T/C

MISSISSIPPI POWER & LIGHT COMPANY

Helping Build Mississippi

P. O. BOX 1640, JACKSON, MISSISSIPPI 39205

PRODUCTION DEPARTMENT

August 10, 1979

Office of Inspection & Enforcement
U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, Suite 3100
Atlanta, Georgia 30303

ATTENTION: Mr. J. P. O'Reilly, Director

Gentlemen:

SUBJECT: Grand Gulf Nuclear Station
File 0272/0260/0275/M-001.0/L-860.0
IE Bulletin 79-02 Revision No. 1
Evaluation
AECM-79/89

On July 6, 1979, Mississippi Power & Light Company submitted its response to IE Bulletin 79-02 Revision No. 1 entitled "Pipe Support Base Plate Designs Using Concrete Expansion Anchor Bolts." At the request of Mr. William Ang of your staff, we have revised our response to clarify several items. Our revised response is attached.

Also, at the request of Mr. Ang, we will be forwarding Reference 3 of the attached response to you in the near future.

Yours truly,

L F Dale

L. F. Dale
Nuclear Project Manager

RTE:dwe
Attachment

cc: Mr. N. L. Stampley
Mr. R. B. McGehee
Mr. T. B. Conner

Mr. John G. Davis, Director
Division of Inspection & Enforcement
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

958140

7909180164

9

This is in response to NRC Bulletin 79-02 (Revision No. 1), dated June 21, 1979, requiring all licensees and permit holders for nuclear power plants to review the design and installation procedure used for Seismic Category I pipe support base plates which are anchored by expansion bolts.

The following types of supports have been reviewed for the Grand Gulf Nuclear Power Station (GG).

a. Pipe Anchors

b. Main Steam Relief Valve (MSRV) Supports

c. Seismic Category I Pipe Hangers

d. Supports for piping systems 2-½ inch in diameter or less

The basic document governing the design and installation of expansion anchors on GG is the Specification 9645-C-103.1.

Procurement of expansion anchors is governed by Specification 3645-M-205.0.

Both documents were prepared by Bechtel Power Corporation.

The concepts which are presented in this response will be applied to all future designs and revisions for Units 1 and 2.

Seismic Category I systems are defined in Regulatory Guide 1.29, Revision 2, with exceptions noted in Grand Gulf's FSAR Appendix 3A.

QUESTION #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 criteria must be justified and the justification submitted as part of the response to the Bulletin. If the base plate is

958141

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.

It has been noted that the schedule for analytical work on base plate flexibility for some facilities extends boyond the Bulletin reporting time frame of July 6, 1979. For those facilities for which an anchor bolt testing program is required (i.e., sufficient QC documentation does not exist), the anchor bolt testing program should not be delayed.

RESPONSE

All pipe anchors and MSRV supports with base plates using expansion anchors were re-analyzed to account for plate flexibility and bolt stiffness. The effects of shear-tension interaction, minimum edge distance and bolt spacing were included in the original designs and were also included in the re-analysis of the base plates. One of the following methods used during the re-analysis to solve for tensile bolt loads:

1. An empirical method based on the results of finite element analysis using ANSYS computer programs for base plates with eight (8) or less bolts. (ATTACHMENT 1)
2. Finite Element Analysis Method using the ANSYS computer program. (ATTACHMENT 2)
3. An empirical method based on the results of finite element analysis using ANSYS computer programs for base plates with twelve (12) bolts. (ATTACHMENT 3).

958142

4. Other acceptable methods of structural analysis with conservative assumptions.

Shear bolt loads were computed by conventional methods. One of the following shear-tension interaction equations was used during the re-analysis:

$$\left(\frac{T}{T_A}\right) + \left(\frac{S}{S_A}\right) \leq 1.0$$

OR

$$\left(\frac{T}{T_A}\right)^{5/3} + \left(\frac{S}{S_A}\right)^{5/3} \leq 1.0$$

Where: T = Design Tension Load

T_A = Allowable Tension Load

S = Design Shear Load

S_A = Allowable Shear Load

Both of these equations are more conservative than the circular interaction equation generally used for this application. Any consideration of shear force is conservative due to friction between the base plate and the concrete surface.

During the design of Seismic Category I pipe hangers, effects of plate flexibility, shear-tension interaction, bolt spacing and minimum edge distances were considered to assure a conservative initial design. Re-analysis was performed for selected plates using methods No. 1 as outlined above to assure that the original design approach was conservative.

Listed below are the total number of hangers checked for each bolt pattern and the total number of hangers which employ those patterns.

BOLT PATTERN	POPULATION (TOTAL NUMBER OF HANGERS)	NUMBER OF HANGER SKETCHES ANALYZED
4 - bolt	304	3
6 - bolt	15	2
8 - bolt	5	3

958143

In each case the original design was found to be conservative.

For design of base plates used to support two inch and under piping, a chart analysis was used. This analysis method is contained in Bechtel Power Corporation Document No. M-18, "Office and Field Engineering User's Manual for Routing and Supporting Two Inch and Under Piping", Rev. 17. This chart analysis has been shown to be very conservative.

It should be noted that all methods of analysis conservatively ignored the effects of redistribution of tensile bolt loads. This phenomenon occurs as the bolt design loads increase which decreases the individual bolt stiffness.

Prying action was considered negligible in the re-analysis for the following reasons:

1. Due to the low stiffness of expansion bolts, it is unlikely that prying action would exist.
2. If prying action does occur, it typically exists at the plate corners which results in the following:
    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 therefore affect the anchorage capacity.
    b. Where the bolt pull out determines the anchorage capacity, the additional load carried by the bolt due to the prying action will be self-limiting since the bolt stiffness decreases with the increasing load. At higher loads the bolt extension will be such that the corners of the base plate will lift off and the prying action will be relieved. This phenomenon has been found to occur when the bolt stiffness in the Finite Element Analysis were varied from a high to a low

value, to correspond to typical values of initial bolt stiffness and values of stiffness at a point beyond allowable design loads.

c. A point load will result in an infinitely high compressive stress in the concrete at the point of prying. In this case, the high stress probably would lead to local concrete crushing which will relieve the prying action.

QUESTION #2

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 can not be shown then justification must be provided.

RESPONSE

Grand Gulf uses only the wedge type anchor bolts for Category I piping systems. For all cases, a safety factor of four was applied to the ultimate capacity of the bolt. These ultimate capacities were obtained from static load tests as furnished by the manufacturer. The factor of safety of four is higher than the factor of safety considered acceptable as specified in Reference 1.

958145

As stated in the responses to Question #1, the effects of shear-tension interaction, minimum edge distance and proper bolt spacing were accounted for.

QUESTION #3

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

RESPONSE

In the original design of the piping systems Bechtel considered deadweight, thermal stresses, seismic loads, and dynamic loads (including steam hammer in the main steam systems) in the generation of the static equivalent pipe support design loads. To the extent that these loads include cyclic considerations, these effects would be included in the design of the hangers, base plates and anchorages.

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 FFTF Tests (Reference 2). 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.

958146

QUESTION #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).

In 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. On 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.

The preferred test method to demonstrate that bolt preload has been accomplished is using a direct pull (tensile test) equal to or greater than design load. Recognizing this method may be difficult due to accessibility in some areas an alternative test method such as torque testing may be used. If torque testing is used it must be shown and substantiated that a correlation between torque and tension exists. If manufacturer's data for the specific bolt used is not available, or is not used, then site specific data must be developed by qualification tests.

Bolt test values of one-fourth (wedge type) or one-fifth (shell type) of bolt ultimate capacity may be used in lieu of individually calculated bolt design loads where the test value can be shown to be conservative.

The purpose of Bulletin 79-02 and this revision is to assure the operability of each seismic Category I piping system. In all cases an evaluation to confirm system operability must be performed. If a base plate or anchor bolt failure rate is identified at one unit of multi-unit site which threatens operability of safety related piping systems of that unit, continued operation of the remaining units at that site must be immediately evaluated and reported to the NRC. The evaluation must consider the generic applicability of the identified failures.

Appendix A describes two sampling methods for testing that can be used. Other sampling methods may be used but must be justified. These options may be selected on a system by system basis.

Justification for omitting certain bolts from sample testing which are in high radiation areas during an outage must be based on other testing or analysis which substantiates operability of the affected system.

Bolts which are found during the testing program not to be preloaded to a load equal to or greater than bolt design load must be properly preloaded or it must be shown that the lack of preloading is not detrimental to cyclic loading capacity. If it can be established that a tension load on any of the bolts does not exist for all loading cases then no preload or testing of the bolts is required.

If anchor bolt testing is done prior to completion of the analytical work on base plate flexibility, the bolt testing must be performed to at least the original calculated bolt load. For testing purposes factors may be used to conservatively estimate the potential increase in the calculated bolt load due to base plate flexibility. After completion of the analytical work on the base plates the conservatism of these factors must be verified.

For base plate supports using expansion anchors, but raised from the supporting surface with grout placed under the base plate, for testing purposes it must be verified that leveling nuts were not used. If leveling nuts were used, then they must be backed off such that they are not in contact with the base plate before applying tension or torque testing.

Bulletin No. 79-02 requires verification by inspection that bolts are properly installed and are of the specified size and type. Parameters which should be included are embedment depth, threat engagement, plate bolt hole size, bolt spacing, edge distance to the side of a concrete member and full expansion of the shell for shell type anchor bolts.

If piping systems $2\frac{1}{2}$-inch in diameter or less were computer analyzed then they must be treated the same as the larger piping. If a chart analysis method was used and this method can be shown to highly conservative, then the proper installation of the base plate and anchor bolts should be verified by a sampling inspection. The parameters inspected should include those described in the preceding paragraph. If small diameter piping is not inspected, then justification of system operability must be provided.

APPENDIX A

SAMPLING METHODS

Item 4 of this Bulletin states that for anchor bolt testing purposes a sampling program is acceptable. Two sampling methods are discussed below, but other methods may be used if justified.

a. Test one bolt on each plate as originally recommended in Bulletin No. 79-02. If the test fails, all other bolts on that base plate should be similarly tested. A high failure rate should be the basis for increased testing.

b. Randomly select and test a statistical sample of the bolts to provide a 95 percent confidence level that less than 5 percent defective anchors are installed in any one seismic Category I system. The sampling program should be done on a system by system basis.

RESPONSE

a. Cyclic loads were considered in the design of the base plate as described in the response to Question #3. The FFTF tests and other tests have demonstrated the capability of expansion anchors to withstand dynamic and fatigue type cyclic loads. In Reference 3 the preload in the dynamic tests was varied from "finger tight" to a value approximately equal to one quarter of the static ultimate capacity. Furthermore, due to creep relaxation of expansion bolt anchorages after installation, it is not possible to predict the preload in expansion anchors at any given time. In conclusion, if the initial installation torque accomplishes the purpose of setting the wedge, then the ultimate capacity of the bolt is not affected by the amount of preload present in the bolt at the time of cyclic loading.

958150

b. The design size and type of expansion anchor is specified on the design drawing for each pipe support. Proper embedment depth is controlled by Specification 9645-C-103.1.

In reference to sub-item a. above, a field testing procedure for installation torque is used. This procedure involves testing a certain number of anchors with calibrated torque wrench and is governed by Section 6.0 of Specification 9645-C-103.1. The testing frequency and acceptance criteria are described in Sections 6.2 and 6.3 as follows:

6.2 Testing Frequency

Expansion anchors shall be tested at the following frequency:

6.2.1 For each support test at least one anchor, but not less than 10 percent of the total expansion anchors used for the support. For supports which have less than five expansion anchors and are installed in continuous repetitious patterns, test 10 percent without regard for the number of supports. Groups selected for 10 percent testing shall not exceed 20 anchors. Select expansion anchors for test at random so that they are representative of the group in which they are located and of the installation conditions.

6.2.2 Accept all the anchors in the test group if the anchors tested according to the procedures in Paragraph 6.2.1 meet the acceptance criteria given in Paragraph 6.3.

6.2.3 Test an additional two, but not less than 30 percent of the expansion anchors from the same group if those tested according to the procedures in Paragraph 6.2.1 do not meet the acceptance criteria given in Paragraph 6.3.

6.2.4 Accept all remaining expansion anchors in the group as satisfactory if those tested according to the procedures given in Paragraph 6.2.3 meet the acceptance criteria as given in Paragraph 6.3.

6.2.5 Test all remaining expansion anchors in the group if one of those tested according to the procedures in Paragraph 6.2.3 does not meet the acceptance criteria as given in Paragraph 6.3. Accept each anchor on an individual basis.

6.3 Acceptance Criteria

Accept the tested expansion anchor if during testing the concrete did not break and/or the anchor did not slip excessively (1/4 inch maximum) or become loose, and the minimum torque or tension values of Paragraph 6.0 are met.

The results of the torque testing are documented and maintained at the jobsite.

In reference to sub-item (b) above, design size and type are governed by Section 6.0 of Specification 9645-C-103.1. This section requires expansion bolt installation to be verified for location (elevation, spacing and edge distance), anchor type maximum bolt projection and anchor diameter and length. These items are checked with the design drawings. The anchor length, which is specified on the design drawings, ensures proper embedment depth. Documentation is kept at the jobsite.

Specification 9645-C-103.1 invokes the quality assurance criteria in accordance with 10 CFR 50, Appendix B. Under the quality assurance program existing during construction, failure to meet the acceptance criteria would create a condition whereby the work would be either corrected or rejected.

958152

REFERENCES:

(1) Proposed Addition to: Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-76), Title No. 75-35.

(2) "Drilled in Expansion Bolts Under Static and Alternating Load", Prepared by Bechtel Power Corporation, San Francisco, California for the U. S. Atomic Energy Commission, Hartford Engineering Development Laboratory, Richland, Washington, BR-5853-C-4, Rev. 1, October 1976.

(3) "Static and Dynamic Loading of 3/8-Inch Concrete Anchors", Prepared by Pacific Gas and Electric Company Department of Engineering Research.

ATTACHMENTS:

(1) Model for base plates with eight (8) or less bolts.

(2) ANSYS computer model and example.

(3) Model for base plates with twelve (12) bolts.