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TVA PROJECTS DIVISION

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Docket No.: 50-260

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Facility Name: Browns Ferry Nuclear Plant, Unit 2

Inspection At: Browns Ferry Nuclear Plant Site
Decatur, Alabama

Inspection Conducted: October 30 - November 10, 1988

Inspector: Thomas M. Cheng
Thomas M. Cheng, Team Leader — 3-16-89 Date

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Special Inspection

Relating To Design Calculations for the Seismic Design Program

Tennessee Valley Authority

Browns Ferry Nuclear Plant, Unit 2

Docket No. 50-260

1.0 INTRODUCTION AND BACKGROUND

As a result of different programs conducted by the Tennessee Valley Authority (TVA) and several inspections conducted by NRC, various concerns were identified at the Browns Ferry Nuclear Plant (BFN) Units 1, 2 and 3, related to the structural design adequacy of safety related suspended systems. These concerns encompass structural response to different loadings including dead load, live load, pressure, and temperature, as well as seismic loads. The root causes of these concerns include a lack of attention to design details when implementing modifications, a weakness in quality control which resulted in failures to identify and adequately track variances, and a lack of seismic design criteria records for the original design.

In order to regenerate new design records for the plant and to improve the plant condition as necessary, TVA initiated and submitted various programs, as documented in the Browns Ferry Nuclear Performance Plan (BFNPP), Volume 3, to correct deficiencies and to resolve the identified concerns. Seismic design is one of these programs.

The seismic design program covers the following areas:

1. large bore piping and supports
2. small bore piping and supports
3. recirculation system piping
4. torus piping (both internal and external)
5. control rod drive (CRD) piping and supports
6. instrument tubing
7. cable trays and supports
8. electrical conduit and supports
9. heating, ventilation and air conditioning (HVAC) ductwork and supports
10. drywell steel platforms
11. miscellaneous steel
12. suppression pool or torus structure including internal structural components
13. mechanical and electrical equipment
14. seismic Class II features over seismic Class I features
15. secondary containment penetrations.

Among these 15 design areas, the corrective actions for areas (4), (6), (7), (12), (13), and (15) have been either completed by TVA or are being resolved as part of the resolution of NRC Unresolved Safety Issue (USI) A-46. The implementation of the A-46 program will be addressed by the staff separately. For the remaining design areas, TVA performed its design calculations based on the restart (or interim) criteria. The restart criteria have been evaluated by the staff as documented in the staff safety evaluation (SE) dated July 26, 1988 (Reference 1). The restart calculations for the design areas will be reviewed by the staff prior to the restart of BFN, Unit 2.

2.0 PURPOSE AND SCOPE

The purpose of this special inspection is to review the seismic calculations in the following design areas: (8) electrical conduit and supports; (9) heating, ventilation, and air conditioning (HVAC) ductwork and supports; (10) drywell access steel platforms; and (11) miscellaneous steel structures. In addition, the results of discussions between the staff and TVA about the approach and analysis method for the generation of new amplified response spectra (ARS) based on the artificial ground motion time history are also documented in this report. The staff will review design areas (1), (2), (3), (5) and (14) in a separate audit or inspection.

3.0 DISCUSSION OF INSPECTION FINDINGS

During the period from October 30 through November 10, 1988, the staff conducted an inspection at the BFN site of the calculations pertaining to the BFN seismic design program. A list of attendees at the entrance meeting is contained in Enclosure 1. Following the entrance meeting, a two day plant walkdown was performed by the staff. The purposes of this walkdown were: (1) to familiarize the inspection team with the as-built condition of the plant and (2) to use the field walkdown as the basis for selecting samples for the calculation review. A sample of design calculations were selected for review in four design areas: (1) miscellaneous steel, (2) drywell access steel platforms, (3) HVAC ductwork and supports, and (4) electrical conduit and supports. Four additional issues were discussed at the inspection: (1) generation of new amplified response spectra (ARS) based on the artificial ground motion time history, (2) the staff's upcoming inspection of the IE Bulletin 79-14 program, (3) acceptability of Design Criteria 7100-7300 for BFN restart, and (4) flexible conduit and supports. The inspection identified a total of 32 issues: CSG-1 through CSG-12 and CSG-14 through CSG-33. These issues are summarized in Enclosure 3.

The exit meeting was held on November 10, 1988. The list of attendees is shown in Enclosure 2.

3.1 Miscellaneous Steel

According to TVA's definition, the miscellaneous steel support frames (MSSF) which are attached to either reinforced concrete floor slabs or walls and the steel frames attached to the steel girders and beams, are included in the scope of miscellaneous steel evaluation. The staff reviewed TVA's calculations related to the MSSF re-evaluation for Part Plans F6, A5, N4 and D2. The calculations were reviewed to determine whether they contained accurate as-built information as well as the adequacy of applied loads. The staff also reviewed the application of the criteria used in the calculations to ensure compliance with the interim operability (or restart) criteria accepted by the staff (Reference 1). A total of three concerns were identified as discussed below.

3.1.1 Design Criteria and Percent of Work Completed

This issue is related to the design criteria used for the MSSF re-evaluation and the percent of total design work available during the staff inspection.

The review of TVA calculations (B22 880820 128, B22 881102 106, B22 881010 177 and B22 880820 126) showed that TVA used the criteria documented in Attachment A to BFN-50-C-7100 Design Criteria for requalifying the MSSF. According to TVA's explanation and staff's understanding, these criteria were adopted directly from the BFN Torus Integrity Long-Term Program (TILTP) and were previously found acceptable by the staff specifically for this program. TVA was requested to formally submit these criteria for review. The staff will review the appropriateness of these criteria for the restart evaluation of the miscellaneous steel support frames.

During this inspection, the staff found that only the calculations of MSSF associated with torus-attached piping (approximately 10-15% of total MSSF design calculations) were completed by TVA and available for the staff review. According to TVA, the remaining 85-90% of MSSF design calculations are primarily related to IEB 79-14 piping and were not completed due to the incomplete status of the IEB 79-14 piping program from which the pipe loads for MSSF evaluation are to be generated. Therefore, this inspection only covered the MSSF calculations related to torus-attached piping. The staff is continuing its review of the remaining 85-90% of the MSSF calculations.

This concern remains open. (CSG-7)

3.1.2 Clarification of Design Criteria Used

The review of TVA calculations (B22 880820 128, B22 881102 106, B22 881010 177 and B22 880820 126) showed that TVA used different criteria for different areas of MSSF evaluation. The staff requested that TVA prepare a summary table to clarify the applicable criteria used in each area of the MSSF evaluations. TVA agreed to prepare a table and an explanation to clarify criteria used for MSSF related to torus and other piping systems. This concern is closed pending staff review of this table when it is available. (CSG-8)

3.1.3 Load Interface

During the review of a TVA calculation (B22 880820 128), it was found that the pipe support load used was not consistent with the recently revised load as shown on pipe support load drawing 478458-239. The revised pipe support load was greater than that used in the re-evaluation. During the inspection, TVA initiated CAQR BFN880951 to determine whether this was a generic problem with load interfaces and will take further action if necessary. As a result of TVA's corrective action, the staff considered this issue closed pending review of the results of CAQR BFN 880951. (CSG-15)

3.2 Drywell Access Platforms

The staff consultant reviewed TVA's design calculations which were completed for the re-evaluation of the lower drywell access platforms located at elevations 563'-0" and 584'-0" and the upper drywell access platform at elevation 616'-0". Before conducting the final design calculation, TVA performed a walkdown of these platforms to determine the as-built configurations as well as the actual loadings on these platforms resulting from the attached piping systems and components. A computer analysis reflecting the as-built configuration and actual loading conditions was performed for each of these platforms. The purpose of the staff inspection of these calculations was to determine whether the platforms were adequately evaluated and satisfied the interim operability criteria approved by the staff (Reference 1). A total of ten concerns were identified as discussed below:

3.2.1 Assumption of Rigid Lower Platforms in the Horizontal Direction

To simplify the seismic analysis, TVA, in calculations B41 860612 006 and B22 870916 101, assumed that both lower drywell platforms were rigid in the horizontal direction. Based on the FSAR commitment, a structure can be considered rigid if the fundamental frequency of this structure is greater than 20 Hz. In order to assure these platforms are rigid horizontally, TVA agreed to select the platform at El. 584'-0" and to analytically demonstrate that the fundamental frequency of these platforms exceeds 20 Hz when considering platform dead weight and attached dead loads. This concern is considered closed pending staff review of the calculation when it is available. (CSG-10)

3.2.2 Equivalent Static Analysis of Drywell Platforms

Equivalent static analyses method was used by TVA for the seismic evaluation of the access platforms at El. 584'-0" and 563'-0". The review of TVA's calculation (B22 870916 101) for the evaluation of platform at elevation 584'-0" found that the vertical acceleration was calculated using the peak spectral acceleration of the ARS (2 percent damping) multiplied by a 1.5 factor to account for multiple mode effects. The resulting vertical acceleration was then multiplied by the total mass of the platform (including all attached dead weight loads) or the total mass of an isolated radial beam model to obtain the equivalent seismic load. This approach is consistent with the guidelines in SRP Section 3.7.2 and, therefore, is acceptable.

The review of a TVA calculation (B41 860612 006) for platform at El. 563'-0" showed that for determining the seismic loads due to the vertical component of the safe-shutdown earthquake (SSE), TVA used the zero period acceleration (ZPA) of the vertical ground motion response spectrum (i.e., 0.13g), as input. The use of the ZPA of the vertical ground motion response spectrum was not appropriate because it had not been demonstrated that this platform was rigid in the vertical direction as previously noted. The staff requested that TVA compute the seismic loads on the platforms using one of the following methods:

(a) Perform detailed dynamic response spectrum analysis using the ARS at platform support as input.

(b) Perform a equivalent static analysis using the peak spectral acceleration of the ARS multiplied by the 1.5 factor to account for the multiple mode effects.

(c) Calculate the fundamental frequency of these platforms and then perform an equivalent static analysis using the maximum spectral acceleration at the frequency equal to or greater than the fundamental frequency, and multiply this spectral acceleration by the 1.5 factor as input.

TVA agreed to perform the seismic analysis of these platforms by one of the three methods. This concern remains open. (CSG-11)

3.2.3 Damping Value for Platform Evaluation

TVA used the two-percent (2%) damped ARS for the seismic evaluation of the upper and lower platforms inside drywell. As discussed in Section 3.5.2 on page 10, one percent damping should be used for all steel structural members inside drywell. One-percent damping is consistent with FSAR Section 12.2.2.8.2. TVA agreed to provide additional information to justify the adequacy of using two-percent damping for the platform evaluation. This concern remains open. (CSG-12)

3.2.4 Thermal Effects on Drywell Platforms

The review of TVA calculations (B41 860612 006 and B22 881015 123) found that the thermal loads on the radial beams due to the expansion of the tangential diaphragm beams were not considered in the platform evaluation. This concern applies to all platforms inside drywell. TVA agreed to demonstrate that thermal effects have been adequately considered in the evaluation of drywell platforms and are not significant. This concern remains open. (CSG-14)

3.2.5 End Moments on Platform Radial Beams

The staff consultant reviewed TVA calculation B41 860612 006 and the computer analysis related to the evaluation of the drywell platform at elevation 563'-0". The computer analysis indicated that there were end moments at the attachment points of the radial beams to the drywell wall. However, the as-built configuration of the radial beam seats indicated that the beam is free to move in the radial direction and no moment can be developed at the beam end. Accordingly, a simply-supported end condition should have been assumed in the computer analysis. TVA clarified that the computer analysis provided to the NRC staff was not the latest analysis and that the latest computer analysis does not contain any end moments. The staff accepted TVA's justification and suggested that TVA update its calculations to include the latest analysis. This concern is closed. (CSG-17)

3.2.6 Evaluation of Embedment Plate Anchors of Radial Beams

The review of TVA's calculation (B22 881011 122) for the embedded plates which support the radial beams of drywell platforms on the reactor pedestal found that the load interaction between the embedded anchors and the embedded plates was not considered. The staff requested that TVA demonstrate that with the inclusion of the load interaction of the embedded anchors, the embedded plates will contain sufficient capacity to accommodate the loads from the radial beams.

The review of the same calculation also found that ultimate strength design allowables for concrete were used for the qualification of the embedded plate assembly. The staff questioned whether this was in accordance with the Browns Ferry FSAR commitments in which the working stress design method is discussed.

TVA agreed to demonstrate that the FSAR commitments have been met and that the embedded plates and anchors have sufficient capacity to resist the loads transferred from the radial beams when load interaction is considered. This concern remains open. (CSG-18)

3.2.7 Platform Clip Angle Criteria

During the inspection the staff identified that both the design calculation and the design modification of clip angle connections completed in the time frame from late 1987 to early 1988 were based on certain TVA test results. These tests result in criteria less conservative than the interim criteria approved by the staff for restart. According to TVA, the test report, "BFN-Test Verification of Drywell Floor Steel Connections (B46870206-001)," has been referenced in its May 26, 1988 submittal and this submittal served as a reference to the staff SE dated July 26, 1988 (Reference 1). However, this test report had not been submitted for the staff review. As a result of discussion, the following conclusions were reached:

(1) The staff does not consider the use of test results for the design and modification of the clip angle connections to be acceptable as restart criteria at this time.

(2) TVA will re-evaluate the clip angle connections using the approved interim (restart) criteria.

(3) The staff will review the revised design calculations using approved interim criteria when they are available.

This concern remains open. (CSG-19)

3.2.8 List of Beam Modifications

From the review of TVA calculation (B22 880707 115) for the platform at El. 584'-0", the staff consultant found that TVA's lists for the required beam/connection modifications and the corresponding lists of modifications completed at site are inconsistent. TVA agreed to revise the applicable documents and resolve the discrepancies. This concern is closed pending staff review of the final list of modifications for the platform at El. 584'-0" when it is complete. (CSG-20)

3.2.9 Superseded Pages of Platform Design Calculation

The staff consultant identified that a number of pages of TVA's platform design calculations were marked superseded, but the replacement pages were not in place. TVA agreed to clarify this issue and amend the calculations as necessary. This concern is closed. (CSG-21)

3.2.10 Use of 1.33 Factor to Increase Stress Allowable

The review of TVA calculations (B22 870402 and B22 881015 123) for the upper drywell platform at elevation 616'-0" showed that TVA used an increase factor of 1.33 for the steel allowable stresses when the dead load was combined with the operating basis earthquake (OBE) loadings. This is inconsistent with TVA design criteria BFN-50-C-7100, Attachment G and the approved interim operability criteria (Reference 1) in which the 33% increase of allowable stress for earthquake loading is not allowed. TVA agreed to remove this increase and compare the calculated stresses to the AISC allowables as required by these design criteria. This item remains open. (CSG-28)

3.3 HVAC Ductworks and Supports

According to TVA, a 100% walkdown of the HVAC duct systems was conducted at the BFN Unit 2 plant. The as-built configurations identified from the walkdown were used in TVA's interim (restart) evaluation as well as the design of necessary modifications. During the inspection, the staff was informed that:

(1) About 11,830 feet of ductwork were evaluated and met the interim criteria.

(2) 1,092 existing supports met the long-term criteria; 509 existing supports met the interim criteria and require modification after restart; 28 existing supports were upgraded and 114 new supports, most of which are three-way supports, are to be added. Both the upgrading and new supports were designed according to the long-term criteria.

The staff selected three ductwork systems (including supports) located in the control room and control bay area for review. They are: 2-SWHVAC-79-00 (at elevation 635'-0"), 0-SWHVAC-75-00 (at elevation 617'-0"), and 1-SWHVAC-94-00 (at elevation 606'-0"). The staff selected these systems because they included insufficient transverse and longitudinal supports, complicated routing geometry, (e.g., horizontal and vertical branches), and long spans. The staff's findings are summarized below:

3.3.1 Buckling of HVAC Ductwork

Due to the complicated configuration of ductwork systems and the characteristics of thin wall sheet metal, local buckling and cracking at end anchor points or conjunctions are the expected failure modes under earthquake loadings. During the inspection, the staff found that no evaluation was conducted for local buckling or cracking of ductwork. This concern is also an open item addressed in the staff SE for BFN interim operability criteria (Reference 1). In order to address this issue, the staff requested that TVA demonstrate either that the amount of leakage of air flow due to cracking will not adversely impact the ability to safely shutdown the plant or that the ductwork structural integrity will be retained during the SSE event. TVA agreed to develop a criterion for the evaluation of HVAC structural integrity under SSE loading. This concern remains open. (CSG-24)

3.3.2 Modeling of HVAC Supports

The analysis model of the ductwork systems are based on the as-built configurations and the planned modifications. TVA computer code TPIPE was used for both the seismic analyses and stress calculations. The analyses were done by the response spectrum method with 7% damped ARS as input (both horizontal and vertical). The staff found the analyses are adequate except for one concern. For system 2 - SWHVAC-79-00, the horizontal support stiffness used in the analyses model (at nodes 6, 25, and 81 of calculation B22-880925-122) was not consistent with the stiffness used in calculation B22-880925-142. TVA agreed to revise the support calculation to reconcile the discrepancies identified. This concern is considered closed pending staff review of the final calculation when it is complete. (CSG-29)

3.3.3 Welding Allowables for HVAC Supports

During the inspection of weld evaluations for HVAC supports (TVA calculations B22 880925 120, 123, 142, 171), the staff found that increased weld allowables to account for seismic loading effects were used. However, the increased weld allowables were not addressed in the approved HVAC interim operability criteria. According to TVA, the criteria used were consistent with the interim operability criteria for piping supports which have been accepted by the staff for Sequoyah Nuclear Plant (SQN) restart evaluation and were documented in Design Criteria BFN-50-C-7303. The SQN interim criteria for pipe supports and the BFN HVAC supports were both developed based on the AISC Specification. Therefore, this concern is closed. (CSG-30)

3.4 Electrical Conduit and Supports

The staff consultant reviewed the calculations related to the evaluation of rod-hung electrical conduit and conduit supports, and also discussed the two open items addressed in the staff SE dated July 26, 1988 (Reference 1) with TVA. The review of Unistrut-supported conduit was not conducted at this time and it will be reviewed by the staff during the next inspection. As a result of the staff's review and discussions with TVA, a total of five concerns were raised as discussed below.

3.4.1 Buckling of Aluminum Conduit

The staff identified a concern regarding the potential buckling of aluminum conduit under seismic loadings. From the review of TVA's calculations for conduit discrepancy DN 40-212, it was found that no evaluation was performed for the conduit buckling under seismic loading. This issue is also an open item addressed in the staff SE for conduit interim operability criteria (Reference 1). In response to the staff concern, TVA agreed to perform the buckling evaluations in accordance with "Alcoa Aluminum Structural Handbook." This concern is closed pending staff review of the updated calculations during next inspection. (CSG-25)

3.4.2 Allowable Stress For Aluminum Conduit

As discussed in the staff SE dated July 26, 1988 (Reference 1), TVA proposed to use 2.0 Fy/(0.75 x 2.3) as the allowable bending stress for aluminum conduit in its restart evaluation. This allowable stress was not acceptable to the staff. The staff stated that an allowable bending stress equal to 1.0 Fy/(0.75 x 2.3) was acceptable for conduit evaluation and has been accepted by the staff for restart evaluation of conduit at the Sequoyah Nuclear Plant. During the meeting discussion, TVA presented its preliminary justification for using the proposed allowable and agreed to formally submit it to the staff for review after TVA finalizes the document. This concern remains open. (CSG-26)

3.4.3 Buckling of Conduit Rod Supports

The evaluation of rod-hung conduit supports was performed by TVA contractor, EQE Incorporated (EQE). During the review of the evaluation of conduit discrepancy DN 40-212, it was found that some threaded rods would undergo compressive forces due to conduit uplift under SSE loading. The staff requested TVA to verify the potential for buckling of these rods under compression forces. TVA agreed to complete a buckling evaluation of these rods and provide the results to the staff for review at the next inspection. This concern remains open. (CSG-31)

3.4.4 Evaluation of Support Rod Hangers

The review of conduit design calculations and computer analysis for conduit discrepancy DN 40-212 showed that the threaded rods were modelled to resist moments and shear forces as well as tension and compression forces. However, the EQE calculations did not specifically consider the effects of these shears and moments on rod hangers. The staff raised a concern that the stresses in the rods might exceed the allowable stresses if the effects of moments and shears were to be considered.

TVA stated that they have performed a fatigue evaluation of the threaded rods considering these effects. However, TVA used test results that were applicable to plants under the Systematic Evaluation Program and to the Shearon Harris Nuclear Plant. The staff requested that TVA submit these tests and the methodology used by TVA for the evaluation of threaded rods to assess whether the tests and the analytical methods are appropriate for the Browns Ferry Nuclear Plant. TVA agreed to have the requested information available before the next inspection. This concern remains open. (CSG-32)

3.4.5 Evaluation of Conduit Supports

Certain conduit supports at BFN are fabricated from structural angles which are welded to plates embedded in the reinforced concrete ceiling. The review of the EQE calculations for conduit discrepancy DN 40-212 showed that these welds were not explicitly evaluated to the interim operability criteria. The staff requested that TVA perform calculations to demonstrate that the welds possess adequate capacity to transfer the conduit loads to the embedded plates in the ceiling. TVA agreed to perform this evaluation and will have the calculation available before the staff's next inspection. This concern remains open. (CSG-33)

3.5 Generation of New Amplified Response Spectra (ARS)

3.5.1. Comparison of New ARS and Original Design ARS

The original design ARS were generated based on the 1940 El Centro earthquake ground motion time history and a single-stick lumped-mass structural model.

Currently, TVA is in process of generating new ARS based on newly developed two-dimensional structural models, (i.e., multi-stick model for reactor building and coupled horizontal and vertical degree of freedom for soil supported structures) and using the artificial ground motion time history as input. These ARS will include broadened peaks in accordance with the criteria accepted by the staff during the September 8, 1988 meeting (Reference 2) and will be used in the reanalysis of piping systems for TVA's IE Bulletin 79-14 program. TVA agreed to provide a comparison of the original ARS and the new ARS for the staff in December 1988. (CSG-2)

3.5.2 Damping Values for Steel Structural Members Inside Drywell

To model the reactor building, TVA proposed to use 5% damping for reinforced concrete members, shield wall and concrete pedestal, 7% damping for the fuel elements, 3.5% and 1% damping for the control rod drive (CRD) housings in the horizontal and vertical directions respectively, 2% for the star truss, stabilizer, refueling bellows and the horizontal component of springs K1 and K2 of the RPV, and 1% for the remaining steel components. The staff found that the damping values proposed by TVA were generally in conformance with the FSAR except that the 2% damping value used for the steel members such as the star truss and stabilizer is higher than the damping value (1%) specified in the FSAR Section 12.2.8.2, for steel members. TVA agreed to either use 1% damping for the steel members inside drywell in the analysis or provide additional information to justify the adequacy of using 2% damping. This concern remains open. (CSG-3)

3.5.3 Soil Amplification Factor for Soil-Supported Structures

The soil-supported safety related structures include diesel generator building (DGB), standby gas treatment building (SGTB), residual heat removal (RHR) service water tunnel, equipment access lock, and off-gas treatment building (OGTB). These structures are either supported on the surface of the layered soil stratum or buried in the soil except the OGTB which is supported on the bedrock and buried in the soil. In developing the horizontal input ground motion for the soil-structure interaction analysis, the FSAR states that a horizontal amplification factor of 1.6 is used for the DGB and SGTB. However, no specific amplification factor is specified for other buildings. As a result, TVA agreed to:

(1) use an amplification factor of 1.6 for calculating the horizontal input ground motion to the DGB, SGTB, RHR service water tunnel and equipment access lock.

(2) compute the vertical soil amplification factor for all structures using same theory and method as for calculating the horizontal amplification factor.

(3) for the roof of the OGTB, calculate the horizontal amplification factor, based on the first mode shape of a soil column, by interpolation between 1.0 (at bedrock) and 1.6 (at top surface of soil stratum).

(4) submit the original basis and calculation from which the horizontal soil amplification factor of 1.6 was calculated for review.

This concern is considered closed pending staff review of the updated calculations of the soil amplification factors when they become available. (CSG-4)

3.5.4 Soil Spring Constants for Soil-Supported Structures

TVA proposed to compute the horizontal soil springs for RHR service water tunnel and equipment access lock, using the same method specified in the FSAR for DGB and SGTB. For calculating the vertical soil-springs for all soil supported safety related structures, TVA proposed to use the method consistent with the method used for the horizontal soil spring calculations. The staff's review found the method proposed by TVA for the soil spring calculation acceptable. This concern is considered closed pending staff review of the calculation of the soil springs when they become available. (CSG-5)

3.5.5 Coupling of Horizontal and Vertical Responses of Soil-Supported Structures

During the inspection, the staff raised a concern regarding the coupling effect of horizontal and vertical structural responses in the seismic analysis of soil-supported structures. TVA agreed to include this effect in the analysis used to generate the new ARS. Therefore, this concern is closed pending staff review of the calculations and resulting ARS when they are available. (CSG-6)

3.5.6 Impact of New ARS

In the review of the preliminary comparison of the original ARS (without peak broadening) obtained from El Centro ground motion time history and the new ARS (with peak broadening according to Reference 2) based the artificial ground motion time history, significant differences where the new ARS exceeded the original were identified. TVA is assessing the impact of these differences on the presently completed evaluation of miscellaneous steel, drywell access platforms, electrical conduit and supports, and HVAC ductwork and supports. TVA will provide the staff the results of its assessment when complete. This issue is open. (CSG-9)

3.5.7 Percentage of Mass Participation in the Vertical Seismic Analysis

In its inspection, the staff identified that TVA considered only three structural modes for frequency less than 20 Hz and included only 70% of the total building mass in the vertical seismic analysis of the reactor building. As a result, the new ARS might be unconservative in comparison with the ARS generated based on at least 90% of mass participation as specified in SRP 3.7.2. The same concern also applies to the vertical seismic analysis of other safety related structures. TVA agreed to either include structural modes beyond 20 Hz in the analysis or provide mathematical justification to demonstrate that the mass participation beyond 20 Hz is insignificant to the total dynamic response of buildings. This concern remains open. (CSG-16)

3.5.8 Definition of Zero Period Acceleration (ZPA) of New ARS

From the inspection, the staff found that TVA calculated the new ARS only up to 20 Hz - the rigid frequency of buildings as defined in the FSAR - and defined the peak of floor acceleration time history as the ZPA for the new ARS. From reviewing the comparison between the spectral acceleration at 20 Hz and the peak of the floor acceleration time history, the difference, for some cases, was significant (over 20%-30%). The staff requested that TVA provide an assessment of the impact of this difference between the spectral acceleration at 20 Hz and the peak of the floor acceleration time history for all ARS. This concern remains open. (CSG-23)

3.6 Review of IEB 79-14 Program

The revised criteria and analysis method for piping under TVA's IEB 79-14 program were discussed between the staff and TVA during the September 8-9, 1988 meeting (Reference 2). The completed calculations for this program are being revised to incorporate the criteria and analysis methods agreed upon between TVA and the NRC staff. According to TVA, approximately 35% of the total detailed analyses will be completed before restart. The staff is planning an inspection during January 1989 of the IEB 79-14 program to evaluate the acceptability of this approach. This item is considered closed for the purpose of this inspection. (CSG-1)

3.7 Design Criteria BFN-50-C-7100 through-7300

TVA considers the Design Criteria BFN-50-C-7100 through 7300 as the long-term criteria for the seismic design program evaluation. However, these criteria have not been formally submitted for staff's review and approval. Any item qualified using these long-term criteria for the restart shall satisfy the approved interim operability criteria for the restart. The adequacy of the long-term criteria will be reviewed by the staff after restart of the plant. This item remains open. (CSG-22)

3.8 Flexible Conduit Program

In the BFN Nuclear Performance Plan, Volume 3, Section 13.4, TVA committed to perform a program for the resolution of the flexible conduit issue including the concern of the structural integrity of flexible conduit system under an earthquake event. The staff's review of TVA's submittal dated April 28, 1988 (Reference 3) found that additional information is required to complete our review. TVA agreed to submit a programmatic description including a brief history of the issue, scope of the program, basis for the evaluation criteria, implementation of corrective actions, and schedule for program completion as well as supporting documents for review before the next inspection. This item remains open. (CSG-27)

4.0 CONCLUSION

As discussed in Section 3.0 of this report, 19 out of 33 concerns identified during this inspection remain open and additional information is required for some closed items. In order for the staff to complete its inspection of the seismic design program, TVA is requested to respond to all of the open items and submit the information requested to the staff by April 1989.

5.0 List of Documents and Calculations Reviewed

Miscellaneous Steel

1. TVA General Design Criteria B41 880413 005, BFN-50-C-7100 Browns Ferry Nuclear Plant Design of Civil Structures, Rev 1, 4/13/88. Attachment A: The Torus Integrity Long Term Program Attachment G: Detailed Design Criteria for Miscellaneous Steel Components for Class I and II Structures.

2. TVA Calculation B22 880820 128, Miscellaneous Steel Torus Attached Piping Core Spray System Pipe Support No. H-4, Revision 1, 8/8/88.

3. TVA Drawing 48W1022-6, Miscellaneous Steel Support Framing Below El. 593.0', Rev 2, 11/1/88.

4. TVA Calculation B22 870604 109, Miscellaneous Steel - Embedded Plates, Rev 0, 6/3/87.

5. TVA Drawing 478458-239, N1-275-1R Pen X-223B Support Load Tables for Torus Analysis Core Spray System, Rev 2, 7/30/87.

6. TVA Calculation B22 881102 106, Miscellaneous Steel Torus Attached Piping Cord Spray Pipe Support # R-65, Rev 2, 10/31/88.

7. TVA Drawing 48W1023-5, Miscellaneous Steel Support Framing Below El. 621.25', Rev 1, 11/1/88.

8. TVA Calculation B22 881010 177, Miscellaneous Steel Torus Attached Piping RHR System No. H-149, Rev 1, 9/29/88.

9. TVA Drawing 48W1023-4, Powerhouse Reactor Building Unit 2 Miscellaneous Steel Support Framing Below El. 621.25', Rev 1, 10/6/88.

10. TVA Drawing 48W1023-6, Powerhouse Reactor Building Unit 2 Miscellaneous Steel Support Framing Below El. 621.25', Rev 2 10/6/88.

11. TVA Drawing 48W1004-2, Powerhouse Reactor Building Unit 2 Miscellaneous Steel Pipe Supports and Anchors Below El. 565.0', Rev 1, 11/1/88.

12. TVA Calculation B22 880820 126, Miscellaneous Steel Torus Attached Piping Core Spray System Pipe Support No. R12, H27, H28, Rev 1, 8/17/88.

13. TVA Drawing 47B458-404, Mechanical Core Spray System Pipe Supports, Rev 4.

Drywell Access Platforms

1. TVA Calculation B41 860612 006, Drywell Floor Structural Steel El. 563'-0", Rev 0, 5/19/86.

2. TVA Drawing 48N442, Structural Steel Drywell Floor Framing El. 563'-0", Rev 7, 11/4/87.

3. TVA Calculation B22 881011 122, Embedded Plate Drywell Floor Beam Support, Rev 0, 10/6/88.

4. TVA Calculation B22 861020 102, Drywell Floor Framing El. 563'-0" Connection Qualification, Rev 0, 9/26/88.

5. TVA Drawing 48N978, Miscellaneous Steel Vessel Support Pedestal Embedded Parts-Sheet 1, Rev 4, 7/11/78.

6. TVA Walkdown Information B22 870410 023, Special Mechanical Maintenance Instruction 1.1-e Instructions for the Inspection of Drywell Steel for NCR BFNCEB8402R1.

7. TVA Calculation B22 870420 104, Failure Evaluation of Drywell Platform El. 616'-0", Rev 0, 4/17/87.

8. TVA Drawing 48W982-2, -3, -4, Miscellaneous Steel Access Platforms El. 616'-0" Sheet 3 (Continued), Rev 2, 3/11/88.

9. TVA Calculation B22 881015 123, Modifications to Drywell Platform El. 616'-0", Rev 3, 10/1/88.

10. Beam Evaluation - B22 870914 104

11. Beam Modification - B22 880707 115

12. Connection Evaluation - B22 880630 318-323, 329-333

13. Connection Modification - Calculation # BFEP-C10481, R1; CD-Q2303-87649, R3; CD-Q2303-87236, R2; CD-Q2303-87238, R2; CD-Q2303-882095, R0

14. Beam Seat Qualification - Calculation CD-Q2303-882953, R0

15. Tangential Differential Seismic Movement Effect on Radial Beams - Calculation # CD-0303-885890, R0

<u>HVAC Ductwork and Supports</u>

1.	System No. 2-79-00	Ducts:	B22 880925 122
		Supports:	B22 880925 142
			B22 880925 123
			B22 880925 171
2.	System No. 0-75-00	Ducts:	B22 881029 153
		Supports:	B22 880925 120
3.	System No. 1-94-00	Ducts:	CD-Q0031-884387
		Supports:	CD-Q1031-883372
			CD-Q1031-885141

Electrical Conduit and Supports

1. EQE Calculation No. 51001.03-C-09, BFNP U2 + Common Conduit Program Operability Criteria Evaluation for Conduit Discrepancy DN 40-212, Rev 0, 10/21/88.

2. EQE Report No. 51001.03-R-001, TVA Browns Ferry Nuclear Plant Conduit System Seismic Evaluation Study Summary Report, Revision 0, November 3, 1988.

3. TVA Browns Ferry Nuclear Plant BFEP PI 85-02, Seismic Qualification of Existing Electrical Conduit and Conduit Supports, Rev 5, 2/25/88.

4. Alcoa Aluminum Structural Handbook, A Design Manual for Aluminum, 1960.

6.0 References

1. Letter from S. Black (NRC) to S.A. White (TVA), "Interim Operability Criteria for the Seismic Design Program for the Browns Ferry Nuclear Plant, Unit 2", dated July 26, 1988.

2. Summary of meetings held on September 8 and 9, 1988 concerning the resolution of IEB 79-14 restart issues, dated September 19, 1988.

3. Letter from R. Gridley, TVA to NRC dated April 28, 1988.

ENCLOSURE 1

Civil Items Inspection

Entrance Meeting

10/31/88

ATTENDEES	ORGANIZATION
Wayne A. Massie	TVA BFN Site Licensing
Jon R. Rupert	TVA BFEP/CEB
Sherri Anderson-Hudgins	TVA BFN - Site Licensing
Mark A. Durka	Project Engineer - SWEC
Ahmet I. Unsal	HEA/NRC Consultant
David Terao	NRC/NRR
Tom N.C. Tsai	NCT/NRC Consultant
Thomas M. Cheng	NRC/NRR
R.D. Cutsinger	TVA BFEP/CEB
Patrick Carier	TVA/Manager Site Licensing
T.C. Cruise	TVA BFEP/CEB
R.E. Gaines	TVA BFEP/CEB

ENCLOSURE 2

LICENSING MEETING - ATTENDANCE LIST
SUBJECT: CIVIL ITEMS EXIT MEETING
DATE: 11/10/88 TIME: 8:30

NAME	TITLE/ORGANIZATION
Wayne A. Massie	TVA/BFN/Licensing
A. L. Watkins	TVA/BFEP
R. W. Miller	TVA/BFN/QA
T. C. Cruise	TVA/BFN/CEB
Emory F. Thomas	TVA/BFN/Project Manager
Tom N. C. Tsai	NCT Engineering/NRC Consultant
A. I. Unsal	HEA/NRC Consultant
Warren Wang	Staff/SWEC
R. D. Cutsinger	TVA/BFEP/CEB
N. Rapagnani	SWEC
R. E. Gaines	TVA/BFEB/CEB
Jon Rupert	TVA/BFEP/CED
Steve Eder	EQE
Robert McKeon	Plt. Support Supt.
Joe Savage	Licensing Manager
Steve Rudge	Site Programs Manager
Sherri Anderson-Hudgins	TVA/BFN/Licensing
Mark Durka	Project Eng./SWEC
R. W. Cantrell	TVA/NE
T. M. Cheng	NRC/NRR
Ron King	TVA/NODS
William Bearden	NRC Resident

ENCLOSURE 3

Concerns Identified During 10/30/88 - 11/10/88 Inspection		Section
CSG-1 (Closed),	Review of IEB 79-14 Program	3.6
CSG-2 (Open),	Comparison of New ARS and Original Design ARS	3.5.1
CSG-3 (Open),	Damping Values for Steel Structural Members Inside Drywell	3.5.2
CSG-4 (Open),	Soil Amplification Factors for Soil-Supported Structures	3.5.3
CSG-5 (Open),	Soil Spring Constants for Soil-Supported Structures	3.5.4
CSG-6 (Open),	Coupling of Horizontal and Vertical Responses of Soil-Supported Structures	3.5.5
CSG-7 (Open),	Design Criteria and Percent of Work Completed	3.1.1
CSG-8 (Open),	Clarification of Design Criteria Used	3.1.2
CSG-9 (Open),	Impact of New ARS	3.5.6
CSG-10 (Open),	Assumption of Rigid Lower Platforms in the Horizontal Direction	3.2.1
CSG-11 (Open),	Equivalent Static Analysis of Drywell Platforms	3.2.2
CSG-12 (Open),	Damping Values for Platform Evaluation	3.2.3
CSG-14 (Open),	Thermal Effects on Drywell Platforms	3.2.4
CSG-15 (Open),	Load Interface	3.1.3
CSG-16 (Open),	Percentage of Mass Participation in the Vertical Seismic Analysis	3.5.7
CSG-17 (Closed),	End Moments on Platform Radial Beams	3.2.5
CSG-18 (Open),	Evaluation of Embedment Plate Anchors of Radial Beams	3.2.6
CSG-19 (Open),	Platform Clip Angle Criteria	3.2.7
CSG-20 (Open),	List of Beam Modifications	3.2.8
CSG-21 (Closed),	Superseded Pages of Platform Design Calculation	3.2.9
CSG-22 (Open),	Design Criteria BFN-50-C-7100 through 7300	3.7
CSG-23 (Open),	Definition of Zero Period Acceleration (ZPA) of New ARS	3.5.8

CSG-24 (Open),	Buckling of HVAC Ductwork	3.3.1
CSG-25 (Open),	Buckling of Aluminum Conduit	3.4.1
CSG-26 (Open),	Allowable Stress for Aluminum Conduit	3.4.2
CSG-27 (Open),	Flexible Conduit Program	3.8
CSG-28 (Open),	Use of Factor "1.33" To Increase Stress Allowable	3.2.10
CSG-29 (Open),	Modeling of HVAC Supports	3.3.2
CSG-30 (Closed),	Welding Allowables for HVAC Supports	3.3.3
CSG-31 (Open),	Buckling of Conduit Rod Supports	3.4.3
CSG-32 (Open),	Evaluation of Support Rod Hangers	3.4.4
CSG-33 (Open),	Evaluation of Conduit Supports	3.4.5