary Bending Stress (DDE + LOCA Load Combination)	55.73 ksi	58.32 ksi	0.96

Table 8: CRDM Nozzle at J-Groove Weld

ASME Classification	Calculated Value	Allowable Value	Interaction Ratio
Local Primary Membrane + Primary Bending Stress (DE Load Combination)	24.35 ksi	34.48 ksi	0.71
Local Primary Membrane + Primary Bending + Secondary Stress (DE Load Combination)	50.21 ksi	69.9 ksi	0.72
Fatigue Usage Factor (DE Load Combination)	0.191	1.0	0.191
Local Primary Membrane + Primary Bending Stress (DDE + LOCA Load Combination)	56.34 ksi	83.88 ksi	0.67

(d) The higher 5 percent critical damping value per this LAR will only be applied to the CRDMs and will NOT be applied to the reactor coolant piping or reactor internals analyses. The original analysis seismic model included the reactor vessel and internals along with the CRDMs and seismic support platform. As discussed above, the new seismic model includes the CRDMs and the IHA that incorporates a seismic support platform but the model ends at the reactor vessel closure head. Time History and response spectra inputs are developed by Westinghouse at the reactor vessel closure head for use in the new CRDM analysis. Regulatory Guide 1.61 Revision 1 damping is used for the IHA and associated components. As discussed with the NRC staff, a LAR will be submitted to obtain NRC approval to use these damping values. Damping values for the reactor vessel internals and reactor piping are unchanged from the original analyses.