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Director, Nuclear Reactor Regulation
Att Mr Dennis M Crutchfield, Chief
Operating Reactors Branch No 5
US Nuclear Regulatory Commission
Washington, DC 20555

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PALISADES PLANT - FINAL RESPONSE TO
IE BULLETIN 79-02

IE Bulletin 79-02, Pipe Support Base Plate Designs Using Concrete Expansion Anchor Bolts, requested that pipe support base plates using concrete expansion anchor bolts be tested.

We have provided interim information on this bulletin as shown in Appendix A. The inspection, testing, and evaluation of seismic Category I piping base plates or structural steel shapes, and concrete expansion anchor bolts has been completed. The "Final Response to US NRC IE Bulletin 79-02 and Its Revisions for Consumers Power Company Palisades Nuclear Plant," report is being transmitted to you as Enclosure 1 of this letter.

David P Hoffman

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Nuclear Licensing Administrator

CC Director, Region III, USNRC
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Attachments Appendix A
Enclosure 1

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APPENDIX A

1. IE Bulletin 79-02, dated March 8, 1979.
2. Letter from D P Hoffman (CP Co) to J G Keppler (Region III), dated March 29, 1979.
3. IE Bulletin 79-02, Rev 1, dated June 21, 1979.
4. Letter from D P Hoffman (CP Co) to J G Keppler (Region III), dated July 6, 1979.
5. IE Bulletin 79-02, Rev 1, Supplement 1, dated August 20, 1979.
6. IE Bulletin 79-02, Rev 2, dated November 8, 1979.
7. Letter from R W Huston (CP Co) to J G Keppler (Region III), dated December 11, 1979.
8. Letter from D P Hoffman (CP Co) to D L Ziemann (Washington, DC), dated February 14, 1980.

ENCLOSURE 1

FINAL RESPONSE TO US NRC IE BULLETIN 79-02

AND ITS REVISIONS

FOR

CONSUMERS POWER COMPANY

PALISADES NUCLEAR PLANT

SOUTH HAVEN, MICHIGAN

July 21, 1980

FINAL RESPONSE TO NRC IE BULLETIN 79-02

AND ITS REVISIONS

CONTENTS

FINAL RESPONSE TO NRC IE BULLETIN 79-02 AND ITS REVISIONS

1. GENERAL

A. INTRODUCTION

This is in response to Nuclear Regulatory Commission (NRC) IE Bulletin 79-02, Revisions 1 and 2, and Supplement 1. It addresses Seismic Category I pipe supports using concrete expansion anchor bolts (CEBs)for loadings obtained from analysis of Seismic Category I piping systems.

The program performed at the Palisades plant included the following elements:

1) Inspection of CEBs to verify acceptable installation

2) Load testing of CEBs

3) Site-specific testing of CEBs to establish torque-tension relationships

4) Evaluation of base plates or structural steel members with CEBs considering support flexibility

5) Modification of base plates or structural steel members, and/or CEBs not satisfying acceptance criteria

The completion of these elements satisfies the intent of the bulletin.

B. SUMMARY

The following summarizes the evaluation performed and the inspection and testing program for base plates or structural steel members and CEBs.

All base plates or structural steel members using CEBs for large piping identified in the course of responding to NRC IE Bulletin 79-14 were evaluated. The evaluation was performed to the load combinations specified in the Palisades plant FSAR. Acceptance criteria were as specified in the bulletin for CEBs and the Palisades plant FSAR for base plates or structural steel members. Those base plates or structural steel members and CEBs which did not satisfy acceptance criteria were modified or will be modified.

All accessible CEBs for large piping within the scope of this bulletin were inspected and load tested. The total number of CEBs in this category is approximately 3,000. The majority of these CEBs were shell type. More than 96 percent of this population satisfied the load testing.

Furthermore, of this population of CEBs, the following percentages satisfied the established inspection criteria noted below.

1) Full expansion of shell type CEBs in order to develop the full design allowable - 81 percent. The site-specific testing performed to define full expansion was addressed in the submittal dated February 14, 1980, to D.L. Ziemann of the NRC from D.P. Hoffman of CPCo.

2) Plate bolt hole size smaller than bolt head dimension - 85 percent. CEBs not satisfying this inspection parameter generally had an installed washer prior to inspection.

3) Thread engagement - 95 percent

Deficiencies noted during the inspection and testing of this population were corrected.

Other inspection parameters, such as embedment depth, bolt spacing, and edge distance to the side of a concrete member, were recorded and considered in the evaluation.

Approximately 4 percent of the CEBs for large piping were not accessible for full testing and inspection. These CEBs and their base plates or structural steel members were evaluated. If these CEBs and base plates or structural steel shapes did not satisfy acceptance criteria they were either modified or the piping support system was revised to yield acceptable results. The inspection and testing performed on the accessible CEB population yield an acceptable confidence level, as defined by the bulletin, indicating that the inaccessible CEBs and their base plates or structural steel members are capable of performing their safety function.

Small piping supports were designed using a conservative chart method. A sample of CEBs used for support of small piping was inspected and tested. Note that the bulletin does not require testing of CEBs for small piping. This sample consisted of more than 1,000 CEBs (more than 66 percent of the population). The results of this inspection and testing indicate similarity with the population of tested and inspected CEBs for accessible large piping supports. This testing and inspection program, used in conjunction with the conservative chart method, yields an acceptable confidence level, as defined by the bulletin, that CEBs and their associated base plates or structural steel members for small piping are capable of performing their safety function.

Thus, the inspection, testing, and evaluation performed as required by the bulletin indicate that the base plates or structural steel members and CEBs for Seismic Category I piping will satisfy the requirements of the bulletin when modifications are completed.

2. ORGANIZATION

Consumers Power Company (CPCo) contracted with Bechtel Associates Professional Corporation (BAPC) of Ann Arbor, Michigan to perform the inspection, testing, and evaluation of CEBs and base plates or structural steel members for Seismic Category I piping systems. BAPC also designed and installed required modifications. The operational/document sequence used is shown schematically in Figure 1.

3. SYSTEM IDENTIFICATION

Those systems having safety-related piping for the Palisades plant were reviewed along with the applicable piping and instrument diagram (P&ID) drawings. These systems were identified in the transmittal dated July 6, 1979, to J.G. Keppler of the NRC from D.P. Hoffman of CPCo.

4. INSPECTION AND TESTING

The inspection and testing of Seismic Category I base plates or structural steel members and CEBs were performed at the Palisades plant during the period from September 1979 to May 1980. More than 1,400 base plates and 4,000 CEBs were inspected and tested.

5. ITEM-BY-ITEM RESPONSE TO NRC IE BULLETIN 79-02

The following is an item-by-item response to the bulletin, its revisions, and its supplement.

A. ITEM 1 - REGARDING BASE PLATE FLEXIBILITY

All pipe anchor and support base plates using expansion anchor bolts were evaluated to account for plate flexibility, bolt stiffness, shear-tension interaction, minimum edge distance, and proper CEB spacing. Depending on the complexity of the individual base plate configuration, one of the following methods was used to determine CEB loads:

1) A quasi-analytical method was used for base plates with eight CEBs or less. A review of typical base plates at the plant indicates that the majority were anchored by either four, six, or eight CEBs. The base plate thickness usually varied from 3/8 inch to 2 inches. The base plate usually was not stiffened. For these types of base plates, an analytical formulation was developed which treated the base plates as a beam on multiple spring supports subjected to moments and forces in three orthogonal directions. Based on analytical considerations, as well as on the results of a number of representative finite element analyses of base plates, empirical factors were introduced in the simplified beam model to account for the following:

    a) The effect of the concrete bearing surface

    b) The two-way action of load transfer in the base plate

    These factors provided a way for considering the interaction effect of such parametric variables as base plate dimension, attachment size, CEB spacing, and CEB stiffness on the distribution of external loads to the CEBs.

    A computer program for the analytical technique described above was implemented for determining CEB loads. The program required base plate dimensions, number of CEBs, CEB size, CEB spacing and CEB stiffness, the applied forces, and the allowable CEB shear and tension loads as inputs.

The results from a number of case studies indicate a good correlation between the results of this formulation and those by the finite element method.

2) For cases where the configuration of the base plate did not lend itself to the foregoing method, the finite element method using techniques with conservative assumptions was employed in the evaluation.

3) Some two- or four-bolt cases were evaluated using an approach based on the strength design method given in the ACI 318-77 code.

Although the effect of plate flexibility has been explicitly considered in the formulations described above, the effect of prying action on the CEBs was determined not to be critical for the following reasons:

1) Where anchorage system capacity was governed by the system concrete shear cone, prying action would result in application of an external compressive load to the cone and, therefore, would not affect the anchorage capacity.

2) Where CEB pull out determined the anchorage capacity, the additional load carried by the bolt due to the prying action would be self-limiting because CEB stiffness decreases with increasing load. At higher loads, the CEB elongation would be such that the corners of the base plate would lift off, and prying action would be relieved. This was found to occur when the bolt stiffness in typical finite element analyses was varied in value from the initial stiffness to a stiffness beyond the allowable design load.

B. ITEM 2 - REGARDING FACTORS OF SAFETY FOR CEBs

In the evaluation, factors of safety (i.e., ratio of manufacturer's specified CEB ultimate capacity to CEB allowable design load) of four for wedge type and five for shell type CEBs were used for all load cases.

The allowable loads for a given CEB considered concrete edge distance and bolt spacing.

Shear-tension interaction in CEBs was considered in the following manner.

In most cases, the applied tension and shear were considered to be carried by the bolts in accordance with the following interaction equation:

$$\frac{T}{T_A} + \frac{S}{S_A} \leq 1.0$$

T and S are the calculated tensile and shear forces, and T_A and S_A are the respective allowable values for the CEB under consideration.

A higher order interaction was used in isolated cases for existing CEBs if it was justified by test results for the CEBs under consideration.

The CEBs were not considered to carry applied shear if it was less than the frictional force developed between the steel and the concrete surfaces.

If the calculated safety factor for an existing CEB was less than the minimum, a modification was designed to yield an acceptable factor of safety.

C. ITEM 3 - REGARDING CYCLIC LOADINGS

In the original design of the piping systems, deadweight, thermal stresses, seismic loads, and dynamic loads were considered in the generation of the pipe support design loads. These loads included cyclic effects and were considered in the design of the base plates and CEBs.

The safety factors used for CEBs installed on supports for safety-related piping systems were not increased for loads which are cyclic in nature. The use of the same safety factor for cyclic and static loads is supported by the Fast Flux Test Facility (FFTF) tests (Report BR-5853-C-4 by Bechtel Power Corporation, January 1975). The FFTF test results indicate:

1) CEBs successfully withstood two million cycles of long-term fatigue loading at a maximum intensity of 0.20 of the static ultimate capacity. When the maximum load intensity was increased beyond this value and cycled for 2,000 times at each increased load value, the observed failure load was approximately the same as the static ultimate capacity.

2) The dynamic load capacities of the CEBs under simulated seismic loading were approximately the same as their corresponding static ultimate capacities.

D. ITEM 4 - REGARDING CEB DESIGN REQUIREMENTS AND INSTALLATION

A testing and inspection program has been completed at the Palisades plant. The intent of the program was to inspect and test 100 percent of the accessible CEBs in large Seismic Category I piping systems. The program was also used to inspect and test a sample of CEBs for small Seismic Category I piping systems.

The testing and inspection program was discussed in detail and agreed upon during meetings between the NRC, CPCo, and BAPC held on October 26, 1979, and November 21, 1979.

Each CEB was inspected to verify adequate thread engagement, CEB size, spacing, and distance to a concrete edge. Shell type CEBs were inspected to verify that the shell did not contact the base plate during load testing. In addition, full expansion of the shell for shell-type CEBs was verified. CEBs in grouted base plates were inspected to verify that leveling nuts, if used, would not interfere with load testing.

Because sufficient documentation was not found to verify which type of CEB was installed in all cases at the Palisades plant, the test values for the program were derived from the manufacturer's CEBs with the lowest design allowable.

Each CEB was load tested to twice its allowable tensile value using either a direct pull or applied torque. The torque-tension relationship was derived from site-specific testing that was reported in the submittal dated February 14, 1980, to D.L. Ziemann of the NRC from D.P. Hoffman of CPCo.

If the CEB passed the testing and inspection described above, it was reloaded to a value that ensured a preload greater than the minimum design allowable load for the type of CEBs used at the Palisades plant. If the CEB did not pass the testing and inspection described above, it was replaced with a wedge type CEB installed in accordance with the manufacturer's recommendations. The wedge type replacement CEBs were also preloaded to a value greater than their design allowable load.

E. ITEM 5 - REGARDING CEBs AND MASONRY WALLS

This item was discussed in the submittal dated December 11, 1979, to J.G. Keppler of the NRC from R.W. Huston of CPCo. The modifications discussed in this submittal, for the masonry wall separating the diesel generators, have been completed.

F. ITEM 6 - REGARDING STRUCTURAL STEEL SHAPES AS BASE PLATES

A portion of the supports at the Palisades plant are structural steel shapes bolted directly to concrete. In cases where this design was encountered, the inspection, testing, and evaluation was in accordance with the criteria used for base plates.

G. ITEM 7 - REGARDING COMPLETION SCHEDULES

The inspection and testing of CEBs has been completed. Evaluation has been performed for the loadings developed in response to NRC IE Bulletin 79-14.

H. ITEM 8 - REGARDING DOCUMENTATION

Documentation of the CEB inspection, testing, and modification program is maintained at the Palisades plant site. The evaluations of base plates or structural steel shapes using CEBs are maintained at the Bechtel Ann Arbor offices.

I. ITEM 9 - REGARDING NRC REPORTING REQUIREMENTS

No response is required.

6. <u>SMALL PIPING (LESS THAN 2-1/2 INCHES IN DIAMETER)</u>

Pipe supports for small pipe (less than 2-1/2 inches in diameter) for Seismic Category I piping systems have been conservatively designed at the Palisades plant using the chart method.

A sampling program to verify acceptable installation of base plates and CEBs was completed for small piping. The program of inspection and testing for small piping supports was the same as that used for large piping supports although testing was not required by the bulletin. A percentage of the CEBs similar to that given for large piping passed the testing criteria for small piping.

This provides an acceptable confidence level, as defined by the bulletin, that these base plates or structural steel shapes are capable of performing their safety function.

7. CONCLUSION

The inspection, testing, and evaluation of Seismic Category I piping base plates or structural steel shapes, and CEBs performed at the Palisades plant has been completed. All those CEBs tested and inspected that did not satisfy acceptance criteria were modified or replaced. Modifications are being completed for base plates or structural steel shapes and/or CEBs if the evaluation indicated that established acceptance criteria were not satisfied.