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50-364

January 7, 1980

Docket No. 50-364

Mr. J. P. O'Reilly
U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, N.W.
Suite 3100
Atlanta, Georgia 30303

Dear Mr. O'Reilly:

In response to I.E. Bulletin 79-02, Revision 2, Pipe Support Base Plant Designs Using Concrete Expansion Anchor Bolts dated November 8, 1979, Alabama Power Company submits the attached response for Farley Nuclear Plant Unit 2.

Yours truly,

F. L. Clayton, Jr.

F. L. Clayton, Jr.

FLCJr/TNE:bhj

Attachment

cc: Mr. R. A. Thomas
Mr. G. F. Trowbridge
Mr. M. D. Hunt, Region II
Office of Inspection & Enforcement
Division of Construction Inspection
Washington, D.C. 20555

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Enclosure 1 - Response to I. E. Bulletin 79-02: Farley Unit 2

Response to Item 1:

Originally, flexibility of the base plate was not specifically taken into account in determining the concrete anchor bolt loads. Alabama Power Company is now performing design reviews that take base plate flexibility into account in determining the concrete anchor bolt loads. These design reviews encompass scoped piping supports already installed and all those yet to be installed. This design review is described below.

Bechtel Power Corporation (or its subcontractors) is utilizing the calculated Westinghouse/Bechtel piping system hanger/seismic restraint design loads and the ICES STRUDL Program or its equivalent to develop design loading conditions (forces and moments) at the centroid of each attachment to the hanger/seismic restraint base plates. For simple cases the forces and moments are obtained by hand calculations. Bechtel then utilizes this information in conjunction with the inspection and test data for analyses of all base plate anchor bolts to determine if the existing base plate anchorage is adequate to meet the design loads with the prescribed safety factor or if corrective action is necessary.

More specifically, a summary of the evaluation of base plate design by Bechtel is as follows:

1. The method of analysis is based on an empirical-analytical technique developed by Bechtel which takes into account design parameters such as flexibility of the base plate and concrete anchor stiffness (based on actual pre-loaded load-displacement curves furnished by the manufacturer). This method has been verified with appropriate finite element analytical solutions. Description of this empirical-analytical technique was provided in Attachment I of Alabama Power's response to bulletin 79-02 for Farley Unit 1 dated August 5, 1979.

   A computer program for the empirical-analytical technique has been implemented for determining the anchor bolt loads for the majority of applications. For other cases refer to Item 3 below. This 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 edge distance, bolt spacing, embedment length, shear cone overlapping, manufacturer's ultimate capacity, and safety factor.

   The program computes the forces on the bolt and calculates a shear-tension interaction based on allowable loads. An interaction value greater than the allowable is evaluated as failure of the bolt (safety factor less than required). Unit 2 shear-tension interactions analyses are computed utilizing a squared (elliptical) relation.

   The empirical-analytical method obviates the consideration of prying action for the following reasons:

   a. Where the anchorage system capacity is governed by the concrete shear cone, the prying action would result in an application of an external compressive load on the cone and would not affect the anchorage capacity.

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b. Where the bolt pull out determines the anchorage capacity, the additional load carried by the anchor bolt due to the prying action will be self-limiting since the bolt stiffness decreases with increasing load. At the higher loads the bolt extensions will be such that the corners of the base plate will separate from the concrete and the prying action will be relieved. This phenomena has been found to occur even when the bolt stiffnesses in the finite element analysis were varied from a high to a low value corresponding to both typical initial stiffnesses and to values beyond the allowable design load.

2. For special cases where the design of the support plate does not lend itself to this method, standard engineering analytical techniques with conservative assumptions are being employed.

3. All anchor bolts within the scope of this program are being evaluated by Bechtel in accordance with the bolt acceptance criteria, "as built" drawings reflecting the existing plant conditions, and the bolt design loads to determine if corrective action is required.

4. If any bolt on a base plate fails the Bechtel evaluation, one or more of the following actions are being taken:

   a. Re-analyze the base plate assuming that the bolt is failed (bolt carries zero load).

   b. Re-analyze the base plate incorporating bolt replacement as corrective action.

   c. In those instances where corrective actions result in a piping support modification, Bechtel (or its subcontractors) will include the effect of such modifications in the analysis of the piping system. In those instances where the analysis of the piping system is completed prior to support modification, Bechtel (or its subcontractors) will determine the effect of such modifications on the analysis.

5. Calculated bolt loads are used to check stresses in the support base plate to ensure they are less than the allowable stress as specified by the American Institute of Steel Construction (AISC) code.

Response to Item 2:

In the original design of Unit 2 at Farley Nuclear Plant a factor of safety of four was used for wedge type and shell type anchor bolts (it is estimated that shell type anchors comprise less than 5% of the total Unit 2 bolt program). Because of this (the original design factor of safety of four), the current verification program (described in the response to Item 4) requires the existing anchor bolts to withstand a load equivalent to 1/4 of the manufacturer's published pullout load. The original design factor of safety of four is consistent with the current industry design practices. In general, the current industry approach concerning the use of safety factors for various design loading conditions are described below. This information is provided as additional support for the factor of safety used in our evaluation and corrective action:

1. Factors of safety (i.e. ratio of bolt ultimate capacity to design load) of four for wedge type and shell type anchor bolts, for service (operating) load cases, are used.

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2. For factored loadings (which include accident/extreme environmental loads) safety factors of 1.2 and 3.0 are used commensurate with the provisions of Section B.7.2 of the Proposed Addition to Code Requirements for Nuclear Safety Related Concrete Structures (ACI-349-76) August, 1978. The factors of safety are consistent with the ultimate strength design method. A factor of safety of 1.2 is used if the failure mechanism for the anchor is controlled by the bolt material. If the failure mechanism is controlled by concrete shear cone action, a factor of safety of 3.0 is used. The utilization of sampling and quality control methods used for concrete work are integral to selecting the factor of safety of 3.0.

3. For general structural design in steel, the AISC Specification has an approximate factor of safety of 1.7 for services loading (for example, a column buckling). For factored accident/extreme environmental loads, a factor of safety of 1.1 is used on nuclear structures for both ductile (yielding) and non-ductile (column buckling) failures. In concrete design for factored loads, a factor of safety of 1.1 is used for flexural and tension action and 1.2 for shear action. It can be observed that a higher factor of safety is assigned to the expansion anchor only if its capacity is governed by the concrete shear cone.

Based on the above interaction of design paramerers and on the following additional factors, Alabama Power Company has concluded that a safety factor of 4 is sufficient to ensure operability of Seismic Category I piping system in the event of a seismic event:

a. 100% verification testing program with total Quality Control coverage of scoped systems (described in Item 4) which minimizes installation uncertainties (e.g. verification of torque, embedment depth, nut engagement, plate configuration, expansion of shell, etc.) which were allowed for in the original design by the factor of safety of four: and,

b. Verification that plates are not overstressed by bolt loadings (e.g. consideration of minimum edge distance and proper bolt spacing).

Response to Item 3:

In the original design of the piping systems Bechtel/Westinghouse considered dead-weight, thermal stresses, seismic loads, and dynamic loads (e.g. certain rapid valve openings and closings) in the generation of the static equivalent pipe support design loads.

The safety factors used for concrete expansion 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 (FFTF) Tests*. The test results indicate:

1. The expansion anchors successfully withstood two million cycles of long term fatigue loading at a maximum intensity of 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 capacity.

*Drilled - In Expansion Bolts Under Static and Alternating Loads, Report No. BR-5853-C-4 Rev. 1, by Bechtel Power Corporation, October 1976.

Response to Item 4:

Since existing Q. C. documentation is not adequate to verify the parameters associated with the original installation of each anchor bolt, the following programs have been undertaken:

Test Program

Alabama Power Company has initiated a program to test and repair as necessary all concrete expansion anchor bolts installed or to be installed on scoped piping systems. The scope includes all safety related piping 2½ inches in diameter or greater; all Seismic Category I piping, regardless of size, which will be dynamically analyzed by computer; and all containment penetrations. The river water system which is common to both Unit 1 (operating) and Unit 2 is excluded since it was addressed under the Unit 1 79-02 program.

Anchor bolts on hangers within the scope of this program are tested for the following parameters:

a. embedment - Actual embedment depth is determined.

b. grout - Grout is removed as required to determine if leveling nuts were used. If leveling nuts were used, they are backed off from contact with the base plate before applying tension or torque testing.

c. type of bolts - Verification is made that installed bolts are in accordance with bill of material.

d. number of bolts - Verification is made that the installed number of bolts is in accordance with bill of material.

e. bolt dimensional measurements - Dimensional measurements are taken to determine the degree of compliance with the manufacturers' recommended bolt installation requirements.

f. torque - Bolts are torqued to a level such that the resultant tensile load on the anchor is equal to 1/4 of the manufacturers' published pull-out load. For shell type bolt torque tests to be considered valid, the shell shoulder must not touch the base plate.

NOTE: A torque/tension relationship was developed for Hilti wedge type anchors based on tests performed at Farley. Torque/tension relationships were developed for Phillips shell type anchors under the direction of Bechtel Corporation with technical consultation from ITT-Phillips Drill Division at Plant Hatch. Torque requirements for Wej-it wedge type anchors were obtained from vendor data.

g. base plate dimensional measurements - Dimensional measurements of base plate parameters which could affect bolt loading or capacity (e.g. bolt spacing, edge distance) are taken.

Based on the results of the test program and the empirical-analytic evaluation, anchors are being repaired according to the following criteria:

i. Repairs are done so that all repaired bolts have a safety factor of at least 4.0 and all base plate anchorages have a safety factor of at least 4.0.

ii. All repairs are done in accordance with written procedures and quality control checks.

The failure to test inaccessible anchor bolts will be justified by analyses which substantiate operability of the affected systems without assuming integrity of those anchorages which are not tested.

Preloading

Even though Alabama Power is preloading all anchor bolts to the design load, available test data indicates that it is not necessary that the bolt preload should be equal to or greater than the bolt design load because pipe supports and anchors are subjected to both static and dynamic loads. The dynamic loads such as the seismic loads are short duration cyclic loads and are not fatigue type loads; therefore, the amount of preload on the bolts will not greatly affect the performance of the anchorage. The initial installation torque on the bolt accomplishes the purpose of setting the anchor, but the ultimate capacity of the bolt is not affected by the amount of preload present in the bolt at the time of cyclic loading. For vibratory loads, the expansion anchors have successfully withstood long term fatigue conditions as discussed in the previous section (FFTF tests).

Response to Item 5:

Alabama Power has completed a field walkdown of all concrete block walls to determine if any supports on scoped systems were attached to these walls using expansion anchors. The walkdown did not identify any supports on piping systems within the scope which were attached to the concrete block walls with concrete expansion anchors.

Response to Item 6:

All anchor bolts within the scope of the Farley Nuclear Plant Unit 2 79-02 program will be tested, analyzed, and repaired as necessary regardless of whether a base plate or structural steel member is used. For those supports using structural shapes, special analyses if necessary, will be performed to determine anchor bolt loading. Based on the experience of Alabama Power Company during its Farley Unit 1 79-02 program, it is estimated that fewer than 1% of the pipe supports on scoped systems are attached by structural steel shapes to changes.

Response to Item 7

Not applicable to plants under construction.

Response to Item 8

Not applicable to plants under construction.

Response to Item 9

The actions being undertaken (described above) are being coordinated with the current construction activities in order to facilitate testing and repair and to eliminate unnecessary duplication of efforts. Documentation of the program will be maintained on site.