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Mr. K. V. Seyfrit, Director
Office of Inspection & Enforcement
Region IV
U. S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 1000
Arlington, Texas 76011

Subject: Arkansas Nuclear One-Units 1 & 2
Docket Nos. 50-313 & 50-368
License Nos. DPR-51 & NPF-6
IE Bulletin 79-02
(File: 1510.1, 2-1510.1)

Gentlemen:

The following is provided in response to your I&E Bulletin 79-02, Rev. 1. Units 1 and 2 are individually discussed within each response.

ITEM

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. 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 hereinafter 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 pipe anchors (seismic category I) and pipe supports (seismic category I) for greater than 2 inch diameter systems were reviewed to determine if they employed base plates that were secured with concrete expansion anchor bolts. Identified base plates were then reviewed to determine if they were flexible using the above criterion.

All flexible (as defined above), pipe anchor and support base plates using concrete expansion anchor bolts (CEB's) are being (re) analyzed to account for plate flexibility, bolt stiffness, shear -tension interaction, minimum edge distance and proper bolt spacing. Depending upon the complexity of the individual base plate configuration, one of the following methods of analysis is being used to determine the bolt forces (bolt design loads):

(i) A computer program ("BOLTS"), developed by Bechtel, is used for base plates with eight bolts or less. The review of our base plates revealed that the majority of them were anchored either by 4, 6, or 8 bolts. The plate thickness was usually between ½" to 2" and the large plates are not generally stiffened. For these types of base plates, an analytical formulation ("BOLTS") was 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 (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 indicated excellent correlation between the results of "BOLTS" and those by the finite element method (using the "ANSYS" code). Additionally, the "BOLTS" method consistently calculates a greater bolt load than the finite element method, that is "BOLTS" is conservative.

"BOLTS" as described above has been implemented for determining the bolt design 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 edge distance, bolt spacing, em-

bedment length, shear cone overlapping, manufacturer's ultimate capacity, and a design safety factor (see paragraph No. 2 for discussion of allowable loads). The program computes the bolt forces and calculates a shear-tension interaction value based on the allowable loads.

The shear-tension interaction in the anchor bolts has been accounted for. The total applied shear is required to be carried by the bolts in accordance with the following interaction formula.

$$(TC/TA)^2 + (SC/SA)^2 \leq 1.0$$

Where TC = Calculated tensile force
TA = Allowable tensile force
SC = Calculated Shear force
SA = Allowable Shear force

This formula is recommended for bolted joints by the 1977 edition of ASME Code, Section III, Appendix XVII-2461.3. This is one of the interaction options within the "BOLTS" program and has been used on the majority of our calculations. Some of our earlier calculations utilized a more conservative interaction option of using the 5/3 power vice the 2 power.

(ii) For special cases where the design of the support didn't 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.

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

(iv) Two inch diameter piping systems (and less) were analyzed with a chart method vice a computer program. We did include these in our inspection program, see paragraph 4, and are in the process of analyzing the "typical base plates" authorized by the chart method. We anticipate having the analysis completed by 1 August 1979.

The current status of this (re) analysis effort is tabulated below.

	UNIT 1	UNIT 2
Total No. of affected supports	498	587
Total of supports (re) analyzed	372	359
Total supports with unacceptable bolt loads	86	33

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The following break down is provided for the "supports with unacceptable bolt loads."

UNIT 1	UNIT 2	COMBINED * SAFETY FACTOR WEDGE	SHELL	ACTION	JUSTIFICATION
29	14	4 > SF > 3	5 > SF > 3	None	See Paragraph 2 (meets proposed ACI 349-76 August 1978)
31	16	3 > SF > 2	3 > SF > 2	Will Conduct an inspection (see paragraph 4 for Due Dates)	See paragraph 2 (Meets AP&L Position)
26	3	2 > SF	2 > SF	Redesign Support	See Paragraph 4 for due dates

We anticipate completing our analytical effort by August 1, 1979. We will submit the results of the remaining analyses by August 15, 1979. It should be noted that our schedule for analytical work on base plate flexibility extends beyond the Bulletin reporting time frame of 6 July 1979. Therefore, we have already started our anchor bolt verification program, as described in paragraph 4.

ITEM

Verify that the concrete expansion anchor bolts have the following minimum factor of safety between the bolt design load the bolt utimate capacity determined from static load tests.

(a) Four - For wedge and sleeve type anchor bolts,

(b) Five - For shell type anchor bolts.

RESPONSE

The bolt allowables utilized in these analyses are based on testing conducted at the Fast Flux Test Facility and on the respective concrete expansion anchor manufacturer's supplied data. These allowable forces account for embedment length, minimum bolt spacing and free edge distance.

*See Attachment 2 for description of method for calculating safety factors.

In the current design review, factors of safety (i.e. ratio of bolt ultimate capacity to design load), four for wedge type and five for shell type anchor bolts were used for service load cases. When extreme environmental loads are included, a factor of safety of three is acceptable 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.

Further, where a specific support has been verified, a factor of safety of two is considered to be satisfactory with extreme environmental loads present.

ITEM

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 in the generation of the 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 Fast Flux Test Facility Tests.* 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

*Drilled - In Expansion Bolts under Static and Alternating Loads, Report No. BR-5853-6-4 by Bechtel Power Corp., January 1975.

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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.

ITEM

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.

RESPONSE

It is not necessary that the bolt preload be equal to or greater than the bolt design load. Pipe supports and anchors are subjected to static and dynamic loads. The dynamic loads are seismic loads which are short duration cyclic loads. This type of cyclic load is not a fatigue load, so the amount of preload on the bolts will not greatly affect the performance of the anchorage. (In addition, preload is lost over the life of the plant due to creep and other similar phenomena). Therefore, if the initial installation torque on the bolt 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. For vibratory loads during plant operation, the expansion anchors have successfully withstood long term fatigue environment as discussed in the previous section.

All concrete expansion anchors are designed, installed and verified as per Specification 6600-2-C-2305 (Attached) for Unit 2 and for Unit 1 additions after June 28, 1974. Prior to this date, concrete expansion anchors for Unit 1 were installed in accordance with manufacturer's instructions. Installation, verification and testing procedures along with acceptance criteria are given in Section 5.0 of this Specification.

Unit 1

ANO-1 did not have sufficient QC documentation to verify that the design requirements had been met for base plates installed prior to 28 June 1974. Therefore, we have initiated a testing program which will assure that the minimum design requirements have been met. Selected CEB's were tested in accordance with Specification 11406-276-5 (Attached). The procedures described in Specification 11406-276-5 requires expansion anchors to be verified for location, elevation, number of anchor bolts, spacing and edge distance as shown on design drawings, type of anchor used, embedment length and projection of anchors, washers, damage to concrete, anchor bolt diameter and anchor bolt length. Also, expansion anchors are tested for Design Loads using a sampling technique specified in Section 3.0 of the specification. Since we are not taking credit for bolt preload, we are not presenting a correlation between torque and tension. Our test program does show that the installation torque on the bolt has accomplished the purpose of setting the wedge which determines the ability of the bolt to develop its ultimate capacity. 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, is available at the jobsite.

A random sampling procedure as per Specification 11406-276-8 (Attached) paragraph 4.6 was used to determined which CEB's to inspect. The acceptance criteria of 11406-276-8 is a 95% confidence level that there are less than 5% defectives in the total population. It should be noted that our sampling technique was developed and executed prior to the receipt of IE Bulletin 79-02 Revision 1. There, fore it was a random sample on a plant basis vice a system basis. This approach did get at least one base plate from the majority of the systems and was intended to reflect the conditions of the plant. Thus, we feel that it has met the criteria of a representative sampling technique. Attachment No. 1 provides a summary of CEB's tested per system.

The results of our in-field inspection revealed that only 1 CEB out of the 122 tested failed the torque test portion of Specification 11406-276-5. This gives the "95% confidence level" that our CEB's are correctly installed. However, there were 52 supports which were found to have deviations from the "as-built" drawings. These deviations were of the following nature:

28 - Discrepancies in anchor bolt size or type (24), baseplate dimensions (2) or structural arrangement of the support (2).

24 - Discrepancies in hanger location. These are judged to have minimal effect on hanger loads, therefore, we do not propose to rerun the hanger guidance at this time.

We have already incorporated these discrepancies into our analytical work and intend to continue our field efforts until we achieve the 95% confidence level that our "as-built" pipe support drawings are correct. This extended effort would be a 100% verification of the Unit 1 seismic category I hanger sketches which employ flexible baseplates and CEB's. The following items will be verified:

a. Hanger location
b. Hanger structural arrangement
c. Baseplate dimensions, including thickness
d. Bolt size
e. Bolting pattern
f. Concrete edge distance, if near the minimum for the bolt size in question.

Additionally, we will be extending the original "in-field" inspection program to include the 31 Unit 1 and 16 Unit 2 CEB's which have $3 > SF > 2$, as reported in paragraph 1.

We anticipate that both of these efforts will be completed during the next refueling outage and that any significant discrepancies will be corrected at the first opportunity subsequent to the outage.

Unit 2

ANO has sufficient QC documentation to verify that the design requirements have been met for each base plate. A review of the "Specification for Installation of Class 1 and Non-Class 1 Concrete Expansion-Type Anchors" (6600-2-C-2305) (Attached) and of "Field Instruction for Installation of Class I Concrete, Expansion

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Anchors (2FI-129) (Attachment) has substantiated this fact. The "as-built" conformance problems discovered on ANO-1 are not present on ANO-2 because: 1) of these two procedures, 2) a much stronger emphasis on QC with system walk downs conducted by A-E and AP&L personnel and 3) ANO-2 utilized "on-site" engineers to do the hanger design vice using a sub-contractor's "off-site" facilities. For these reasons an extensive in-field program will not be required on ANO-2.

Very truly yours,

Donald A. Rueter

for David C. Trimble
Manager, Licensing

DCT/MCW/ew

cc: Mr. Normal L. Moseley
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ATTACHMENT 1

UNIT 1

CONCRETE EXPANSION BOLT TESTING

	Seismic Cat. I System	# Tested	Not Safety Related
RCS	Reactor Coolant	28	
MU	Make Up and Purification	20	
CF	Core Flooding	1	
DH	Decay Heat Removal	25	
SMP	Sampling	3	X
FPC	Spent Fuel Cooling	0	X
MS	Main Steam	3	
ED	Emergency Diesel Gen. and Fuel Oil	0	
FW	Feedwater	22	
RBS	Reactor Bldg. Spray	2	
AS	Instrument and Service Air	0	X
ICC	Intermediate Cooling	0	X
SW	Service Water	12	
LW	Gaseous Radioactive Waste	1	
CH	Chilled Water	0	X
PH	Plant Heating	0	X
CA	Chemical Addition	0	X
FW	Fire Water	0	X
	Containment Test Conn.	No Support	
H&V	Heating and Ventilating		
	Spare Containment Flued Head	No Support	
HP	Heat and Vent. (Hydrogen Purge Air System)	5	
	Total	122	

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ATTACHMENT 2

COMBINED SAFETY FACTORS (CSF)

In communicating the result of the CEB-base plate review, it is more straight forward to use CSF than Interaction Value (IV). IV is the result of the interaction equation. The CSF may be computed based on the following formulas:

$$CSF = 4/\sqrt{IV},$$ for wedge type CEB

$$CSF = 5/\sqrt{IV},$$ for Phillips Self-Drilling Anchors and other shell type CEB.

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