Central files

PACIFIC GAS AND ELECTRIC COMPANY

PG&E

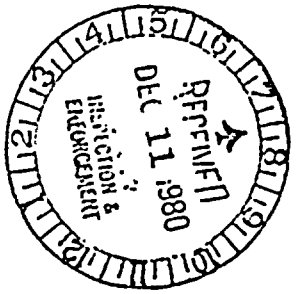
P. O. BOX 7442 • 77 BEALE STREET, 31ST FLOOR, SAN FRANCISCO, CALIFORNIA 94106
TELEPHONE (415) 781-4211 TELECOPIER (415) 543-7813

MALCOLM H. FURBUSH
VICE PRESIDENT AND GENERAL COUNSEL
ROBERT OHLBACH
ASSOCIATE GENERAL COUNSEL
CHARLES T. VAN DEUSEN
PHILIP A. CRANE, JR.
HENRY J. LaPLANTE
JOHN B. GIBSON
ARTHUR L. HILLMAN, JR.
CHARLES W. THISSELL
DANIEL E. GIBSON
ASSISTANT GENERAL COUNSEL

GILBERT L. HARRICK
GLENN WEST, JR.
JOSEPH F. KELLY
HOWARD V. GOLUB
JAMES C. LOBDON
ROBERT L. RUBDEN
PETER W. HANSEMEN
RICHARD F. LOCKE
DAVID L. LUDWIDSON
EDWARD J. McDANNEY
DAN GRAYSON LOBDELL
JAMES F. FALLIN, JR.
BERNARD J. DELLABANTA
JOSHUA BAR-LEV
JOSEPH B. ENGLERT, JR.
ROBERT L. HARRIS
DOUGLAS A. DOTTSBY
SENIOR COUNSEL

DAVID W. ANDERSON
DIANA BERGHAUSEN
LEIGH B. CASSIDY
AUDREY DAINES
WILLIAM H. EDWARDS
DONALD D. ERICKSON
DAVID C. GILBERT
STEVEN F. GREENWALD
JOAN M. HAYD
F. RONALD LAUPHEIMER
HARRY W. LONG, JR.
A. KIRK MCKENZIE
RICHARD L. MEIRD
ROGER J. PETERS
ROBERT R. RICKETT
SHIRLEY A. SANDERSON
JO ANN SHAFFER
LOUIS E. VINCENT
SHIRLEY A. WOO
KENNETH YANG
J. PETER BAUMGARTNER
STEVEN P. BURKE
PAMELA CONSTABILE
MICHAEL G. DESMARAIS
DARY P. ENGINAS
JOHN N. FRYE
PATRICK D. DOLOGEN
PAULA Y. HAYNES
RICHARD C. JONES
MEREK E. LIPSON
JOHN R. LOW
ROBERT B. MCLENNAN
RICHARD H. MOSS
J. MICHAEL REIDENBACH
IVOR E. SAMSON
SUE ANN LEVIN SCHIFF
JACK W. SHUCK
DAVID J. WILLIAMSON
BRUCE R. WORTHINGTON
ATTORNEYS

December 3, 1980



Mr. R. H. Engelken, Director
Office of Inspection and Enforcement
Region V
U. S. Nuclear Regulatory Commission
1990 N. California Boulevard
Walnut Creek Plaza, Suite 202
Walnut Creek, CA 94596

Re: Docket No. 50-275-OL
Docket No. 50-323-OL
Diablo Canyon Units 1 and 2

Subject: NRC IE Bulletin 79-02 Rev. 2

References:
(a) PG&E Letter to NRC, July 20, 1979
(b) PG&E Letter to NRC, September 19, 1979
(c) NRC Letter to PG&E, November 28, 1979
(d) PG&E Letter to NRC, February 14, 1980
(e) Diablo Canyon Units 1 and 2
Report on Inspection, Tests, Analysis and Rework of Seismic Category I Pipe Supports with Concrete Expansion Anchor Bolts.
(f) NRC Letter to PG&E, October 9, 1980

Dear Mr. Engelken:

This letter contains two attachments which complete our response to IE Bulletin 79-02 and which further answer questions raised in References (c) and (f). Attachment I is a summary of the actions taken, and is organized according to the questions raised in Reference (c).

Attachment II is a detailed report on the inspection, tests, analysis, and rework performed, and is referred to in Attachment I as Reference (e).

A0 2

8101 111

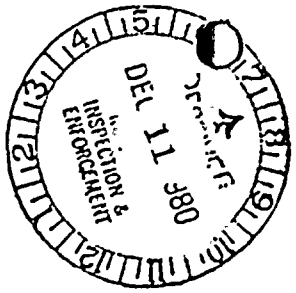
Kindly acknowledge receipt of this material on the enclosed copy of this letter and return it to me in the enclosed addressed envelope.

Very truly yours,

Philip A. Crane, Jr.

Attachments
CC w/attachments: Director
Office of Inspection and Enforcement
Division of Reactor Construction Inspection
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Service List



ATTACHMENT I

BRIEF HISTORY OF PG&E ACTION ON CONCRETE EXPANSION ANCHOR BOLTS

1. In August 1972 PG&E issued Report No. 7745.10-72: "Static and Dynamic Loading of 5/8-inch Concrete Anchors". It has been submitted to NRC with Ref. (b).

2. In December 1976 PG&E issued "Procedure for Establishing Acceptance Criteria for Concrete Anchor Installations - Diablo Canyon Power Plant" also submitted to NRC with Ref. (b).

3. The 1976 "Procedure" has been implemented by PG&E. The test data, inspection records and anchor rework details have been documented and the documents are available at the jobsite. As a result of this program we have reworked about 10,000 bolts, 6,000 in Unit 1, and 4,000 in Unit 2.

4. In 1980 we retained Teledyne Engineering Services (TES) to:

   a. Review the effect of support baseplate flexibility on anchor bolt loads and check their safety factors as specified in the Bulletin.

   b. Redesign supports that do not meet the Bulletin requirements.

   c. Test Hilti HDI anchor bolts to develop shear/tension interaction curves and fatique-test them to evaluate their adequacy to resist cyclic loading.

RESPONSE TO ACTION ITEMS LISTED IN Ref. (c)

Note: The following numbers correspond to action items listed in the November 28, 1979 NRC letter to PG&E.

1. Base Plate Flexibility .

The base plate flexibility has been taken into account for the calculation of bolt loads. The methods of analysis, mathematical models, bolt load allowables, etc., are described in PART I of Ref. (e).

Due to the large number of supports under review, (about 1700 for Unit 1 and part of Unit 2 north of the Security Barrier, with a total of about 3500 plates), two simple but conservative calculation methods have been used to "screen" the support base plates and determine their anchor bolt loads.

The first level of screening allowed for very low bolt loads to account for plate flexibility and prying action as well as shear-tension interaction.

Those supports not passing the first level of screening were subjected to a second level of screening which was more precise and less conservative. The theory for the development of Level 2 Screening method is included in PART I of Ref. (e).

Supports not passing second level screening were either analyzed by rigorous computer techniques (Finite Element Analysis), or they were modified to achieve acceptable bolt loads.

The modifications consisted of one or more of the following:

a. Plate stiffening with gussets.
b. More bolts - if space allowed.
c. Replace bolts with others of higher strength.
d. Add new members or braces to support.

As a result of the review, about 270 pipe supports (16%) had to be modified to meet the Bulletin requirements. With the completion of modifications, all Seismic Category I pipe supports will have anchor bolts loaded no more than Pu/4 or Pu/5, whichever applies. Pu is the manufacturer's specified ultimate pullout strength of the expansion anchor bolt.

PART I of Ref. (e) contains examples of application of Level 2 screening and Finite Element Analysis on actual Diablo Canyon supports.

2. Safety Factors

The safety factors mandated by the Bulletin have been observed for all anchor bolts of the reviewed pipe supports, i.e.

a. Four - For wedge type anchor bolts
b. Five - For shell type anchor bolts

Those supports found with bolt load safety factors less than the above, have been, or are being modified to conform with the Bulletin.

For the evaluation of the safety factors we have taken into account the effect of shear-tension interaction.

Furthermore we have introduced the following two conservatisms:

a. We have assumed straight-line shear/tension interaction, although the Teledyne tests indicate an elliptical relationship in more realistic (see PART II and PART IV of Ref. (e), and the 1977 ASME Code, Section III, Appendix XVII - 2461.3 allows exponent=2.

b. In most cases we have assumed that half of the bolts of a base plate take the whole shear load.

We have also observed the bolt spacing criteria ($S \geq 10d$) and the minimum concrete edge distance criteria ($E > 5d$). For closely spaced bolts (down to $S=5d$), the bolt allowables have been reduced according to:

$$T' = (S/10d) * T$$

T'=Reduced allowable tensile force
S=Bolt spacing (when $S < 10d$)
d=Bolt diameter
T=Nominal allowable bolt load

The load combination used to calculate the bolt loads and factors of safety included the SSE, which in the case of Diablo Canyon can be either the postulated Hosgri event earthquake, or the Double Design Earthquake (DDE), whichever governs in each case. The analysis of each pipe support was performed for the worst of the two loading cases:

Dead Load + Thermal Load + DDE Load

Dead Load + Thermal Load + Hosgri Seismic Load

3. Cyclic Loading - Anchor Bolt Preload

A. Each Diablo Canyon Seismic Category I piping system has two types of pipe supports:

(a) Supports welded to steel insert plates.

(b) Supports with baseplates attached to concrete surfaces with expansion anchor bolts.

On the average, there are approximately 40% type (a), and 60% type (b) supports installed at Diablo Canyon. The type (b) supports utilize

1. Shell-type expansion anchors; or

2. Wedge-type expansion anchors; or

3. Anchors of both the above types.

Approximately 60% of the anchors used are of the shell-type, and the balance are wedge-type.

B. For the shell-type anchors, the manufacturers do not recommend torque/preload to any specific value. One reason for this is the possibility that excessive torquing can result in failure of the bond between the shell and the concrete due to high torsional shear at the interface. Nevertheless, it is common installation practice to torque/preload even the shell-type anchors. Because specific torquing was not required during installation, torque/preload was not measured or documented.

C. To verify that preload does exist, PG&E has issued "Procedure for for Testing and Inspection of Shell-Type Concrete Fasteners - As Installed" Part III of Ref. (e). NOTE: This procedure supplements the 1976 "Procedure for Establishing Acceptance Criteria for Concrete Anchor Installations - Diablo Canyon Power Plant" Attachment 4 in Ref. (b).

The above procedure has established an experimental torque/tension correlation for the following anchors:

1. Phillips Self-Drilling: 1/2", 5/8", 3/4" and 7/8"

2. Hilti HDI: 1/2", 5/8" and 3/4"

3. Phillips Wedge Anchors: 1/2", 5/8", 3/4", 7/8", 1" and 1-1/4"

4. Hilti Kwik Bolts: 1/2", 5/8", 3/4", 1" and 1-1/4"

D. The tabulated results of the testing are given in Appendix C of the above procedure.

Of 213 randomly selected shell-type anchor bolts:

1. 90% were found to have preload at or above Pu/5.

2. 99% were found to have preload at or above their design load.

These tests were performed on accessible and removable hangers to avoid the time and expense of cutting out and rewelding hanger members. During the testing we experienced three loss-of-bond type failures. With the exception of these three failures, the existence of the torque/preload which is greater than the design load was verified in every case. We do not plan to extend the testing beyond the number of anchor bolts tested.

E. An additional parameter of the above test procedure was the verification of gap between the anchor shell and the back of baseplates. Of the 213 bolts tested, 25% of the anchor shells were in contact with the back of the baseplates. However, the maximum measured shell slippage at preload (Pu/5) was 0.008", with 88% of the shells measuring no slippage whatsoever. Because of this negligible shell slippage at preload, we feel that preload is achieved regardless of shell contact with the back of baseplates.

F. As outlined above, there are both Phillips Wedge Anchors and Hilti Kwik Bolts installed at Diablo Canyon. Though Hilti Kwik Bolts do not have a manufacturer's specified installation torque, the torque values specified in the 1973 edition of the Phillips Redhead Anchoring System Catalog have been applied for both Phillips Wedge Anchors and Hilti Kwik Bolts since August of 1977. For the Kwik Bolt installations prior to August of 1977, on the basis of the above mentioned torque/preload test results for shell-type anchors, an "average fitter installation torque", or a torque resulting from a manufacturer's specified three or four turns of the nut will guarantee an adequate preload.

4. Verification of Proper Installation

Our existing Q.A. documentation and the data obtained from our extensive 1976/1977 reinspection program prove that Bulletin design requirements are fulfilled for all anchor bolt installations.

Following are the inspection parameters which assure that the Diablo Canyon anchor bolts are installed in a manner that provides the required factors of safety.

A. Bolt Spacing/Edge Distance

Up until the implementation of the 79-02 criteria, all anchor bolt installations at Diablo Canyon have been governed by PG&E Drawing 054162. Reference (b). The original revision of this document required that, unless otherwise specified in the hanger design drawing, bolt spacing shall be limited to 12 diameters and concrete edge distance to three inches minimum. Later revisions of this drawing specified that anchor spacing shall not be less that six times the nominal anchor diameter.

This drawing is first referenced in the June 1974 revision of Pullman Power Products ESD-223*, Section 2.8.2. Deviations from the above criteria have been incorporated into the 79-02 analysis of the affected hangers.

B. Base Plate Bolt Hole Size

The requirements to drill anchor bolt holes in base plates according to the drawing has been in existence since 1973. (Per Pullman Power Products ESD-223, Section 2.10.1, dated 12-17-73.)

Though hanger design drawings have typically specified bolt holes as 1/16" oversize, a tolerance to drill 1/8" oversize holes was granted because of the extreme difficulty of drilling and setting anchor bolts to within a 1/16" tolerance. Any oversized or elongated bolt holes that are in violation of the 1/8" tolerance have been fitted with welded washers or fish plates as required and as-built. (Per Pullman Power Products ESD-223, Section 2.10.1, dated 6-20-74.)

C. Thread Engagement

The thread engagement criteria for shell-type anchors is four threads of engagement minimum. (Per Pullman Power Products Quality Assurance Instruction Number 98**, Section 6.3.7, Revision 0 dated 1-21-77. This instruction preceded the implementation of the 1977 anchor reinspection program.)

*Engineering Design Specification - "Installation and Inspection of Class I Pipe Supports."

**"Procedure for Inspection of Existing Concrete Expansion Anchor in Hanger Installations"

C. (Continued)

For a comparison between four threads and the number of nominal diameters of thread engagement by anchor size, see the table below:

(A) Shell Size	(B) # Threads/Inch	4/(A)x(B)= # Diameters Engagement
1/2	13	0.62
5/8	11	0.58
3/4	10	0.53
7/8	9	0.51

Per J. E. Shigley, "Mechanical Engineering Design" 3rd Edition, Section 6-8, page 252, full bolt strength will be achieved with only three full threads of engagement.

D. Shell-Anchor Embedment Depth and Degree of Expansion

The December 1976 "Procedure for Establishing Acceptance Criteria for Concrete Anchor Installations was submitted to the NRC with our letter of September 19, 1979. Reference (b). This procedure determined the extent that a shell-type concrete anchor (either Hilti HDI or Phillips Redhead Self-Drilling) could deviate from an optimum installation, yet meet the design load requirements in existence at that time. These imperfect installations affect both embedment depth and degree of shell-type anchor expansion.

The implementation of the above procedure resulted in a 100% reinspection program, with anchors falling outside the acceptance criteria being reworked or replaced if necessary. For those concrete anchors in floor-mounted baseplates, stud-type anchors were installed adjacent to the shells in order to eliminate the costly operation of chipping the grout out from under the baseplate so the required reinspections could be performed. The total number of anchors reworked amounts to approximately 10,000 bolts, with 60% of those in Unit I and the balance in Unit II.

Though this procedure and rework program satisfactorily fulfilled the 1976/1977 design requirements, it did not satisfy the new factors of safety required by the 79-02 Bulletin. Additionally, the scope of the 1976/1977 testing program was too narrow to develop conclusions about the ultimate capacity of imperfectly installed shell-type anchors.

For these reasons, PG&E issued a "Procedure for Developing Ultimate Pullout Capacity Criteria for Imperfectly Installed Shell-Type Concrete Anchors at Diablo Canyon". Reference (e), Part V This procedure supplements the 1976/1977 program, but allows for the determination of the factors of safety afforded by imperfect anchor installations.

D. (Continued)

From the above procedure, ultimate pullout capacities were determined for shell-type anchors (both Hilti and Phillips) with plug depths covering the entire tolerance range considered acceptable in 1976/1977. These ultimate capacities were divided by five so a comparison between anchor bolt design loads and the maximum allowable pullout for imperfectly installed anchors could be made.

With this criteria established, a sample of four large bore hanger series were randomly selected from the 1976/1977 anchor reinspection data. These hangers (a total of 89) covered the following areas:

Series 11 - Unit I, Area F above El. 117'.
Series 15 - Unit I, Area GE-GW above El. 98'.
Series 41 - Unit I, Area F, at El. 107'.
Series 74 - Unit I, Area H, at El. 85'.

The sample included a total of 469 bolts from the following systems:

*Reactor Coolant System	28 bolts
*Safety Injection System	106 bolts
*Residual Heat Removal System	107 bolts
*Component Cooling Water System	136 bolts
*Chemical & Volume Control System	44 bolts
*Feedwater System	4 bolts
*Turbine Steam Supply System	24 bolts
Liquid Radwaste System	16 bolts
Ventilation & Air Conditioning System	4 bolts

Of the 469 bolts, only 10 bolts failed to provide a factor of safety of five above the design load. Of these 10 bolts, the minimum factor of safety afforded was 4.3. We feel this sample overwhelmingly confirms the adequacy of the existing shell-type anchor installations.

5. Anchor Bolts in Concrete Block Walls

At Diablo Canyon no supports of Seismic Category I piping systems are mounted on concrete block walls using expansion anchor bolts.

6. PG&E Drawing 054162 - Option to Increase Bolt Load Allowables

The review, reanalysis and modification of supports to conform with the NRC IEB 79-02 criteria makes this question moot.

*Safe Shutdown System

7. Inspection of Stud-Type Anchor Bolts

Prior to 1977, the type of anchor bolt installed was almost exclusively the shell-type. The use of stud-type anchor bolts began essentially with the implementation of the Anchor Reinspection Program (Ref. b) and the policy of installing adjacent stud-type anchors to replace unacceptable shell-type anchors.

Stud-type anchors installed as a result of the Anchor Reinspection Program were installed in accordance with the manufacturer's recommended procedure as per Pullman Power Products Quality Assurance Instruction Number 98, Section VI, Paragraph A, Revision 0 dated January 21, 1977. This instruction mandated a Quality Assurance inspection and acceptance of the hole diameter, hole alignment and anchor embedment depth. In the case of Phillips Wedge Anchors, verification of an installation torque per the manufacturer's requirements is also performed. (See above Section 3, Paragraph F).

Other inspection parameters, applicable to both shell and stud-type anchors, have been previously described in Section 4 above.

We feel the above and previously described inspection criteria satisfactorily confirms that our stud-type anchor installations meet the Bulletin design requirements.