UNITED STATES
NUCLEAR REGULATORY COMMISSION
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SAFETY EVALUATION BY THE OFFICE OF SPECIAL PROJECTS

RELATING TO INTERIM OPERABILITY CRITERIA FOR THE SEISMIC DESIGN PROGRAM

TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT, UNITS 1, 2 AND 3

DOCKET NOS.50-259, 50-260 AND 50-291

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 cause of these concerns includes a lack of attention to design details when implementing modifications and 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. These programs need staff review and approval prior to the restart of BFN, Unit 2, and 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. Recirculating 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) and (13) are either completed by TVA or are to be taken as a part of the resolution of NRC Unresolved Safety Issue (USI) A-46 for which the implementation will be started in the near future. For the rest of the design areas, TVA has developed two sets of evaluation criteria for the resolution of each of these areas, namely the design criteria (or long term criteria) and interim criteria (or restart criteria). According to TVA, the design criteria conform with either the Final Safety Analysis Report (FSAR) requirements or the design criteria applied in the nuclear industry such as the American Institute of Steel Construction (AISC) design specifications, and the American Society of Mechanical Engineers (ASME) Code. Due to the limitations of time and resources prior to the restart of BFN Unit 2, TVA has proposed interim criteria. The general TVA application procedures of these two sets of criteria are as follows:

1. All in-scope safety-related features (piping, supports, steel platforms, steel frames, etc.) will be evaluated first against the design criteria;

2. Those features which do not meet the design criteria will again be evaluated against the interim operability criteria;

3. Those which do not meet the design criteria, but are within the interim criteria, will be modified to the design criteria after restart; and

4. Those which do not meet the interim criteria will be modified to the design criteria before restart unless some relief is approved by the staff on a case-by-case basis.

The purpose of this Safety Evaluation (SE) is to document the staff's review and conclusions drawn for areas (8), (9), (10) and (11) above. For areas (1), (2), (3), (5), (14) and (15), the interim criteria will be reviewed separately and a separate SE will be issued on a later date.

2.0 EVALUATION

2.1 Drywell Access Steel Platforms

The proposed interim criteria for seismic qualification of the two lower drywell steel platforms at Elevations 584'-11" and 563'-2" are contained in References 1 to 3. The remainder of the drywell steel platforms, which are located at the higher elevations, have been evaluated to Design Criteria BFN 50-C-7100, Revision 1, Attachment G, "Miscellaneous Steel Components for Class I and Class II Components," (Reference 3).

a. For structural steel members and connections, the proposed allowable is 1.6S for load combinations including the design basis earthquake (DBE) seismic loads where S is the allowable specified in the 1978 AISC Specification, Part I, without the 30 percent increase due to the

consideration of seismic loading. This is acceptable for the interim evaluation. For long term evaluation, however, TVA is required to address any effect of the deviation of the 1978 edition from the 1963 edition of the AISC Specification because the plant was designed based on the 1963 edition. For example, the 1978 edition does not contain the analysis procedures or boundary condition assumptions, while the 1963 edition does.

b. For both the wedge and shell type concrete expansion anchors, the proposed interim criteria are based on TVA Civil Design Standard DS-C1.7.1 and subjected to a minimum factor of safety of 2.0. This interim criteria is consistent with past staff practices for IE Bulletin 79-02 and is acceptable.

c. For applied loadings, the interim criteria assume a zero live load (i.e., L = 0.0) on the platforms during plant operation and exclude the jet impingement load, Yj. To justify the use of L = 0, TVA committed to establish an adequate project procedure to control additional loads that might be imposed to the platforms resulting from maintenance or modification activities during plant operation. The commitment was made during the May 18, 1988 review meeting (Reference 17), and the staff found it acceptable provided that the project procedure meets or exceeds the corresponding requirements from the procedure committed to for the Sequoyah Nuclear Plant (SQN), Unit 2. Regarding the exclusion of the jet impingement load, TVA appears to have violated the commitment made in Subsection 12.2.2.7.1 of the FSAR. Because this concern has also been identified by the staff during the second inspection for the Design Baseline & Verification Program (DBVP) during April 1988, TVA has agreed to resolve this concern prior to the third staff DBVP inspection.

d. Based upon the review of the interim criteria presented in References 1 to 3, it is not clear what phase relationship was assumed among the various dynamic reactions from all attached systems such as piping, HVAC, and cable trays, for the restart evaluation. During the May 18, 1988 meeting, TVA committed to combine these dynamic reactions on an absolute sum basis, regardless of their phase relationship. The staff found this commitment acceptable. However, TVA, prior to restart, should revise Enclosure 2 of its submittal dated May 26, 1988 (Reference 3) to conform with the commitment made at this meeting.

e. The interim criteria do not address the effect of the tangential component of the relative seismic displacements between the two ends of the radial platform support beams. Such differential movement arises because the drywell would respond differently from the shield wall during earthquakes. It is evident from the difference between the seismic response acceleration of the reactor building including the drywell, and the reactor pressure vessel (RPV) - shield wall - pedestal structure as shown in Figures 12.2-26, -30 and -37 of Section 12.0 of the FSAR. According to FSAR Subsection 12.2.2.8.1, the seismic response of the

reactor building and the drywell was determined from an 8-mass stick model and the response of the shield wall was determined from a coupled analysis model containing both the reactor building and the RPV - shield wall - pedestal structure, as discussed in FSAR Subsection 12.2.2.8.2. Therefore, TVA is required to account for the effect of the tangential component of the relative seismic displacements between the two beam ends in the restart evaluation of the steel platforms.

2.2 Miscellaneous Steel

References 4 to 6 specify the interim seismic criteria for the miscellaneous steel, including the upper drywell platforms, equipment access platforms, field-routed piping supports and other nonstructural support framings. The staff review findings are as follows:

a. For structural steel members, TVA adopted the restart criteria for SQN large bore pipe supports, i.e., the smaller of 1.2 Fy and 0.7 Fu for allowable axial tension and bending stresses which conform with the ASME Code Level D Service limit; 0.8 Fcr for allowable compression stress; and 0.6 times the allowable tension stress for allowable shear stress. Here, Fy, Fu and Fcr are the yield stress, ultimate stress and buckling stress, respectively, as defined in the AISC Specification. The staff found the interim criteria for the structural steel members acceptable.

b. For bolting, TVA proposed to use Fy or 0.7 Fu, from the ASME Code, when Fy is not available (e.g., A307 bolt), for tension, and 0.6 times the allowable bolt tension for the interim shear allowable. The staff found the interim allowables for bolting acceptable.

c. For concrete expansion anchors, the method for the restart evaluation will be based on TVA Civil Design Standard DS-C1.7.1 with a minimum factor of safety of 2.0. As discussed in 1.b above, this is acceptable.

d. In the restart evaluation of the upper drywell steel platforms, TVA should also consider effect of the tangential component of the relative seismic displacements between the supports of the radial support beams as discussed in 1.e above.

2.3 Electrical Conduit and Conduit Supports

The interim criteria for the seismic qualification of electrical conduit and conduit supports are contained in References 7 to 10. These criteria proposed to use 5% damping for steel conduit, 15% damping for 0.5" to 1.5" aluminum conduit, 10% damping for 2" to 3" aluminum conduit, and 7% damping for 4" and larger size aluminum conduit. During the May 18, 1988 meeting (Reference 17), the staff indicated that any damping values exceeding 7% are not acceptable for the restart evaluation of conduit. Since a number of calculations have already been completed based on the proposed high damping values and "Design Criteria," in order to demonstrate that the existing conduit systems do possess

enough margin to withstand the seismically induced loading corresponding to low damping values, TVA committed to perform a screening evaluation of the 0.5" to 3" aluminum conduit and supports based on a 7% damping and revised interim allowables. In its May 27, 1988 letter (Reference 11), TVA proposed revised interim criteria and committed to modify those conduit and conduit supports which do not comply with the revised interim criteria. The staff evaluation of the revised interim criteria is discussed in the following:

a. For conduit, TVA originally proposed Fy/(0.75 x 2.3) for the allowable bending stress based on Design Criteria BFN 50-C-7104, Revision 1, Section 5.0 (References 7 through 10). Here, the factor of "2.3" is a stress intensification factor for threaded connections to account for the lower strength of such connections which may occur anywhere along the conduit run and Fy, defined as yield stress, is equal to 25,000 psi for mild steel conduit (ASTM A-72 or similar) and 13,000 psi for aluminim conduit (6063-T1 or similar), respectively. Recently, TVA proposed a revised interim allowable bending stress which is equal to 2.0 Fy/(0.75 X 2.3) (Reference 11). The staff found this revised interim bending allowable unacceptable. TVA should use the allowable previously proposed, i.e, Fy/(0.75 X 2.3) for the restart conduit evaluation, which is acceptable to the staff according to SQN 2 restart evaluation. In addition, buckling criteria for the aluminum conduits were not specified in the submittals. TVA should submit the buckling criteria for review and approval.

b. For the steel members of conduit supports, TVA, at first, proposed 1.33S as the interim allowable stress (References 7 through 10), where S is the allowable stress defined in the 1978 AISC Specification, Part I, without 30 percent increase due to consideration of seismic loading. In the same references, TVA also proposed to use the service load design allowable specified in TVA Civil Design Standard DS C1.7.1 as the interim allowable for conrete anchors. Recently, TVA revised its interim criteria and proposed the use of miscellaneous steel interim criteria for the restart evaluation of conduit supports (Reference 11). The staff found the revised interim criteria for both conduit supports and concrete anchors acceptable according to the staff review of interim criteria for miscellaneous steel (Section 2.2 above).

c. In its presentation during the May 18, 1988 meeting (Reference 17), TVA proposed the allowable pull-out, slip-along (lateral) and slip-through (axial) loads which conformed with the Unistrut Engineering Category for the restart evaluation of Unistrut P1100 series members and P2558 clamps. The staff found these allowable loads acceptable.

d. TVA proposed to use earthquake experience data for the interim qualification of the outliers identified from the screening evaluation such as trapeze supports for gang-hung conduit systems. This approach is not acceptable to the staff, because the evaluation guidelines for using the earthquake experience data for the seismic qualification of conduit systems are still being developed by the Seismic Qualification Utility

Group (SQUG) and have not yet been accepted by the staff under NRC USI A-46. As a result of discussions during the May 18, 1988 meeting, TVA proposed and the staff agreed, that TVA will perform a more sophisticated evaluation on these outliers and the staff will review the evaluation results on a case-by-case basis.

2.4. HVAC Ductwork and Supports

The interim criteria for the seismic qualification of HVAC ductwork and supports are contained in References 12 to 16. Findings from the staff evaluation are as follows:

a. For ductwork, TVA proposed 12,000 psi and 15,000 psi as the interim allowable binding stress for rectangular and circular ducts, respectively, and 1.33 X 0.4 Fy = 0.53 Fy as the interim allowable shear stress for circular duct. These allowables were established based on the test data documented in reports TVA-CEB-79-7 and MA2-79-1 (Attachments to Reference 16). Based on the same test reports, TVA also proposed to use the allowable shear capacity for the rectangular duct shear allowables. The staff reviewed these test reports and found the interim allowables for ductwork acceptable. However, buckling criteria for the ductwork were not specified in the submittals. The buckling criteria for ductwork should be submitted for review and approval.

b. TVA proposed to use the miscellaneous steel interim criteria for the restart evaluation of duct supports. The staff found this to be acceptable.

3.0. CONCLUSIONS

Based on discussions during the May 18, 1988 meeting, it is the staff's understanding that the design criteria (or long-term criteria) conform with either the FSAR requirements or the criteria generally applied in the nuclear industry such as AISC Specification, ASME Code, etc. However, some exceptions were identified during the staff review of TVA 7100 series criteria. Therefore, as a post-restart action item, the staff will review the design criteria to determine if they conform with the FSAR requirements.

The staff conclusions regarding the acceptability of the interim seismic qualification criteria for the BFN drywell steel platforms, miscellaneous steel, conduit and conduit supports, and HVAC ductwork and duct supports are summarized in the following:

3.1 Lower Drywell Steel Platforms

The interim criteria are acceptable provided the following concerns are adequately addressed by TVA prior to restart:

- Establish a project procedure for the control of additional loads that might be imposed to the platforms resulting from modification activities during plant operation to justifiy the use of a live load L = 0 in the restart evaluation.

- Justifiy, under the DBVP program, that the exclusion of the jet impingement load Yj does not constitute a violation of the FSAR requirements for lower steel platforms.

- Include the tangential component of the relative seismic displacement between the two ends of the radial platform support beams in the platform restart evaluation.

In addition, as a post-restart action item, TVA is required to address the adequacy of applying the 1978 edition of the AISC Specification for the restart evaluation of the platforms with respect to the FSAR design criteria which were based on the 1963 AISC Specification.

3.2 Miscellaneous Steel

The interim criteria are acceptable provided the following concern is adequately addressed prior to restart:

- Consideration of the tangential component of the relative seismic displacement between the two ends of the radial platform support beams in the restart evaluation of the upper steel platforms.

3.3 Electrical Conduit and Conduit Supports

The interim criteria are acceptable provided the following concerns are adequately resolved prior to restart:

- The use of 2.0 X Fy/(0.75 X 2.3) as the interim allowable stress for conduit is not acceptable. TVA should use the allowable accepted for SQN 2 restart, Fy/(0.75 x 2.3).

- TVA should provide buckling criteria for aluminum conduits.

3.4 HVAC Ductwork and Supports

The staff found the interim criteria for the HVAC ductwork and duct supports acceptable, pending TVA's submittal of buckling criteria for the ductwork.

4.0 REFERENCES

1. Letter from R. Gridley (TVA) to NRC, "BFN - Seismic Qualification of Drywell Steel," dated March 10, 1988.

2. Letter from R. Gridley (TVA) to NRC, "BFN - Seismic Qualification of Drywell Steel - (NRC Tac No. 00302)," dated April 28, 1988.

3. Letter from R. Gridley (TVA) to NRC, "BFN - Seismic Qualification of Drywell Stell - (NRC Tac No. 00302)," dated May 26, 1988.

4. Letter from R. Gridley (TVA) to NRC, "Seismic Qualification of Miscellaneous Steel," dated March 10, 1988.

5. Letter from R. Gridley (TVA) to NRC, "Seismic Qualification of Miscellaneous Steel - (NRC Tac No. 00296)," dated April 28, 1988.

6. Letter from R. Gridley (TVA) to NRC, "BFN - Seismic Qualification of Miscellanous Steel - (NRC Tac No. 00296)," dated May 26, 1988.

7. Letter from R. Gridley (TVA) to NRC, "Seismic Design Issues - Response to Request for Additional Information," dated April 8, 1987.

8. BFN Program Document, "Inspection and Seismic Qualification of Existing Electrical Conduit and Conduit Supports," dated October 16, 1986.

9. BFEP-PI 85-02, "Seismic Qualification of Existing Electrical Conduit and Conduit Supports," dated October 15, 1986.

10. TVA Design Criteria BFN-50-C-7104 (R1), Section 5.0.

11. Letter from R. Gridley (TVA) to NRC, "BFN - Seismic Qualification of Conduit - (NRC Tac 00022, 00023 and 00024)," dated May 27, 1988.

12. Letter from R. Gridley (TVA) to NRC, "Seismic Qualification of HVAC Ductwork and Supports," dated March 10, 1988.

13. Letter from R. Gridley (TVA) to NRC, "Seismic Qualification of HVAC Ductwork and Supports," dated May 4, 1988.

14. TVA Civil Engineering Branch Instruction CEB-CI 21.100, "BFN Class I HVAC Duct and Duct Support Seismic Qualification Interim Operability Acceptance Criteria," Revision 1, dated March 31, 1988.

15. TVA Design Criteria BFN-50-C-7104 (R1), Section 3.0.

16. Letter from R. Gridley (TVA) to NRC, "BFN - Seismic Qualification of HVAC Ductwork and Supports - (NRC Tac No. 00299)," dated May 26, 1988.

17. Summary of May 18, 1988 meeting dated June 9, 1988.

Mr. S. A. White
Tennessee Valley Authority

cc:
General Counsel
Tennessee Valley Authority
400 West Summit Hill Drive
E11 B33
Knoxville, Tennessee 37902

Mr. R. L. Gridley
Tennessee Valley Authority
5N 157B Lookout Place
Chattanooga, Tennessee 37402-2801

Mr. H. P. Pomrehn
Tennessee Valley Authority
Browns Ferry Nuclear Plant
P.O. Box 2000
Decatur, Alabama 35602

Mr. M. J. May
Tennessee Valley Authority
Browns Ferry Nuclear Plant
P.O. Box 2000
Decatur, Alabama 35602

Mr. D. L. Williams
Tennessee Valley Authority
400 West Summit Hill Drive
W10 B85
Knoxville, Tennessee 37902

Chairman, Limestone County Commission
P.O. Box 188
Athens, Alabama 35611

Claude Earl Fox, M.D.
State Health Officer
State Department of Public Health
State Office Building
Montgomery, Alabama 36130

Regional Administrator, Region II
U.S. Nuclear Regulatory Commission
101 Marietta Street, N.W.
Atlanta, Georgia 30323

Resident Inspector/Browns Ferry NP
U.S. Nuclear Regulatory Commission
Route 12, Box 637
Athens, Alabama 35611

Dr. Henry Myers, Science Advisor
Committee on Interior
and Insular Affairs
U.S. House of Representatives
Washington, D.C. 20515