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THE CINCINNATI GAS & ELECTRIC COMPANY

CINCINNATI, OHIO 45201

May 6, 1980

E. A. BORGMANN
VICE PRESIDENT

U.S. Regulatory Commission
Office of Inspection and Enforcement
Region III
7999 Roosevelt Road
Glen Ellyn, Ill. 60137

Attn: Mr. James G. Keppler, Regional Director

Re: WM. H. ZIMMER NUCLEAR POWER STATION - UNIT 1
ADDITIONAL RESPONSES TO IE BULLETIN 79-02, PIPE SUPPORT
BASE PLATE DESIGNS USING CONCRETE EXPANSION ANCHOR BOLTS
DOCKET 50-358, W.O. 57300, JOB E-5590, ITEM #400

Gentlemen:

The following information is being furnished as an additional response to IE Bulletin 79-02, Rev. 2 regarding pipe support base plates using concrete expansion anchor bolts. This is considered an interim report.

This information covers the five (5) unresolved items pertaining to IE Bulletin 79-02 as delineated in an inspection conducted by the Nuclear Regulatory Commission on January 22-24, 1980. The Cincinnati Gas & Electric Company response consists of the following:

a. Item 1 regarding the developing of anchor bolt loads including base plate flexibility has been reviewed by the NRC staff (NRR). Their review indicates that the bolt stiffness used in the flexibility analysis is not acceptable in that the stiffness used is too low. In addition, the staff intended the flexibility analysis to use the maximum design load rather than four times the load, as indicated in Section 3.3.1 of the July 6, 1979 submittal. This item is considered unresolved (358/80-03-02).

   Response: A meeting was held with the Nuclear Regulatory Commission staff in Bethesda, Maryland on December 13, 1979, to review the method of analysis Sargent & Lundy used to perform the base plate flexibility assessment required by Item 1 of IE Bulletin 79-02. The Nuclear Regulatory Commission staff accepted the approach presented in the report, entitled, "Evaluation of Analysis Procedures for The Design of Expansion Anchored Plates in Concrete," dated May 31, 1979.

   This report and method of analysis was submitted in Cincinnati Gas & Electric Company's response to IE Bulletin 79-02, dated July 6, 1979. The Nuclear Regulatory staff, however, commented

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a. Continued - that the anchor stiffness used in the analysis was acceptable for wedge type anchors only, and that it did not represent the stiffness of shell type expansion anchors. The attached report, entitled, "Evaluation of Analysis Procedures for the Design of Shell Type Expansion Anchored Plate Assemblies in Concrete," dated January 2, 1980, justifies a base plate flexibility approach for shell type expansion anchored plate assemblies. It should be noted, however, that Cincinnati Gas & Electric Company has used exclusively wedge type expansion anchors for the support of safety related piping at the Zimmer Station; shell type concrete expansion anchors have not been used in this regard.

b. Item 2 required the licensee to verify that a minimum factor of safety of four for wedge type anchors and five for shell type anchors exist between bolt design load versus bolt ultimate loads. The licensee's response is considered unacceptable in that a minimum factor of safety of two was used for emergency and faulted conditions. This item was brought to the attention of the licensee and is considered unresolved pending submittal of a revised response (358/80-03-03).

   Response: Cincinnati Gas & Electric Company has previously stated that a factor of safety equal to 2.0 was used by Sargent & Lundy as a design basis for concrete expansion anchor assemblies designed for safety related piping systems under SSE loads. The expansion anchor assemblies are currently being reassessed, using the actual loads to determine the safety factors. In addition, Cincinnati Gas & Electric Company is participating in a comprehensive static and dynamic test program as part of the review and reassessment.

c. Item 3 required the design requirements for anchor bolts to withstand cyclic loads. The licensee's response indicated that the base plate design used Operating Basis Earthquake event. The bulletin intended the licensee to use Safe Shutdown Earthquake (SSE) event. The licensee's response is considered unacceptable pending submittal of a revised response to include the effects of SSE loading. The item is considered unresolved (358/80-03-04).

   Response: Cincinnati Gas & Electric Company will conduct a reanalysis of the concrete expansion anchor base plate assemblies used to support safety related piping for Zimmer, Unit 1 to assess the actual factors of safety for a Safe Shutdown Earthquake event. The reanalysis will utilize the actual in-place concrete strength and a conservative elliptical shear tension interaction diagram for this reassessment. The Cincinnati Gas & Electric Company is also participating in a test program to determine the capacity of the anchors using cyclic loading.

d. Item 4 required the licensee to perform a field verification of base plate installations using concrete expansion anchors. The licensee did establish a field inspection program to verify installation of the expansion anchors. The program has identified a significant number of nonconformances and deficiencies.

The S&L procedure DDC-328 Section 2.2.2 requires "one bolt per hanger shall be inspected for torque and minimum embedment. If this selected bolt is unacceptable, all bolts of the hanger shall be inspected." This inspector questioned the validity of the one bolt per hanger sample in view of the significant number of nonconformances identified on the first bolt inspection.

The inspector requested the licensee to develop a summary identifying the nonconformance number, the hanger support affected, a description of the nonconformance, and the status of the nonconformance in order to evaluate whether a 100% inspection is required. This item is considered unresolved pending the above review (358/80-03-05).

Response: Cincinnati Gas & Electric Company met with the members of NRC Region III staff in Glen Ellyn, Illinois on March 7, 1980, to review our plan for implementing pipe support and expansion anchor bolt inspection per the requirements of IE Bulletin 79-02. During this meeting, Cincinnati Gas & Electric Company agreed to an initial 100% inspection of associated concrete expansion anchor bolts. This 100% inspection will continue until the Cincinnati Gas & Electric Company is confident that expansion anchors are being installed correctly and are acceptable to design criteria. After developing this confidence level, inspection will revert to the specified project frequency.

e. Item 5 required the licensee to determine the extent that concrete expansion anchors were used to attach piping system to masonry block walls. In addition, this item required a list of systems, the number of supports, line size and accessibility of supports attached to block walls.

The licensee's response indicates the use of block walls to support piping systems; however, is incomplete in that the information requested was not included in the response.

The inspector determined by S&L letter (SLC-11991) dated January 9, 1979 that the Zimmer plant has 311 masonry block walls that are used to support pipe supports.

This item is considered unresolved pending submittal of the required information requested by Item 5 of the subject bulletin (358/80-03-06).

The subject of concrete expansion anchors used in block walls to support cyclic loads is under review by the NRC staff.

Response: Sargent & Lundy is presently involved in determining the extent that concrete expansion anchors were used to attach piping systems to masonry block walls. A listing will be developed and available for your use by May 15, 1980, which will identify supports with concrete expansion anchors, its system/subsystem designation, the line size it supports, the accessibility of the supports, and the number of supports involved.

Very truly yours,
THE CINCINNATI GAS & ELECTRIC COMPANY

E. A. Borgmann,
Senior Vice President

EAB:JCH/jb

Enclosure

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EVALUATION OF ANALYSIS PROCEDURES FOR THE DESIGN OF SHELL TYPE EXPANSION ANCHORED PLATE ASSEMBLIES IN CONCRETE

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January 2, 1980

Sargent & Lundy Engineers

Chicago, Illinois

EVALUATION OF ANALYSIS PROCEDURES

FOR THE DESIGN OF SHELL TYPE EXPANSION ANCHORED

PLATE ASSEMBLIES IN CONCRETE

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1.0 PURPOSE

The purpose of this report is to demonstrate that rigid plate analysis procedures may be used in the design of shell type expansion anchored baseplate assemblies when appropriate amplification factors are applied to the resultant anchor forces to account for baseplate flexibility. It will subsequently be shown that amplification factors may be derived in conjunction with the actual load versus displacement curve using a finite element solution to properly account for baseplate flexibility.

Baseplate flexibility may result in increased anchor forces over and above those determined by rigid plate analysis for the following reasons:

A. Prying action forces acting between the baseplate and the concrete surface.

B. Unequal load distribution in plate assemblies in which the applied load is not equidistant to each anchor in the assembly.

This report presents the amplification factors for three typical shell type expansion anchor baseplate assemblies used to support mechanical components in nuclear power stations. These amplification factors are subsequently applied to anchor reactions based upon rigid plate analysis to conservatively account for the effects of baseplate flexibility. The finite element model used to determine the amplification factors utilizes conservative load-displacement curves for shell type expansion anchors based upon manufacturer's data. The analysis also considers the complete range of applied tension/moment load combinations.

2.0 METHOD OF ANALYSIS

The effect of baseplate flexibility on the anchor reaction was analyzed using a finite element idealization of the baseplate. The ratio of maximum anchor reaction to the anchor reaction obtained by the rigid plate analysis is defined as the amplification factor. Amplification factors were obtained for the applied load acting as a pure tension load on the plate as well as at an eccentricity of three inches, and making an angle ϕ with the plane of the baseplate. By varying the angle ϕ, various combinations of tension and moment load were considered.

The concrete was modeled with unidirectional springs which resist compression only. This behavior introduces nonlinearity into analysis, and makes the amplification factors dependent on the magnitude of applied loading. For each value of the angle ϕ, a series of analyses were performed by varying the magnitude of the applied loading, such that the most stressed anchor was loaded from $P_u/12$ to $P_u/4$, where P_u is the manufacturer's recommended ultimate load.

The results of this study indicate that, in this range, the amplification factors are rather insensitive to the load amplitude. All the results presented subsequently correspond to the most conservative values which were thus obtained.

In the analysis, the anchors were modeled as truss members, the stiffness of which was conservatively determined from the manufacturer's test results described in Section 4.0 of this report.

3.0 ASSEMBLIES CONSIDERED

Three typical assemblies, consisting of one each of four, six and eight anchors, as shown in Figure 1, were considered in the analysis.

4.0 LOAD-DISPLACEMENT DIAGRAMS FOR ANCHORS

Shell type anchors show a nonlinear softening type behavior. Manufacturer's test data indicate that shell type expansion anchored plates do not behave as rigid supports; as the anchor load increases, the anchor displaces, thus reducing the effects of prying action.

In this report, a conservative bilinear idealization was used for the load-displacement behavior of anchors. The initial slope (k_1) was selected to correspond to the highest initial slope of the manufacturer's curves for that anchor diameter. The second slope (k_2) was chosen as the average slope of the clearly curving portion of the test results. The ultimate load of the anchor was assumed to equal the ultimate load value recommended by the manufacturer.

The conservative idealized load-displacement diagrams established for 1/2-inch and 3/4-inch diameter anchors are shown in Figure 2. Values of load and corresponding displacement at the knee and ultimate for these idealizations are listed in Table 1.

5.0 RESULTS

Calculated amplification factors are given in Table 2. It will be noted that the amplification factors for the four anchor assembly is equal to unity for all values of ϕ. The prying action forces are relieved in this assembly due to the load-displacement characteristic of the anchor. This conclusion can be generalized to a two anchor assembly, also.

For the six anchor assembly, the maximum amplification factor is 2.1 for the pure tension case. The most stressed anchor in this case is the middle anchor. It is evident that this is due to unequal distribution of loads on the anchors in the pure tension case. For other values of ϕ, amplification factors are smaller.

For the eight anchor assembly, the maximum amplification factor is 1.88 for the pure moment case for the four anchors nearest to the plate centerline. For other angles of load application, the amplification factor is 1.67.

These amplification factors, when applied to anchor reactions computed by rigid plate analysis, conservatively give the effect of plate flexibility.

Diameter (inches)	Values at Knee		k_1	Values at Ultimate		k_2
	P kips	δ inches	$\frac{kips}{inch}$	P kips	δ inches	$\frac{kips}{inch}$
1/2	6	0.0344	174	8.5	0.0995	38.4
3/4	9	0.0374	241	16.2	0.213	41.0

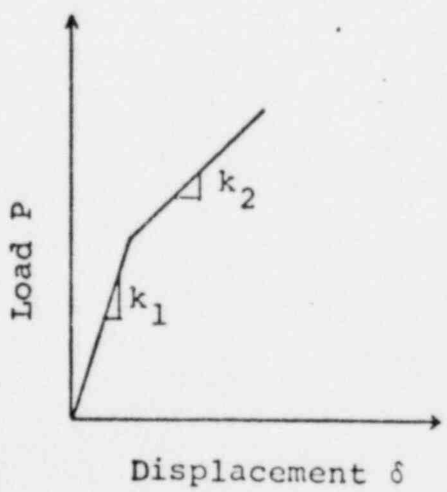
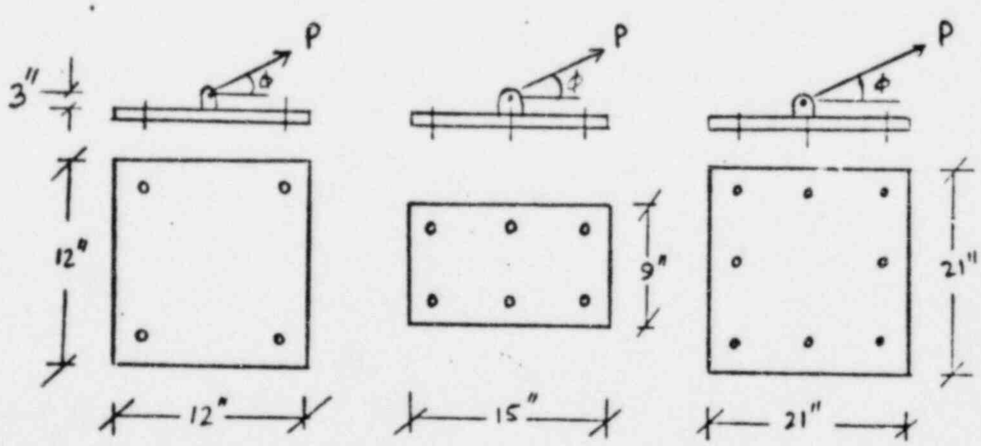


TABLE 1 Parameters of Idealized Load-Displacement Diagrams for Shell Type Anchors

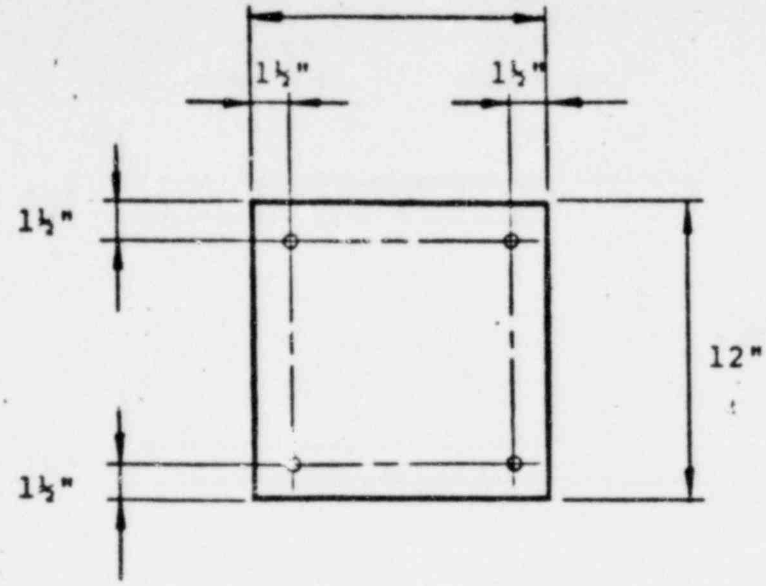
AMPLIFICATION FACTORS

Angle	Anchor Assembly 1	Anchor Assembly 2	Anchor Assembly 3
0	1.0	1.0	1.88
15°	1.0	1.0	1.67
30°	1.0	1.0	1.67
60°	1.0	1.5	1.67
90°	1.0	2.1	1.67



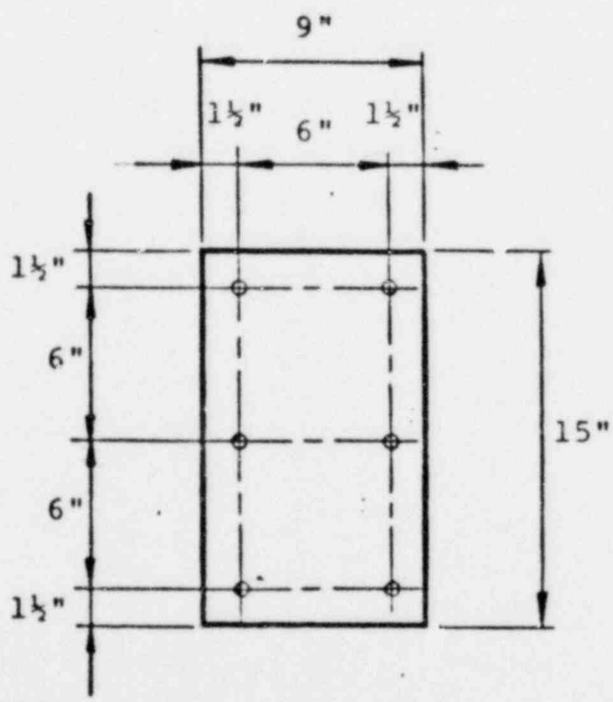
Anchor Assembly 1 | Anchor Assembly 2 | Anchor Assembly 3

TABLE 2 Results of Analysis for Baseplates with Shell Type Anchors



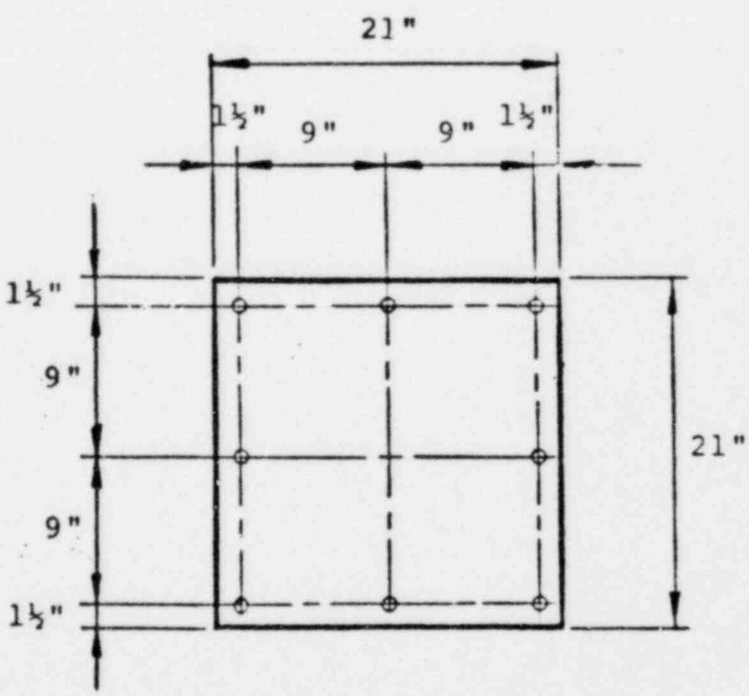
ASSEMBLY NO. 1

Plate 3/4" × 12" × 12"
Four 3/4-inch Diameter Anchors



ASSEMBLY NO. 2

Plate 1/2" × 9" × 15"
Six 1/2-inch Diameter Anchors



ASSEMBLY NO. 3

Plate 3/4" × 21" × 21"
Eight 3/4-inch Diameter Anchors

FIGURE 1 Types of Expansion Anchor Assemblies

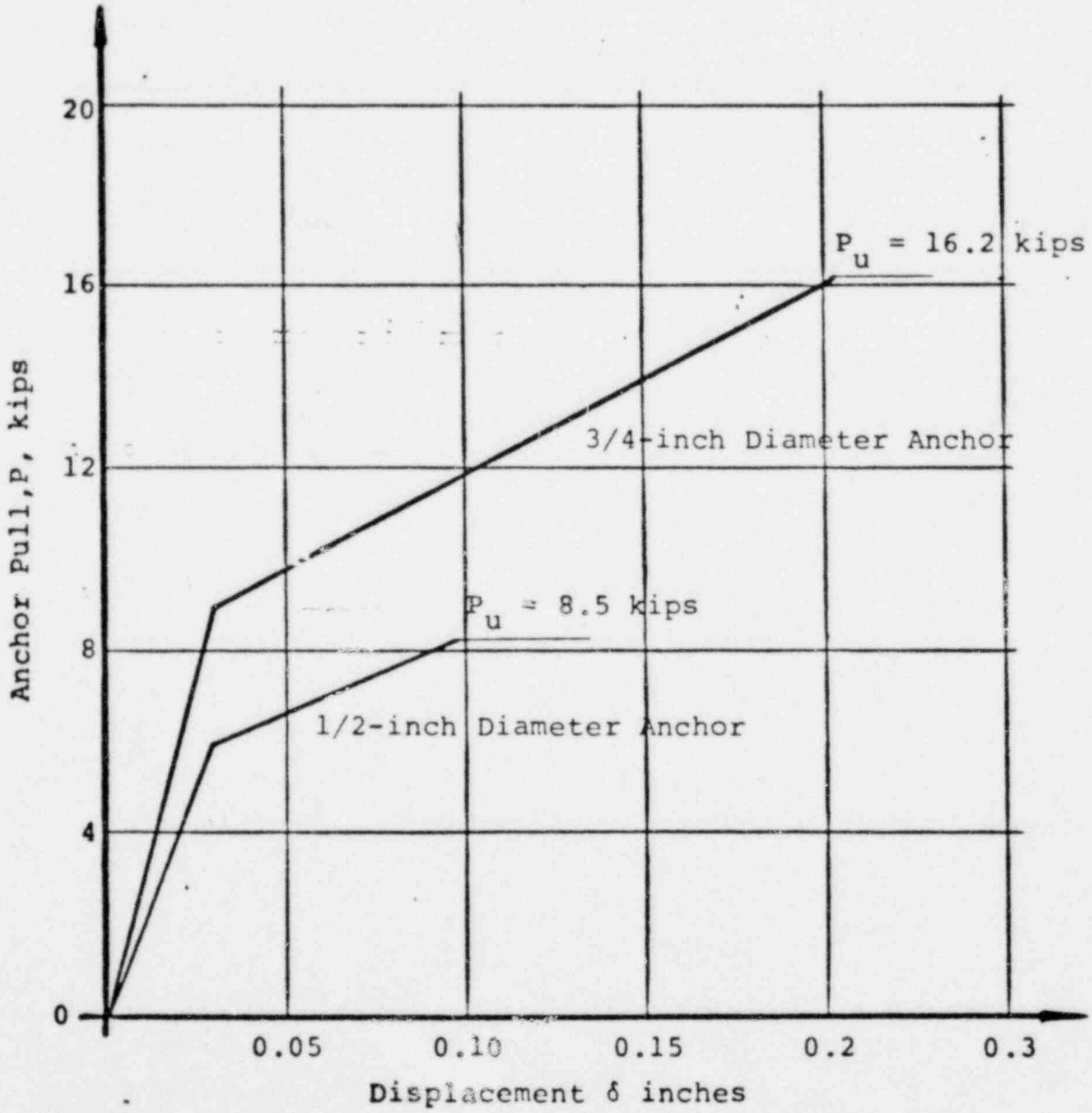


FIGURE 2 Idealized Load-Deformation Diagrams for Shell Type Anchors