Enclosure 1

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

PACIFIC GAS AND ELECTRIC COMPANY

DIABLO CANYON NUCLEAR POWER PLANT, UNITS 1 AND 2

RESOLUTION OF ALLEGATIONS ON HITI ANCHOR BOLTS

DOCKET NOS. 50-275 AND 50-323

1.0 INTRODUCTION

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Region V requested NRR assistance to resolve allegations on Hilti anchor bolts at Diablo Canyon Nuclear Power Plant, Units 1 and 2, on March 3, 1987. Telephone conferences had been held between the NRR staff and the alleger before the allegations were formally submitted to NRR, dated July 24, 1987. The staff reviewed the allegations and determined that they could be categorized into two technical issues. One is that the excessive embedment length of some bolts had caused a cone shaped volume of concrete to pop out from the opposite side of a ceiling slab directly under the bolt. The other is whether the bolts on opposite sides of concrete slabs have ever been designed and detailed for proper spacing.

With respect to the excessive embedment length issue, the specific bolts cited by the alleger were located in Area: GE, Elevation: 85, Column/Line: T & 12, Support 55S/41A, on Revision 4 of Drawing #049258, Line 1-K-106-18 C, Sys. #14. The alleger reported that a cone shaped section of concrete popped out of the ceiling directly under three of the Kwik bolts as they were being set or torqued. He also reported that these bolts were designed to have a minimum embedment length of $10\frac{1}{2}$ inches in a 12 inch thick concrete floor. The alleger questioned the design adequacy of such long embedment lengths of bolts; because the embedment lengths used have exceeded the ones recommended by the manufacturer in its recently published Hilti Anchoring Manual.

With respect to the anchor spacing issue, it was reported that while drilling bolt holes for hanger 44-79R in the intake structure, the drill encountered the back end of an abandoned anchor bolt for hanger 44-78R. The alleger questioned whether the bolts on both sides of a floor slab had ever been designed for the two adjacent bolts located and pulled in the opposite directions, and detailed on the drawings for proper spacing. The alleger believed that the concrete between two adjacent bolts would be stressed less favorably when the bolts were located and pulled in the opposite directions of a floor than the case in which the bolts were located on and pulled from the same direction. The alleger questioned how the safe spacing between bolts was established by the licensee when the adjacent bolts were located and pulled in the opposite directions.

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The staff was convinced that additional information including bolt capacity related research data is needed to resolve the two technical issues. Therefore, the staff requested the licensee to address the issues, and at the same time contacted the anchor bolt manufacturer, Hilti inc., for specific research information pertinent to resolution of the issues.

Responses submitted by the licensee and research information furnished by Hilti have contributed to the resolution of the issues. The bases for the resolution are discussed in Section 2, and the staff conclusion is stated in Section 3.

2.0 EVALUATION

The licensee submitted its response on the two technical issues on November 12, 1987. The licensee stated, in the submittal, that only anchor bolts that can be set to the required installation torque were used. In a submittal, dated June 1, 1984, related to the same issue, the licensee had acknowledged that the concrete spalling did occur either during hammering the bolt into the hole or during the torque-setting operation. Inspite of the spalling, the anchor bolts held the design torque of 360 ft-lb and, therefore, were accepted, and the spalled areas were repaired. Furthermore, the licensee believes that the concrete that resists the pulling force from the steel anchor bolt is from the baseplate to the tip of the bolt, and is, therefore, unaffected by any concrete spalling on the surface opposite to the baseplate. The staff agrees with the licensee on this reasoning. The staff further agrees with the licensee's acceptance criterion for anchor bolts i.e. only anchor bolts that can be set to the required installation torque are used. Therefore, the use of some bolts with excessive embedment length, which has caused occasional concrete spalling on the opposite side of the slab directly under the bolt, may be undesirable with respect to appearance, but has no structural safety concern because the bolt could still hold 360 ft-lb torque as designed. Since the thickness of the spalled concrete in the direction of the depth of the slab is only one and one-half inches and the volume of the cone-shaped hole on the backside of the bolts is small, the strength of the slab containing a few such small holes is virtually unaffected. In addition, the licensee filled the holes with dry-pack grout, which is consistent with the industry practice and is acceptable.

Test reports furnished by the Hilti bolt manufacturer have indicated that tests were made using two 3/4 inch x 10 inch bolts with 7½" embedments installed from opposite sides of a 12 inch thick reinforced concrete wall with centerline-to-centerline spacings at 3, 2, and 1½ anchor bolt diameters. Test results have indicated that there is no significant lowering of ultimate tensile load capability (less than 10%) of Hilti anchor bolts when the anchor spacing was reduced from 3 bolt diameters to 1½ bolt diameters. A reduction in ultimate strength of 10% for expansion anchor bolts is insignificant because the ultimate strength is usually about 400% or 500% of the design. Based on the test results, the staff can conclude that those Hilti bolts at Diablo Canyon plant installed from opposite

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sides of a concrete structural element, spaced more than 1½ times bolt diameters, centerline-to-centerline, can be considered as properly spaced. Since there is no test data for bolts installed from opposite sides of a wall, spaced less than 1½ bolt diameters, available or known to the staff, it is not known whether there will be a sharp reduction in the bolt holding strength when the bolt spacing is less than 1½ bolt diameters.

In the November 12, 1987 submittal, the licensee stated that anchor bolt locations and types of anchors to be installed were shown on design drawings and the as-built drawings were reviewed and accepted by PG&E engineering, but no installation procedures were written for anchor locations on opposite sides of concrete structural elements. The licensee determined that the anchor bolt installation procedures did not need to address the spacing of adjacent bolts in the opposite directions for the following reasons: (1) Thin concrete slabs, concurrent with deep. embedments from opposite sides, and near back-to-back anchor bolts is a rare configuration, (2) the simultaneous loading of adjacent bolts from opposite sides of a structural element to their maximum design load in tension is extremely unlikely, and (3) the allowable bolt loads used at Diablo Canyon plant are conservative. The staff believed that the stated reasons might be qualitatively correct but were quantitatively insufficient to resolve the spacing issue. Therefore, the staff requested that the justification of bolt integrity be supported by sample inspections and calculations. Furthermore, the staff requested that the downgraded bolt strengths for some of Hilti bolts with deep embedments provided in the NRC IE Information Notice No. 86-94 be considered for its applicability for the sample calculations.

The licensee stated in its May 11, 1988 submittal that it had reviewed its bolt design and the NRC IE Information Notice No. 86-94. The review results indicated that the design of bolts other than those in the pipe supports was based on the allowable strengths corresponding to minimum embedment lengths and, thus, the NRC IE Information Notice No. 86-94, which is only applicable to bolts with deep embedments, had no impact on the design. The review results also indicated that only four out of 1500 pipe supports, which were sampled, had taken credits for the additional bolt strengths beyond the strengths corresponding to minimum embedment lengths. However, a factor of safety of at least 4 was still demonstrated for the bolts of those four pipe supports after the downgraded bolt strengths as indicated in NRC IE Information Notice No. 86-94 were used. The staff concurs with the licensee's assertion that the NRC IE Information Notice No. 86-94 had no adverse impact on the bolt integrity at Diablo Canyon Units 1 and 2.



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The licensee submitted the results of sample inspections of bolts located back-to-back in walls and slabs on June 9, 1989. The licensee had inspected approximately 980 expansion anchor bolts, about 30% of the expansion bolts in walls and slabs, with thickness equal to or less than 12 inches, which contained expansion anchor bolts on both faces. The inspection results revealed the following:

- ° For expansion anchor bolts greater than 1/2 inch diameter, there are no back-to-back expansion anchor bolts having centerline-to-centerline spacings less than 1-1/2 diameters.
- * For a combination of two back-to-back expansion anchor bolts, one greater than 1/2 inch diameter and one equal to 1/2 inch diameter, there are no back-to-back expansion anchor bolts having centerline-to-centerline spacings less than 1-1/2 diameters.
- [°] For 1/2 inch diameter expansion anchor bolts, there is only one pair of back-to-back expansion anchor bolts having centerline-to-centerline spacing less than 1-1/2 diameters. One bolt has been abandoned, which does not support any load; the other is one of four bolts used to support a 3/4 inch diameter electrical conduit and the factors of safety of these four bolts are very large (>4).
- For expansion anchor bolts less than 1/2" diameter, since the maximum specific embedment does not exceed half the specified concrete thickness, back-to-back expansion anchors do not overlap.

From the above results of the sample inspection the licensee has concluded that back-to-back expansion anchor bolts that overlap in thin walls and slabs are rarely found at Diablo Canyon. In one case where such a condition exists, evaluation showed that existing design margins can accommodate the design and functional requirements of those anchor bolts.

3.0 CONCLUSION

Based on the research results furnished by Hilti bolt manufacturer, licensee responses to earlier staff questions and the results of the recent sample inspections and calculations performed by the licensee for walls and slabs with thickness less than 12 inches, the staff concludes that the allegations on the expansion anchor bolts at Diablo Canyon Units 1 and 2 have been satisfactorily resolved.

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