ATTACHMENT 1

TR-3501-1, Revision 1

Summary Report

Generic Response to U.S. NRC I&E Bulletin 79-02

Base Plate/Concrete Expansion Anchor Bolts

August 30, 1979

7912170222

OCONEE NUCLEAR STATION

Responses to USNRC Bulletin 79-02, Revision 1

Original: July 6, 1979

Revision 1: August 14, 1979

Revision 2: October 23, 1979

Oconee Nuclear Station is a three (3) unit operating station located near Seneca, South Carolina. The following is a summary, by item, of the extent and manner in which Duke Power Company intends to satisfy Actions 1 through 4 of IE Bulletin 79-02, Revision 1.

Response 1: Duke Power Company is accounting for base plate flexibility in the calculation of expansion anchor bolt loads for all Nuclear Safety Related/seismic pipe support base plates using a conservative hand calculation method which has been verified by non-linear finite element analysis. The models and boundary conditions, including appropriate load displacement characteristics of the anchors used for the finite element analyses, are based on Duke studies and on work performed by Teledyne Engineering Services which was sponsored by a group of fourteen (14) utilities formed to respond to generic items of IE Bulletin 79-02. A complete description of the finite element model is submitted in the Teledyne Engineering Services report attached (Attachment #1). A description of the hand calculation methods is also attached (Attachment #2).

All re-analysis is complete for Nuclear Safety Related/seismic support base plates located in Unit #3 Containment, Auxiliary Building, and Turbine Building; in Unit #1 Containment, Auxiliary Building, and Turbine Building; and in Unit #2 Containment, Auxiliary Building, and Turbine Building. In some cases, conservatively including the effect of plate flexibility has reduced the expansion anchor factor of safety below that outlined in Response 2. Any that had a factor of safety less than two were given immediate attention and determination of system operability was immediately begun in parallel with a rigorous (finite element model) analysis of the expansion anchor factor of safety. All anchors in this category have been resolved by demonstrating computed factors of safety in excess of two (2) or that the expansion anchor is on a non-essential segment of pipe.

Response 2: Self-drilled type, wedge type, and sleeve type expansion anchors have been used in Nuclear Safety Related/seismic pipe support applications at Oconee Nuclear Station. The majority of expansion anchors are of the self-drilled type. Duke Power Company is presently verifying that the minimum factor of safety between expansion anchor design load and anchor ultimate capacity determined from static load tests, is five (5) for shell type expansion anchors and four (4) for wedge and sleeve type expansion anchors. This process of verification is outlined in Response 1.

Oconee Nuclear Safety Related/seismic pipe support expansion anchor installations are restricted to normal weight structural concrete of varying nominal strengths. Expansion anchor bolt ultimate load capacities are based on manufacturer's test results and recommendations for normal weight concrete and installed concrete strengths. None are installed in concrete block masonry.

The effects of shear-tension interaction, minimum edge distance and bolt spacing on expansion anchor ultimate capacity is properly accounted for in computing the expansion anchor factors of safety.

<u>Response 3</u>: Duke power Company designs pipe supports to resist all applicable loadings including seismic loads, hydro test loads, normal operating loads, thermal loads, etc. Each support is designed for a static or quasi-static load resulting from the most critical combination of applicable loadings. Duke Power Company co-sponsored tests performed by Teledyne Engineering Services to demonstrate that expansion anchors installed at Oconee Nuclear Station will perform adequately under both low cycle/high amplitude loading (seismic) and high cycle/low amplitude loading (operating). The report on cyclic testing of concrete expansion anchors by Teledyne Engineering Services is provided in Attachment #1.

<u>Response 4</u>: Existing QC documentation for expansion anchor installations at Oconee is not sufficient to provide written verification that each expansion anchor meets the requirements of Action 4(a) and 4(b) of IE Bulletin 79-02. Duke Power Company has initiated a test program, as required by IE Bulletin 79-02 to verify that applicable design requirements have been met. Oconee Unit 3 was down for refueling during the reporting interval of this Bulletin and therefore the pipe supports within Containment and high operating radiation areas of the Auxiliary Building were selected for initial inspection and testing because of future inaccessibility. Testing and inspection on all supports for Nuclear Safety Related/seismic piping systems is complete with the exception of those supports determined to be inaccessible due to mechanical interferences or high radiation. Documentation justifying the inaccessibility of these supports is available at the site.

Inspection and testing of expansion anchors in the accessible areas of Units 1 and 2 Auxiliary Buildings will be a continuing effort supplemented by inspection and testing of inaccessible areas of each unit when it is down for refueling.

The verification program consists of two (2) phases. Phase 1 is a field surveillance program to identify each Nuclear Safety Related/seismic pipe support which was installed using expansion anchors and compare its "as built" configuration, location, and expansion anchor size and type to existing documents. Phase 2 is a field inspection and testing program to verify that specified design size and type is correctly installed. The Phase 2 program for shell type expansion anchors was developed and implemented on Unit 3 in accordance with the requirements of IE Bulletin 79-02, Revision 0. Pull testing and a thread engagement check was required for one randomly selected shell-type anchor per plate on each pipe support hanger in addition to a general visual inspection. The anchors were pull tested at 25 percent of ultimate load which is 25 percent in excess of the maximum envelope design load. If the anchor failed pull test or thread engagement, then each anchor on the plate was tested or inspected for the parameter which failed. All bolts in shell type anchors were turned and retorqued to assure operability.

A total of 304 pipe supports were inspected inside Unit 3 Containment. 560 shell type anchors were pull tested and/or visually inspected with bolts removed. 32 anchors were classified as having rejectable installation deficiencies. One anchor failed the pull test and the remaining deficiencies were identified visually. 178 of the 304 pipe supports are actually Nuclear Safety Related/seismic. 15 of these supports contained one or more expansion anchors which were classified as rejectable. The 15 supports were well distributed among the Nuclear Safety Related/seismic systems, i.e. there was no grouping preference for a single system. A total of 26 Nuclear Safety Related/seismic anchors were rejected for installation deficiencies, from a test and inspection sample of 353 anchors. This sample represents approximately 49 percent of the Nuclear Safety Related/seismic anchors in Unit 3 Containment. Further review of the 32 rejected anchors indicates that 17 had deficiencies which significantly reduced their ultimate load carrying capacity while 15 contained deficiencies of a lesser nature (see Attachment #3). Duke Power Company has additionally analyzed the 15 pipe supports with all deficient anchors assumed to be absent and concluded that existing design margins were adequate to assure operability of all Nuclear Safety Related/seismic piping systems in accordance with the plant design bases.

A total of 737 supports have been tested in the Unit 3 Auxiliary Building. 1188 shell type anchors have been pull tested and/or visually inspected. 181 anchors were classified as having rejectable installation deficiencies. 10 anchors failed the pull test and the remaining deficiencies were identified visually. The 181 anchors were in a total of 97 supports. Further review of the 181 rejected anchors indicates that 41 had deficiencies which significantly reduced their ultimate load carrying capacity while 140 had deficiencies of a lesser nature (see Attachment #3). The 41 anchors were located in 22 supports.

A total of 35 supports have been tested in the Unit 3 Turbine Building. 89 shell type anchors have been pull tested and/or visually inspected. 15 anchors were classified as having rejectable installation deficiencies. No anchors failed the pull test and the remaining deficiencies were identified visually. The 15 anchors were in a total of four supports.

In response to numerous discussions with Region II inspectors, the testing crews were instructed to gather two additional pieces of information not addressed in Duke's test procedure. They were instructed to provide the dimension of any holes showing signs of oversizing and they were also instructed to measure shoulder to plug dimensions on all anchors which have their bolt removed during testing. All holes identified as being oversized are being repaired where required by analysis. The acceptable shoulder to plug dimension was the anchor length minus plug length + 1/8" or - 1/4". Any bolts exceeding the +1/8" tolerance but passing pull test were determined acceptable, but any bolt exceeding the -1/4" tolerance was rejected, even if it passed the pull test, due to possible insufficient shear cone capacity (see Attachment #3).

Any anchor that passes pull test and has minimum acceptable embedment depth is considered fully adequate even though it may fail to meet certain visual requirements deemed to be indications of proper installation. After completion of the inspection and testing program, each support containing anchors passed by the pull test but having a visual deficiency will be reviewed by Design Engineering for adequate margins of safety and future repairs deemed prudent. A pull test is an actual capability test assuring a minimum anchor capacity equal to the test load and has sufficient margin of safety due to the following reasons:

a. The test load (Pu/4) is 25 percent greater than the maximum envelope design load. The actual expansion anchor design loads were not available for each anchor prior to testing, therefore, each shell anchor design load was conservatively assumed to be equal to the full Pu/5 for purposes of the testing.

b. Calculation techniques to establish expansion anchor design loads contain inherent margins for the following reasons:

1. Conservative specification of site seismic event.

2. Conservative generation of "in structure" response spectrums.

3. Conservative structural damping used.

4. Seismic input spectra used for piping analysis is enveloped by elevation, then each support is simultaneously subjected to this input.

5. Inherent conservatism in response spectrum analysis technique when combining intermodel components without phase consideration.

6. Conservative piping damping used in dynamic analysis.

7. Conservative "hand calculation technique" used to include base plate flexibility.

8. Differential seismic building motions conservatively input to piping analysis.

c. There were just three anchors with deficient shoulder to plug dimensions which failed pull test out of a sample of 282 anchors.

d. The shear-tension interaction relationship used is a very conservative relationship with which to establish anchor factor of safety. This is verified by the Teledyne Engineering Services report attached (Attachment #1).

e. It is conservative to assume that the anchors carry all the shear. All or some of the plate shear will be taken through concrete/plate friction without or with limited bolt engagement. The anchor allowable tensile load is unfairly reduced by assuming frictionless concrete/plate interface and theoretically relying on the anchor to carry the full shear.

The remaining pipe supports in Oconee balance of plant and inside Units 1 and 2 Containments are expected to exhibit a similar distribution and number of improperly installed expansion anchors. A limited number of these anchors would have a significantly reduced ultimate load carrying capability. The strength margins originally designed in these connections and bolt patterns provide considerable reserve in the event that an expansion anchor fails to carry its load and redistribution of this load is necessary to the adjacent anchors, as was shown for each of the 15 supports containing a deficient anchor in Unit 3 Containment. Duke therefore concludes that Nuclear Safety Related/seismic piping system operability is not jeopardized by the presence of a limited number of distributed expansion anchors which have been "improperly installed".

Duke is currently revising its shell type expansion anchor testing and inspection program for Units 1 and 2 to include revisions as required to comply with IE Bulletin 79-02, Revision 1. The sleeve and wedge type expansion anchor testing and inspection program fully complies with IE Bulletin 79-02, Revision 1.

In addition to revising the shell type expansion anchor testing and inspection program for Units 1 and 2 to include Revision 1 of IE Bulletin 79-02, the sample size for both the inspection and the pull test have been revised. Based on the data obtained from Unit 3, it was concluded that the visual inspection program was very significant in identifying anchor deficiencies and the pull test was insignificant in identifying anchor deficiencies. The test and inspection data supporting this conclusion was presented to USNRC, Region II, in a meeting on October 9, 1979. Therefore, the program has been modified to require 100% visual inspection of Nuclear Safety Related/seismic expansion anchors and to require a "confirmation" pull test of 3% of the Nuclear Safety Related/ seismic expansion anchors. The 3% pull test sample will be on anchors which have passed the visual inspection and is performed to confirm that the visual inspection adequately identifies an anchor deficiency which has the potential for causing a pull test failure in Units 1 and 2. The 3% sample will be appropriately revised, if pull test failures occur, to assure a minimum 95% confidence level.

In order to address the question of relationship of cyclic/load carrying capacity to installation procedure (anchor preload), the tests referred to in Response 3, performed by Teledyne Engineering Services and sponsored by the group of fourteen (14) utilities, have been performed on anchors installed in accordance with manufacturer's recommended installation procedures and have no more preload than is provided by the use of these procedures. Based on Duke's understanding of the behavior of expansion anchors and on the cyclic testing which has been performed, Duke Power Company is confident that the anchors will perform adequately.