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July 6, 1979

Mr. Boyce H. Grier, Director
Office of Inspection and Enforcement
Region I
631 Park Avenue
King of Prussia, Pennsylvania 19406

Dear Mr. Grier:

Subject: Oyster Creek Nuclear Generating Station
Docket No. 50-219
IE Bulletin No. 79-02

The purpose of this letter is to respond to the directives set forth in IE Bulletin No. 79-02.

Our responses to the specified action items in Bulletin No. 79-02 are given in Attachment 1. As noted in Attachment 1, a test program is presently in progress and will not be completed until the next extended outage of the Oyster Creek Station. At the completion of the test program, a follow-up report will be submitted.

Very truly yours,

Donald A. Ross

Donald A. Ross, Manager
Generating Stations-Nuclear

pk

Attachment

cc: NRC Office of Inspection and Enforcement
Division of Reactor Operations Inspection
Washington, DC 20555

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RESPONSE TO IE BULLETIN 79-02
OYSTER CREEK NUCLEAR STATION UNIT #1

The Nuclear Regulatory Commission IE Bulletin No. 79-02, dated March 8, 1979, directs that holders of Nuclear Power Plant Licenses respond to the concerns of the NRC regarding the reliability of pip support base plates that use concrete expansion anchor bolts in Seismic Category I systems as defined by Regulatory Guide 1.29, "Seismic Design Classification" Revision 1, dated August 1973, or as defined in the applicable FSAR. In the reply, the NRC "Action Item" is first stated and the Oyster Creek response follows:

NRC Action Item No. 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. If the base plate is determined to be flexible, then recalculate the bolt loads using an appropriate analysis which will account for the effects of shear-tension interaction, minimum edge distance and proper bolt spacing. These calculated bolt loads are referred to hereafter as the bolt design loads."

Response to Action Item No. 1

1.0 INTRODUCTION

Pipe support base plates have mainly been designed by subcontractors of the mechanical contractor. These subcontractors are Bergen-Paterson Pipesupport Co., Clifton, N. J. for piping inside the Reactor Building and Atlanta Engineering Co., New York, N. Y. for Seismic I piping systems inside the Turbine Building. Seismic Class I pipe supports are supported either from structural steel, embedded plates, cast in place inserts or drilled in expansion bolts. The expansion bolt installations are the subject of this response.

2.0 DESIGN CRITERIA

The design approach used by the major piping support subcontractor, Bergen-Paterson is defined in Ref. 1 as follows: "The distribution of loading on bolts was calculated on the basis of a rigid base plate with pure tension and shear loadings distributed equally on the bolts." Bending and torsion were resisted by the respective moments of inertia of the bolt group.

The type of concrete fastener used by the subcontractors was the Phillips "Red Head" self-drilling type (shell type as referenced in Bulletin 79-02). Reference I states t. allowable loads

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were established using Pittsburgh Testing Laboratory Report No. 93110, dated October 31, 1956 which gives pullout loads for these fasteners. Tension loading was rated as 10% of the average pullout force and shear loading as 20% of this same force. In view of these high design factors of safety, it is reasonable to expect that the reanalysis to be performed in compliance with Bulletin 79-02 will show the plates and bolts to be adequately designed.

Table I shows the values of shear and tension allowable force used in the current reanalysis, for the four bolt sizes used. These values were determined by dividing by 5 (per IE Bulletin Item #2 for shell type anchors) the ultimate load based on test given in the current Phillips Red Head Catalog F1000 for 3500 psi concrete. The force so determined was further reduced by the ratio of 3000 to 3500 to account for the lower value of concrete strength stipulated in the Oyster Creek design documents.

TABLE I

	Allowable Force #	
Bolt Size	Tension	Shear
1/2	1457	1152
5/8	2006	2040
3/4	2777	2777
7/8	3060	3163

The basic loads for tension in conjunction with the basis loads for shear are used in a linear interaction formula to account for combined effects of shear and tension on the bolts. This formula is:

$$\frac{f_t \text{ (actual tension)}}{F_t \text{ (allowable tension)}} + \frac{f_s \text{ (actual shear)}}{F_s \text{ (allowable shear)}} \leq 1$$

3.0 Current Analysis Method

In order to achieve a more realistic assessment of bolt tension loads for flexible plates, plate deflections giving rise to a "dishing" effect must be calculated and the resultant prying load of the concrete must be distributed to the bolts. This is best achieved by finite element analysis using one of the accepted computer codes. Teledyne Engineering Services of Waltham, Mass. has prepared a pre- and post-processor, which defines the parameters and lists the steps required to perform the analysis.

These parameters are place and concrete stiffness, expansion bolt preload and proper dimensions of attachment. A detailed description of this program (Revision B, dated 6/11/79) is appended as Reference 5. Teledyne has prepared tables of anchor bolt shear and tension stiffness (Ref. 2) based on available test results. The preprocessor calculates a value of concrete stiffness from the inputted ultimate strength of the concrete using a formula developed in Reference 3.

The program accepts 3 components of force and 3 components of moment applied by the structural loading element of the plate along with plate geometry, and prints out tension and shear loads for each bolt, and maximum plate stresses. Plate deflections and concrete reactions are also listed.

4.0 Reanalysis Performance Review

The following steps were taken to comply with the requirements of Bulletin 79-02, Item 1.

a. A determination was made of the systems that were Seismic Category I (Reference 4) considering the plant design and based on Reg. Guide 1.29, latest revision.

b. For these seismic systems, approximately 1000 hanger drawings were scrutinized and those having concrete expansion anchor bolts in a base plate were segregated. The number of base plates to be reviewed came to over 325 designed by Bergen-Paterson and 80 designed by Atlantic Engineering.

c. Plates were separated into types based on number of bolts and types of loading and further divided into categories having closely similar plate and attachment configurations. For each category one plate having the highest total load was chosen for detailed analysis. It is clear that acceptability of this plate and its bolts with respect to their respective allowables would qualify all the plates in its category.

   To illustrate the breakdown of the plates into categories, Tables II and III have been appended showing types and categories. The total number of plates selected for individual analyses came to 86.

d. The plate types qualified as flexible by the NRC criterion were coded for computer analysis and run on the Teledyne/ANSYS Program. Rigid plates were also analyzed by the conventional methods. Values of shear and moment for the most highly stressed bolt in each plate and in each category were tabulated and transmitted to the field for use in the testing program.

5.0 Discussion of Analyses Results

The analysis described above has been completed. A review of the results of these analyses shows that over 98% of the plates and bolts are within the allowable loads. Corrective action has been initiated on the plates and/or bolts which do not meet the allowable load criterion.

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Additional areas under investigation:

a. A field check is being made and the data collected will be reviewed for small diameter piping using concrete anchor bolts. Based on the information collected, loads will be developed and compliance of the anchors with shear and tension allowables will be verified.

b. Some Containment Vessel penetrations have been designed with supports (snubbers attached to base plates) to accelerate seismic forces, and both axial and lateral jet impingement loads. The drawings of these penetrations do not list design loads. Therefore, it will take until August 6, 1979 to accomplish the required analysis to assure compliance of the anchors associated with these supports.

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References

1. Letter, H. R. Erikson, Chief Engineer, Bergen-Pipesupport Co. to A. S. Dam, Burns and Roe, Inc. dated April 25, 1979.

2. Anchor Bolt Shear and Tension Stiffness May 25, 1979, by Teledyne Engineering Services.

3. "Theory of Elasticity" by Timoshenko and Goodier, 2nd Ed. P. 366-372.

4. Oyster Creek Component/Subsystems Quality Group and Seismic Category Listing.

5. Project 3501 Revision B, June 11, 1979 by Teledyne Engineering Services, Waltham, Mass.

NRC Action Item No. 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 To Action Item No. 2

The response to item #1 indicated the procedure in developing the allowable loads for the shell type anchor bolts used was based on a minimum factor of safety of five, and factoring in the concrete strength properties (see Table I). It also cited the standard linear interaction formula used to determine acceptability where both shear and tension are present. For minimum edge distance and proper bolt spacing the following table is presented as representing present-day industry practice:

TABLE IV

	Size	Min. Spacing	Min. Edge Distance
Phillips Redhead	1/2"	5"	3"
Self Drilling	5/8"	6"	3"
Anchors	3/4"	7"	4"
	7/8"	8"	4"

The review of the existing plates discussed under item 1 has included a check of conformity to this present-day guidelines. Where there is a difference either in spacing or edge distance guidelines, the allowables in Table I have been reduced by a linear factor. The bolt design load was then compared to this reduced allowable load.

In those cases where either the Table I allowable load or the reduced allowable load is not being met corrective action is being taken to strengthen the configuration by installing additional bolts and/or bolts of greater capacity, or by other modifications to the baseplate or support.

Action Item No. 3

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

Response to Action Item No. 3

Pipe support loads from thermal constraint of piping and from seismic excitation, as well as dead weight loads were considered in the design of all the piping support systems.

Anchor bolt design loadings were chosen to accommodate all the above loads, utilizing the appropriate factor of safety as established by the manufacturer under static primary loading conditions.

Since there were no specific design requirements for cyclic loading for the anchor bolts, verification of cyclic and seismic load capabilities are reported in Action Item No. 4 below.

NRC Action Item No. 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, assume 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).

Response to Action Item No. 4

Sufficient QC documentation does not exist to verify that design requirements have been met for each anchor bolt insofar as consideration of cyclic loads and installation of specified design size and type.

a. As indicated in the generic program presented to the NRC (group headed by William Rutherford) by the Teledyne/Utility Owner's Group on April 26, 1979, a testing program has been initiated to determine the seismic and cyclic loading capabilities of the various types and sizes of anchor bolts used by the member utilities.

The schedule for the completion of these tests, also stated at the April 26th meeting, is July 15, 1979. Analyzing the test results and incorporating this information into a final plant specific report for Oyster Creek shall be accomplished by August 6, 1979.

b. An in-plant inspection and test program has been initiated to verify proper anchor bolt installation and specified design size and type.

The test method involves a pull test of the anchor bolt to a minimum test load of 125% of the bolt design load calculated in the analysis in Action Item #1 above. The sampling method being used is that listed as a) in Appendix A of the supplement to the bulletin, i.e. testing one bolt per base plate.

The program schedule for responding to the March 8th Bulletin includes identification and analysis of the base plates, lab testing of anchor bolts to verify cyclic load capabilities and, prior to July 6, 1979, initiating in-plant testing of anchor bolts using the bolt design loads calculated in the analyses.

However, the identification and analysis portions of the effort have been adversely affected by the involvement of Burns & Roe, the A/E for Oyster Creek Station, in the support of the Three Mile Island Recovery effort. Most documentation and original analyses for the Oyster Creek Station are available only through Burns & Roe.

Revision 1 to the Bulletin, issued on June 21, 1979, clarified the NRC's position that Item 4 of the original Bulletin 79-02 did not only require that a testing program be "initiated" but that it be effectively completed by July 6th. The magnitude of the effort did not permit completion of this entire program on such short notice. However, the testing program schedule was immediately accelerated to a seven days a week overtime effort to maximize the collection of test data prior to the July 6th deadline. This program will continue as a full-time effort until the required tests, inspections, and modifications are completed.

The current status of the program is summarized below:

<u>Identification of Base Plates</u>

Collection of data, drawings, loads, analyses, etc. with Burns & Roe is more than 99% complete. Additional hangers, if found, during the inspection and test program shall be analyzed and tested as soon as they are identified in the field.

<u>Analysis for Flexibility</u>

For all base plates identified above, the flexibility analysis has been completed. If additional base plates are identified, analysis shall immediately be performed.

<u>Cyclic Loading Capability Testing</u>

As indicated on 4 a) above, testing of anchor bolts is scheduled for completion by July 15, 1979, with a final plant--specific report for Oyster Creek complete by August 6, 1979.

<u>In-Plant Inspection and Test Program</u>

To date, anchor bolts have been tested in 6% of the base plates with satisfactory results in all but the following:

- One anchor bolt failed (remaining bolts were satisfactory; failed bolt being replaced.

- One stud sheared when attempting to remove nut for inspection/test; repair in progress.

- One base plate found with 2 of 4 bolts missing; bolts being replaced.

Test completion for the remaining accessible base plate anchor bolts will be approximately 8-10 weeks. Those anchor bolts which are inaccessible due to plant operations shall be inspected and tested during the next extended outage.

In summary, the in-plant testing program is in progress, but with the misinterpretation of the schedule requirements of the March 8th bulletin and the need for design load information from the analysis portion of the program, testing shall be completed in approximately 8 weeks.

The results of the testing completed and the results and conservatisms of the design based on the reanalysis support the assurance or proper operability of the systems addressed by this bulletin.

Therefore, it is believed that continued operation of the Oyster Creek Station during the remainder of the test program is justified.

TABLE II Sh. 1

OYSTER CREEK NUCLEAR STATION UNIT #1

Index of Bergen-Paterson Designed Plates for Bulletin 79-02

	Category	No.	Total
1. Floor Mounted Plates, No bolt load			52
2. Plates Shear Load Only			57
3. Square Plates, 4 holes pull load	1	38	
	2	1	
	3	2	
	4	1	
	5	1	
	6	11	
	Total	54	54
4. Square Plates, 4 holes shear and moment loading	1	12	
	2	2	
	3	1	
	4	4	
	5	1	
	6	2	
	7	2	
	Total	24	24
5. Square Plates, 4 holes shear tension and moment	1	18	
	2	1	
	Total	19	19
6. Rectangular Plates, 4 holes shear and moment loading	1	3	
	2	3	
	3	1	
	4	1	
	Total	8	8
7. Rectangular Plates, 4 holes shear tension and moment loading	1	2	
	2	1	
	Total	3	3
8. Rectangular plates, 4 holes shear and pull	1	3	
	2	2	
	3	1	
	Total	6	6

TABLE II Sh. 2

OYSTER CREEK NUCLEAR STATION UNIT #1

Index of Bergen-Paterson Designed Plates for Bulletin 79-02

		Category	No.	Total
9.	1 Hole Plate, shear and tension	1	1	
		2	1	
		3	1	
		Total	3	3
10.	2 Hole Plate, shear, tension moment load	1	15	
		2	2	
		3	3	
		4	3	
		5	3	
		6	3	
		7	1	
		8	1	
		9	2	
		10	1	
		11	7	
		12	6	
		13	1	
		14	1	
		15	3	
		16	7	
		17	4	
		18	2	
		19	1	
		20	5	
		21	2	
		22	1	
		23	1	
		Total	75	75
11.	3 Hole Plate, shear and moment load	1	2	
		2	5	
		3	1	
		4	4	
		5	[illegible]	
		6	[illegible]	
		7	[illegible]	
		8	1	
		9	2	
		10	1	
		Total	20	20
12.	5 Hole Plate, shear and moment load	1	1	
		2	2	
		Total	3	3
	TOTAL			324

TABLE III

OYSTER CREEK NUCLEAR STATION UNIT #1

Index of Base Plates Designed by Atlanta Engineering to be reviewed in compliance with USNRC Bulletin 79-02

SET	CATEGORY	NO.	TOTAL
1. Plates Shear Load Only	-	-	28
2. Square Plates, 4 Holes, Pull Load	1	2	
	2	1	
	3	2	
	4	1	
		6	6
3. Square Plates, 4 Holes Shear and Moment Loading	1	3	3
4. Square Plates, 4 Holes, Pull and Shear Loading	1	2	2
5. Rectangular Plates, 4 Holes, Pull and Shear Loading	1	9	
	2	3	
	3	4	
		16	16
6. Rectangular Plates, 4 Holes, Shear and Moment Loading	1	2	2
7. Rectangular Plates, 2 Holes, Pull and Shear Loading	1	2	
	2	2	
	3	3	
	4	3	
	5	1	
	6	1	
	7	2	
	8	1	
		15	15
8. Square Plates, 6 Holes, Pull and Moment Loading	1	2	2
9. Rectangular Plates, 6 Holes, Pull and Shear Loading	1	1	
	2	4	
	3	2	
		7	7
TOTAL			81

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