TENNESSEE VALLEY AUTHORITY

EMPLOYEE CONCERN PROGRAM
INVESTIGATION REPORT

Concern No: ECP-86-BF-421-001

Subject: Cable Tray and Conduit Seismic Qualification

Dates of
Investigation: June 23 - July 7, 1986

Investigator: J. M. Pleva — August 26, 1986 (Date)

Submitted: T. F. Newton — 8/29/86 (Date)

Approved: E. K. Sliger — 10/16/86 (Date)

I. BACKGROUND

The Browns Ferry Nuclear Plant (BFN) Employee Concern Site Representative received an allegation that was transmitted to TVA from NRC Region II (L12 860523 801). The alleger stated certain concerns related only to BFN. The NRC allegation (R11-86-A-0119) can be described as follows:

Element A: Errors in engineering calculations and inadequate number of employees to operate the Structural Design Language (STRUDL) computer program.

Element B: (1) He observed a poorly laidout network of cable trays without proper identification or easy access, (2) Many of the cables and conduits are rigidly connected to the building, and (3) There are some loose connections and inadequate and insufficient number of supports at several places. These concerns were observed in the cable spreading rooms below the instrument and control room. This inspection program that the alleger was involved in was called the "Seismic Qualification of Existing Class 1E Conduits and Supports."

A previous concern on the inadequacy and lack of adherence to site procedures governing inspection of conduit supports in Category I structures was received, investigated, and substantiated in Investigation Report ECP-86-BF-199-001. Recommendations were made which have been responded to by the BFN plant staff. Implementation of corrective actions will be at least indirectly applicable to concern element B(3).

The concern was determined to be nuclear safety related, and it was categorized as an engineering concern since it relates to the adequacy of the design and construction practices and the quality of as-constructed facilities.

II. SCOPE

The scope of this investigation was determined from the stated concerns to be that of issues that only affect BFN. The investigation consisted of review of site program documents and procedures' reviews, interviews with site employees and supervisors, and field observations.

III. SUMMARY OF FINDINGS

A. Element A

1. STRUDL is a computer program that is used to perform structural analyses of conduits and cable trays. Division of Nuclear Engineering (DNE) personnel can learn to utilize STRUDL by on-the-job training, by depending on assistance from trained individuals, or by following a step-by-step manual of instructions.

III. SUMMARY OF FINDINGS (Continued)
Element A (Continued)

2. All design engineering calculations are performed in accordance with OEP-7 (Office of Engineering Procedure, Calculations) (currently NEP Nuclear Engineering Procedure 3.1). These calculations are checked by an independent checker in accordance with NEP 3.1. All review work of calculations is governed by OEP-10 (Office of Engineering Procedure, Review) (currently NEP 5.2).

3. DNE personnel interviewed feel that the vast majority of engineering calculations performed by the STRUDL program have been correct from the inception of the program. During requalifications of deficient conduit supports, errors were sometimes found in the original calculations. When these errors are found, a Significant Condition Report (SCR) is generated to resolve the problem. SCR BFN CEB8522 documents an instance that was reviewed as an example of error documentation. According to DNE records, approximately 99 percent of the original calculations that were rechecked have been determined to be correct.

Element B

1. Design Criteria BFN 50-714, "Conduit Support Seismic Design" was initially issued on January 14, 1971, and provided the criteria for conduit supports within seismic Category I structures at BFN. Various deviation or adverse condition reports have been generated since 1983 dealing with BFN deficiencies of information and acceptance criteria for installation of conduit systems required to be seismically qualified. These include Corrective Action Reports (CAR) 83/174 and 84/088 and Discrepancy Report (DR) X03-S-84-0014-03. Subsequently, typical conduit support drawings were issued for all future installation of conduit supports beginning in May of 1984.

2. A task force was also established at BFN to determine the disposition of existing supports. As a result of the task force study, it was determined that a representative sample of plant areas would be inspected to determine the condition of the existing conduit supports. Conduit (and supports) in each area selected was inspected with intent that it be deemed to be seismically qualified or analyzed to determine if it was seismically supported. Numerous problems were found related to inadequate conduit support, the worst cases being improper types of supports and conduit clamps not properly tightened. Tests were run at Singleton Materials Engineering Laboratory to determine the capacity of the existing types of clamps; it was determined that some would qualify but would have to be torqued. The DNE notified BFN Design Services of the acceptable types of clamps, strap thicknesses, etc. DNE also prepared a

III. SUMMARY OF FINDINGS (Continued)
Element B (Continued)

project specification (PI 85-02) for an OE conduit reinspection effort. Later, DNE contracted with Wyle Laboratories (Huntsville) to perform a triaxial shaker table test in order to develop good acceptance criteria as a basis for replacing design criteria BFN 50-714 with BFN 50-723. The test was completed in February and BFN 50-723 was issued on March 28, 1986 (B42-860404 505).

3. The intent of the conduit/conduit support inspection programs was for DNE to perform a visual inspection for seismic adequacy as defined by PI 85-02 and for the plant Modifications Group to inspect and verify existent conduit supports, replace unacceptable components, check bolt torquing, etc. Because of this division of responsibilities for the plant inspection effort, memorandums were transmitted from OE to Design Services initially on July 8, 1985 and also by memorandums of July 26, August 28, and November 20, 1985. It was during the Modification's Group inspection effort that concern ECP-86-BF-199-001 was expressed.

4. In interviews, it was found that the current conduit program is an effort to seismically qualify existing conduit and supports to the standards to which the plant was originally licensed. This is accomplished by degreed civil or mechanical engineers walking down the present conduit systems and assessing the seismic capabilities of those systems as a function of the degree of conformance to design criteria and demonstrated engineering benchmarks. Design aspects, such as span lengths, support types, connection designs, and anchorage details are evaluated. Since the original plant design did not require detailed conduit drawings, those conditions deemed satisfactory by the evaluation effort are not detailed. When a problem exists or is perceived to exist, an inspection form is completed and a further evaluation is performed. If the discrepancy requires a modification, detailed designs are performed and appropriate drawings depicting the fixes along with the required quality information are generated and issued. The cost of this program is estimated to be $9.3 million and the estimated completion date is prior to restart. As a result of this program, it was intended that TVA have confidence that the existing conduit systems would be capable of withstanding a postulated Design Basis Earthquake (DBE) so that electrical cable systems would be able to provide continuous power to electrical components.

III. SUMMARY OF FINDINGS (Continued)
Element B (Continued)

5. The current program requires degreed TVA civil or mechanical engineers familiar with conduit support design requirements to perform the seismic qualification of the existing conduit and conduit supports installed prior to May 1984. In addition to being a degreed engineer to qualify as a lead engineer/inspector, these engineers were to (1) have designed conduit supports for BFN, (2) have had previous evaluation experience on the unit 3 conduit sample program at BFN, (3)have completed and have been certified in the welding class for the drywell inspection at BFN, or (4) have had six-months experience at BFN, (5) have completed the welding class and received on-the-job training by a lead engineer for a minimum of one week.

6. This program was used until November 1985, at which time contract engineers replaced the original TVA engineers. Therefore, to make the transition of contract engineers into the program the requirements for lead engineers were modified to be: (1) degreed civil or mechanical engineers with a minimum of 18 months' experience in the design of conduit/pipe supports or other miscellaneous steel items, (2) trained by an experienced lead engineer in the specific BFN requirements for conduit support design/inspection for a minimum of two weeks.

7. During this investigation, two engineers were chosen as a "typical cross-section" for contract engineers that performed the span and support seismic analyses for all essential conduit supports at BFN installed prior to May 1984. Since these engineers had a B.S. degree in civil engineering and had performed similar work at several nuclear plants, they were hired for work as inspectors and designers at the BFN site. Each engineer was placed in an on-the-job training program under a "lead engineer" for a period of three to four weeks. In this training, the lead engineer observes the trainees' use of various source documents (see Appendix A) in analytical proficiency in conduit support design and in-field inspections. During training, engineers were to inspect supports and discuss why each support was or was not qualified (i.e., insufficient weld length, oversized holes, concrete inserts sticking out, member span too big, etc.). Conduit support calculations from each engineer are reviewed by the lead engineer and are maintained to document analytical proficiency. Upon successful completion of training, a form was signed by the lead engineer and the section supervisor that certifies the individual met the qualifications. However this form did not indicate the specific qualification requirements for support analyses. Four examples of span and support qualifications documentation were examined to determine if the analyses were acceptable. These examples evaluated both acceptable and unacceptable spans and supports. The documents accurately reflected the analysis and the appropriate corrective action if it was needed.

III. SUMMARY OF FINDINGS (Continued)
Element B (Continued)

8. An observation of the unit 1 spreading room was made on July 1 to determine if the cable trays were properly labeled. It was determined that cable trays are properly labeled for identification; however, flamemastic has partially covered some labels. The flamemastic that was used on the cables to eliminate the potential of a future cable fire contributes to the difficulty in identifying various cables. It was observed that there is no easy access to most of the cable trays in the cable spreading room. This is an original design feature and changes to this configuration are not necessary to be able to pull future cables.

9. During investigative interviews it was learned that the scope of the MRs for torquing the straps on conduit supports will be reduced because of the problem encountered in the performance of SEMI-51. Originally, the work of each MR covered an entire area but now each MR covers only one column line per elevation. The amount of MRs will therefore increase from 15 to approximately 40 when work resumes. Plans have been made to torque all Unit 2 support straps prior to startup unless a study that DNE is having performed at Wyle Laboratories in Huntsville shows different results that lower torque values are adequate to meet the DBE. This test, developed by BFN Civil Section C-8 and CEB Central Staff will check a statistically representative number of supports at various torque levels to determine if the seismic capacity meets the criteria in BFN 50-723. It has been indicated that if this test is successful, then Modifications personnel would incorporate the results into SEMI 51 which would result in not having to retorque the straps to the manufacturer's torquing values. This study should be complete by August 31, 1986.

10. An United Engineers (UE) unit 2 Interim Cable Tray Seismic Qualification study, which was requested by Design Services, showed that all conduits attached to cable trays had sufficient flexibility so as not to endanger the cable trays or the conduits.

11. An interim seismic qualification of cable tray supports for unit 2 was completed by United Engineers (UE) in February 1986 (see reference A for details). In this 5-volume report, 14 design fixes were identified that required completion so that the unit 2 cable tray structural integrity would be maintained during a safe shutdown earthquake (SSE). NRC, Region II, has reviewed this proposed fix by TVA and they have closed an inspector follow up item (50-259, 260, 296, 85/51-02, paragraph 8). NRC, Office of Nuclear Reactor Regulation, is currently evaluating this proposal. DNE issued drawings for six fixes in January 1986 during initial work activities. They used drawings for the

III. SUMMARY OF FINDINGS (Continued)
Element B (Continued)

eight fixes in May during later work activities. DNE has concurred with UE's recommendations. BFN Modifications is currently working on the implementation of these fixes. The work in the cable tunnels and spreading room has been completed. All other items are being worked and will be completed prior to unit 2 startup.

12. DNE has contracted with EQE Inc., to perform a long-term cable tray seismic qualification program for all BFN units. The long-term program for units 1, 2, and 3 has been presented to TVA in draft form (see reference S for details). This program presented by EQE is unique to the nuclear industry in that it uses actual data from plants that have experienced seismic events. The actual configuration at BFN is to be compared to the cable tray configurations in incident plants. The formal report is expected from EQE around August 1. At this time, CEB will evaluate the report and then discuss the details with NRC personnel in Region II and NRR.

13. The adequacy of the current program for conduit and conduit supports in Category I structures has been questioned by plant QA. In interviews, they have indicated a disagreement with design engineering personnel on the application of the requirements of 10 CFR 50, Appendix B and the plant technical specifications to conduit regarding adequate assurance that it will withstand the SSE. The basic issue was whether the current conduit program provides adequate regulatory compliance with respect to design control and configuration management.

14. DNE has discussed conduit programs with personnel at other utility plants having licensing requirements similar to those of BFN and they indicated that those plants presently are in a design control and configuration condition similar to that of BFN (i.e., no configuration drawings for conduit). Additionally, they have not been questioned to date regarding the lack of design and configuration control for conduit and have not been required to provide specific conduit design. DNE has not discovered any specific commitment that BFN have a complete configuration control system for conduit. If this were required, it could be a long-term program that would require many years to complete.

15. Discussions between QA and DNE considered the extent of work required to meet a complete configuration definition and configuration control system for conduit. Two additional options versus the current program have been discussed. However DNE and site project management personnel do not consider that the gain by either option is economically or technically justifiable especially since they consider the current program is satisfactory.

III. SUMMARY OF FINDINGS (Continued)
Element B (Continued)

a. Option a could be pursued to accomplish the objective of the current program except that conduit drawings would uniquely detail each conduit support identified in the plant. The cost for this option was estimated to be $30 million and the estimated completion date would be June 1992. Utilization of this program would provide the same level of confidence in seismic load carrying capability as does the current program plus the specific configuration definition. In addition, this option would provide capability for maintenance information on the removal and installation of conduit and support systems so as to ensure maintenance of the original configuration.

b. Option b could be developed to expand on option a. The detailed calculations could be developed to analytically demonstrate the seismic capability of the detailed configuration. Then, QA could utilize this detailed information to perform inspections of each conduit and support system in order to provide complete documentation to meet the requirements of 10 CFR 50 Appendix B.

This option would cost approximately $55 million and the estimated completion date would be December 1993. This option would provide a totally documented configuration program that demonstrates the seismic adequacy of the conduit program. The increased degree of confidence of this option to ensure adequate seismicity of the conduit system in a DBE over the current scope of option b is negligible.

16. DNE/CEB agree that if the current program is maintained, actions should be taken to ensure that seismic integrity is not degraded by maintenance activities. This would require policy being defined by the Site Director to ensure that design drawings are provided by DNE to the plant to remove and reinstall any future conduit supports through plant modification.

17. The entire DNE conduit program will be controlled by a new program document. This document entitled, "Inspection and Seismic Qualification of Existing Electrical Conduit and Conduit Supports" has been prepared and should be officially issued for implementation by mid-August. The purpose of this program is "to assure that the plant has a conduit system which is seismically supported, which allows safe operation and which provides the capability to maintain the units in a safe shutdown mode following a design basis earthquake. Additionally, this program will provide a documented design baseline from which engineering decisions may be made for future modifications with a degree of confidence as to the seismic qualification of the existing features." This document was designed to be a "living" document (incorporate changes as necessary to ensure that the program continually meets the applicable requirements).

SUMMARY OF FINDINGS (Continued)
Element B (Continued)

IV. CONCLUSIONS

The first concern is not substantiated. The error rate of original engineering calculations is very low (approximately one percent). The probability of several errors in critical locations in a run of conduit is much lower than the one percent. The cognizant engineer is the sole person responsible for STRUDL training. All engineers that need to use the program are able to do so without timely delays. The work progress has not deteriorated due to lack of STRUDL operators.

The second concern has three distinct elements. Element B1 is not substantiated. The cable trays are laid out with proper identification and they are laid out such that future cables could be pulled. Element B2 is not substantiated for cable trays or conduits. Element B3 is substantiated. There have been approximately 1000 discrepancies identified by analyzing the conduit supports to the criteria in PI 85-02. This is about 5 percent of the total amount of conduit supports. The issue has been fully recognized by DNE and the current program overall is adequate. However, some modifications should be made to improve overall quality.

V. RECOMMENDATIONS

1. Develop a coordinated TVA-BFN official position on the current conduit support program with respect to configuration management.

2. Inspection and evaluation packages of any discrepancies (actual or perceived deviations from the design requirements of BFN 50-723) should be maintained as permanent plant records. If changes are made, proper reevaluations should be performed.

3. Verify that no changes to the baseline conduit support program have occurred since project inception.

4. Modify training records to reflect that specific minimum requirements for supports have been met for each contract engineer utilized in the conduit support program.

5. Ensure that appropriate controls, for disturbing or reconfiguring conduit supports are addressed in Maintenance and Modifications procedures. In addition, all reconfigurations should have DNE approval which may include reanalysis and/or the issuance of engineering drawing.

V. RECOMMENDATIONS (Continued)

6. During this investigation, Quality Wheel meetings were used in a very positive manner by DNE, Modifications, QA, and Project Management to enhance communications and complete action items. It is recommended that this be pursued in the future. This item is not a management response item.

VI. DOCUMENTS REVIEWED

A. United Engineers and Constructor's Report on Interim Evaluation of Cable Tray/Supports for Unit 2, Document No. 7841.008-S-E-001, Rev. 1 dated February 28, 1986

B. Browns Ferry Nuclear Plant (BFN) - ECP Investigation Report - ECP-86-199-001, dated April 16, 1986

C. Special Electrical Maintenance Instruction (SEMI) - 51, Inspection Program for Verification of Correct Conduit Installation

D. Browns Ferry Nuclear Plant Conduit Seismic Qualification Program - Quality Wheel Meeting of July 9, 1986 Notes

E. OEP-7, Office of Engineering Procedure, Calculations (Currently NEP 3.1).

F. Division of Nuclear Engineering, Program Document, BFNP, "Inspection and Seismic Qualification of Existing Electrical Conduit and Conduit Supports."

G. Browns Ferry Nuclear Plant - Conduit Seismic Qualification Program - Quality Wheel, Initial Meeting Notes, June 21, 1986.

H. Browns Ferry Nuclear Plant - Meeting Minutes - Quality Wheel Concept (B22 860612 008)

I. Design Criteria No. BFN 50-714, "Conduit Support Seismic Design"

J. Design Criteria No. BFN 50-723, Rev. 0 dated March 28, 1986 (B42 860404 505)

K. MAI-27, "Installation of Electrical Conduit Systems and Junction Boxes"

L. 10 CFR 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants"

M. ANSI N45.2.4-1972 - "Installation, Inspection, and Testing Requirements for Instrumentation and Electric Equipment During the Construction of Nuclear Power Generating Stations"

N. ANSI N45.2.6-1978 - "Qualification of Inspection, Examination, and Testing Personnel for the Construction Phase of Nuclear Power Plants"

VI. DOCUMENTS REVIEWED (Continued)

O. Regulatory Guide 1.33

P. ANSI N45.2.11.1974 - "Quality Assurance Requirements for the Design of Nuclear Power Plants"

Q. ANSI N45.2.5, "Supplementary Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete, Steel, Soil, and Foundation During the Construction Phase of Nuclear Power Plants"

R. D.31-1

S. EQE Inc. - Application of Seismic Experience Data to Browns Ferry Nuclear Conduit and Cable Trays - Draft Report - May 1986

T. NRC Inspection Report Nos. 50-259/83-09, 50-260/83-09, 50-296/83-09 dated April 18, 1983

U. BFEP Class 1E Conduit Inspection Logs from spreading room and Reactor Building for Unit 2.

V. Resumes from typical contract engineers

W. Deviation Report X03-S-84-0014-03

X. SCR BFN CEB 8522 - Inadequate Conduit Support Design Criteria BFN-50-714 R2

Y. Inspection Certification Form 6.1 from PI 85-02

Z. Conduit Support Calculations, Conduit Support 48 B810-59

AA. OEP-10, Office of Engineering Procedure, Review (Currently, NEP 5.2)

BB. BFEP-PI- 85-02, "Seismic Qualification of Existing Electrical Conduit and Conduit Supports."

CC. Corrective Action Report (CAR) 83/174

DD. Corrective Action Report (CAR) 84/088

EE. General Construction Specification, G-3

FF. Memo from Beasley to Hall dated July 8, 1985 "Test Results for the Unistrut P1100 Series and Similar Conduit Clamps." (B22 850708 009)

GG. Memo from Beasley to Hall dated July 26, 1985 "Qualification of Conduit Clamps for Seismic Use." (B22 850726 002)

VI. DOCUMENTS REVIEWED (Continued)

HH. Memo from Beasley to Hall dated August 28, 1985 "Requirements for Interim Qualification of Existing Class IE Conduit." (B22 850828 004)

II. Memo from Beasley to Hall dated November 20, 1985 "Requirements for Qualification of Existing Class IE Conduits." (B22 851120 013)

JJ. TVA Drawings 48B810-33, 48B810-113, 48B810-121 and 48B810-161

KK. NRC Inspection Report Nos. 50-259/85-51, 50-260/85-51, 50-296/85-51

LL. Georgia Tech STRUDL User's Manual

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APPENDIX A

Source Documents for Conduit Support Design

1. AISC 8th Edition
2. "Specification For The Design Of Cold Formed Steel Structures," AISI, 1983 Edition
3. "Design of Welded Structures," O. Blodgett
4. "Formulas For Stress and Strain," 4th Edition, R. Roark
5. "Formulas For Stress and Strain," 5th Edition, Roark and Young
6. Earthquake Analysis , Reactor Building, Blume (CEB 800619 006)
7. "Torsion Analysis For Rolled Steel Sections," Bethlehem Steel
8. Unistrut General Engineering Catalog, Nos. 9 and 10
9. BFN - Qualification of Conduit Clamps - CEB 840124 007, B46 850709 001, and B46 850725 001
10. Design Criteria BFN-50-723
11. Seismic Qualification of Existing Electrical Conduit and Supports, PI 85-02 R2
12. Addendum to the report on the Earthquake Analysis of the Reactor Building Floor Response Spectra (B41 851112 048)
13. General Construction Specification G-29C R9
14. General Construction Specification G-32 R11
15. GT STRUDL, Georgia Institute of Technology
16. Baseplate II, Cybernet Services
17. T-Pipe Program
18. Standard Unistrut channel and parts material list, Unistrut Bulletin UNI-A-5, February 2, 1984
19. AWS D1.1, 1985
20. Civil Design Standard DS C1.7.1 R3
21. General Construction Specification G-40 R9, Section 3.2.6
22. General Construction Specification G-3 (used through March 1986)

All references were used for inspection and design calculations except Mods 4.5, 7, 15, 16, 17, and 18 which were used for design calculations only.