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V. S. BOYER
VICE-PRESIDENT

JUL - 6 1979

Mr. Boyce H. Grier, Director, Region I
United States Nuclear Regulatory Commission
631 Park Avenue
King of Prussia, Pa. 19406

Subject: NRC Region I Letters dated March 8, 1979 and June 21, 1979
RE: IE Bulletin No. 79-02
IE Bulletin No. 79-02 Revision No. 1
Limerick Generating Station - Units 1 and 2
Docket Nos. 50-352 and 50-353

File: GOVT 1-1 (IE Bulletin 79-02)

Dear Mr. Grier:

Philadelphia Electric Company has reviewed IE Bulletin No. 79-02 submitted with the subject letter received on March 9, 1979, and IE Bulletin No. 79-02 Revision 1 received on June 25, 1979.

Our responses to the action to be taken by construction permit holders are listed below:

1. Verify that pipe support base plate flexibility was accounted for in the calculation of anchor bolt loads. In lieu of supporting analysis justifying the assumption of rigidity, the base plates should be considered flexible if the unstiffened distance between the member welded to the plate and the edge of the base plate is greater than twice the thickness of the plate. It is recognized that this criterion is conservative. Less conservative acceptance criteria must be justified and the justification submitted as part of the response to the Bulletin. If the base plate is determined to be flexible, then recalculate the bolt loads using an appropriate analysis. If possible, this is to be done prior to testing of anchor bolts. These calculated bolt loads are referred to hereafter as the bolt design loads. A description of the analytical model used to verify that pipe support base plate flexibility is accounted for in the calculation of anchor bolt loads is to be submitted with your response to the Bulletin.

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RESPONSE

All previously designed pipe anchor and support base plates using expansion anchor/bolts were analyzed to account for plate flexibil y, bolt stiffness, shear-tension interaction, minimum edge distance, and bolt spacing. Depending on the complexity of the individual base plate configuration, one of the following methods of analysis was used to determine the bolt forces:

(1) A quasi-analytical method, developed by Bechtel was used for base plates with eight bolts or less. A review of the typical base plates used in supporting the subject piping systems indicate that the majority of them were anchored either by 4, 6, or 8 bolts. The plate thicknesses vary from 1/2" to 2" and are not generally stiffened. For these types of base plates an analytical formulation has been developed which treats the plates as a beam on multiple spring supports subjected to moments and forces in three orthogonal directions. Based on analytical considerations as well as the results of a number of representative finite element analyses of base plates (using the "ANSYS" Code), certain empirical factors were introduced in the simplified beam model to account for (a) the effect of concrete foundation and (b) the two way action of load transfer in a plate. These factors essentially provided a way for introducing the interaction effect of such parametric variables as plate dimensions, attachment sizes, bolt spacings and stiffnesses on the distribution of external loads to the bolts.

The results of a number of case studies indicate excellent correlation between the results of the present formulation and those by the finite element method (using the "ANSYS" Code). The quasi-analytical method generally gives bolt loads greater than the finite element method.

A computer program for the analytical technique described above has been implemented for determining the bolt loads for routine applications. The program requires plate dimensions, number of bolts, bolt size, bolt spacing, bolt stiffness, the applied forces, and the allowable bolt shear and tension loads as inputs. The allowable loads for a given bolt are determined based on the concrete strength and edge distance, bolt spacing, embedment length, shear cone overlapping, manufacturer's ultimate capacity, and a design safety factor. The program computes the bolt forces and calculates a shear-tension interaction value based on the allowable loads.

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(2) For special cases where the design of the support did not lend itself to the foregoing method, the finite element method using the "ANSYS" code and/or other standard engineering analytical techniques with conservative assumptions were employed in the analysis.

(3) Other cases were solved using an approach based on the strength design method given in the ACI 318-77 code.

Future design of pipe supports will employ the foregoing methods.

2. Verify that the concrete expansion anchor bolts have the following minimum factor of safety between the bolt design load and the bolt ultimate capacity determined from static load tests (e.g. anchor bolt manufacturer's) which simulate the actual conditions of installation (i.e. type of concrete and its strength properties):

a. Four - For wedge and sleeve type anchor bolts,

b. Five - For shell type anchor bolts.

The bolt ultimate capacity should account for the effects of shear-tension interaction, minimum edge distance and proper bolt spacing.

If the minimum factor of safety of four for wedge type anchor bolts and five for shell type anchors cannot be shown then justification must be provided.

RESPONSE

In the current design review, factors of safety (i.e. ratio of bolt ultimate capacity to design load) of four for wedge type and five for shell type anchor bolts were used for service load cases. In the cases when extreme environmental loads are included, a factor of safety of at least three is used for acceptance in accordance with Section B.7.2 of the Proposed Addition to Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-76) August, 1978.

In cases where a program of 100% verification of acceptable anchor bolts has been implemented, a factor of safety of two is used with extreme environmental loads.

3. Describe the design requirements if applicable for anchor bolts to withstand cyclic loads (e.g. seismic loads and high cycle operating loads).

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RESPONSE

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. To the extent that these loads include cyclic considerations, these effects have been included in the design of the hangers, base plates, and anchorages.

The safety factors used for concrete expancion anchors, 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 based on the Fast Flux Test Facility Tests. (Drilled - In Expansion Bolts Under Static and Alternating Loads. Report No. BR-5853-C-4 by Bechtel Power Corp., January, 1975.) The test results indicate:

(1) The expansion anchors 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 steadily increased beyond the aforementioned value and cycled for 2,000 times at each load step, the observed failure load was about the same as the static ultimate capacity.

(2) The dynamic load capacity of the expansion anchors, under simulated seismic loading, was about the same as their corresponding static ultimate capacities.

4. Verify from existing QC documentation that design requirements have been met for each anchor bolt in the following areas:

(a) Cyclic loads have been considered (e.g. anchor bolt preload is equal to or greater than bolt design load). In the case of the shell type, assure that it is not in contact with the back of the support plate prior to preload testing.

(b) Specified design size and type is correctly installed (e.g. proper embedment depth).

If sufficient documentation does not exist, then initiate a testing program that will assure that minimum design requirements have been met with respect to sub-items (a) and (b) above. A sampling technique is acceptable. One acceptable technique is to randomly select and test one anchor bolt in each base plate (i.e. some supports may have more than one base plate). The test should provide verification of sub-items (a) and (b) above. If the test fails. all other bolts on that base plate should be similarly tested. In any event, the test program should assure that each Seismic Category 1 system will perform its intended function.

RESPONSE

(a) Expansion anchor bolt tests conducted at the Hanford Engineering Development Laboratory and contained in a report - (HEDL TC-1116 Concrete Expansion Anchor Tests Performed at the Fast Flux Test Facility-June-August, 1977) show that the ultimate capacity of anchor bolts are essentially equal under the following loading conditions:

1 - Dynamic load with preload

2 - Dynamic load without preload

3 - Static load

Since these tests have demonstrated that preload is not necessary to safely accommodate dynamic loads which include seismic effects, preloading of the anchor bolts is not a requirement.

(b) All concrete expansion anchors are inspected for location, elevation, numbers of anchor bolts, spacing and edge distance as shown on design drawings, type of anchor used, embedment length and projection of anchors, washers, anchor bolt diameter and anchor bolt length. Expansion anchors were tension tested to a load of 1.1 to 1.4 times the design strength of the anchor.

The test loads were recently increased to twice the maximum design load which considers plate flexibility.

Shell type anchors are installed wrench tight only, since torquing is not required for setting the anchor as per manufacturer's recommendations.

The specified bolt size and anchorage type were verified. However, the length of the bolt, hence thread engagement was not verified. Shell type anchors were installed as per manufacturers recommendation which included a requirement that hole depth may not exceed anchor length more than 1/8 inch below concrete surface. This was verified but no documentation of this aspect of verification exists. The setback is not significant because the anchor installation is verified, by tensioner or Schnorr washers before the base plate is installed. The proper documentation, indicating the location of expansion anchor and group represented, method of test (torque or tension), test results, type of failure when applicable, date of test along with name and signature of the inspector, are maintained at the jobsite.

SAMPLING PROGRAM

We will verify the previously installed anchors by sampling in accordance with IE Bulletin 79-02 Revision 1 Appendix A method (a) by:

a) Tension load testing of 1/2" and 7/8" to two times the design load without exceeding 1/16 inch slip. Previous testing of other anchor bolts has confirmed a load carrying capability of at least 1.4 times the bolt design load which we consider satisfactory.

b) Verifying minimum thread engagement for all sizes (Bolt diameter minus 1/16 inch).

In cases where the support plate is on a wall, the initial bolt to be tested will be at the top of a group. All nonconforming bolts will be replaced.

We plan to begin the verification of installed anchor bolts prior to July 31, 1979, and will complete the verification as expeditiously as possible.

Sincerely,

V. S. Boyer

Copy to: U. S. Nuclear Regulatory Commission
Office of Inspection and Enforcement
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Washington, D. C. 20555