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MAR 02 1992

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Gentlemen:

In the Matter of	)	Docket Nos. 50-259
Tennessee Valley Authority	)	50-260
		50-296

BROWNS FERRY NUCLEAR PLANT (BFN) - HEATING, VENTILATION AND AIR CONDITIONING (HVAC) SEISMIC DESIGN CRITERIA - RESPONSE TO NRC QUESTIONS

References: 1. NRC Letter, dated February 3, 1992, Summary of Meeting with the Tennessee Valley Authority Regarding Seismic Design Criteria for Supports and Ductwork of Class I Heating, Ventilation and Air Conditioning Systems (TAC Nos. M82125, M82126, and M82127)

2. TVA letter, dated November 15, 1991, Heating, Ventilation and Air Conditioning (HVAC) Seismic Design Criteria

This letter provides TVA's responses to questions and/or requests for information, identified by the staff, regarding BFN's Class I HVAC seismic design criteria for ductwork and supports. The information was requested by NRC during a meeting on January 23, 1992, at NRC headquarters in Rockville, Maryland. The meeting had been requested by the staff to support their technical review of BFN's Class I HVAC design criteria. Subsequently, the staff provided their request for additional information in Reference 1.

BFN submitted seismic design criteria for ductwork and supports of Class I HVAC systems in Reference 2 as a post restart TVA Nuclear Performance Plan commitment. Additionally, TVA requested an expeditious review and issuance of a supplemental Safety Evaluation Report to support design and modifications which TVA committed to complete on Unit 2 prior to the restart from the next refueling outage.

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ENCLOSURE

BROWNS FERRY NUCLEAR PLANT (BFN)
HVAC SEISMIC DESIGN CRITERIA
RESPONSE TO NRC QUESTIONS

1. NRC Question

"Does the proposed long-term design criteria adequately accomodate normal operation and accident load combinations (excluding earthquake loads)?"

TVA Response

Initially, HVAC ducts and supports at BFN were fabricated and installed in accordance with industry practice. General Design Criteria BFN-50-C-7104 is being revised to require evaluation for normal operating conditions (dead weight). The duct will be evaluated using the allowable bending stresses of 8,000 psi and 10,000 psi for rectangular and round duct, respectively, which is consistent with the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) requirements. Duct supports will be evaluated to the American Institute of Steel Construction (AISC) normal allowables.

The only loads in addition to dead load and seismic loads are wind loads, which are considered under Section 1.3.2 (Special Considerations) of the Design Criteria. The factor of 1.5 increase in the allowable stress remains applicable when the wind loads are added to the dead load and seismic loads. Therefore, the long-term criteria adequately accomodates normal operation and accident load combinations.

2. NRC Question

"Has the actual type of anchor for each and every support been identified and documented for use in the determining load allowables?"

TVA Response

Documentation reviews and field inspection programs determined the type of concrete anchors installed in various supported features, including HVAC supports, to be predominantly Phillips Red Head self drilling anchors. TVA intends to perform an additional field survey using a representative sample of Class I HVAC supports to provide further assurance of the type of anchors installed. TVA intends to give special consideration to the most limiting cases when selecting supports for the survey.

The existing anchors will be evaluated in accordance with the guidelines presented in the Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment (Appendix C). Appropriate GIP capacity reduction factors will be applied to the anchor capacities used in the support calculations.

The enclosure to this letter provides a summary of NRC questions/requests and TVA's responses. TVA's responses to the questions were discussed with NRC technical reviewer, J. E. Carrasco, during a site visit on February 4-6, 1992.

There are no new commitments contained in this letter. If you have any questions, contact Raul R. Baron, Manager of Site Licensing, at (205) 729-7566.

Sincerely,

O. J. Zeringue

Enclosure
cc (Enclosure):
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3. NRC Question

"Provide rationale for using an analytical method based on "Absolute Sums" (ABS) of two components when Appendix C of the Updated Final Safety Analysis Report (UFSAR) refers to the use of "Square Root of the Sum of the Square" (SRSS)."

TVA Response

As stated in the BFN FSAR, Section C.3.2.1 for Seismic Analysis of Piping Systems: "The results for earthquakes acting in the x and y (vertical) directions simultaneously, and z and y directions simultaneously, were computed separately. Maximum joint displacements, member forces, and support reactions were determined by a Square Root of the Sum of the Square (SRSS) combination of each of these parameters for each mode and for each set of earthquake directions." The method used for the HVAC criteria is an absolute summation of two earthquake directions for determination of resulting stresses. This method is utilized when the input motion is that developed from the artificial time history generated smooth Housner curve. As documented in NUREG 1232, Volume 3, Supplement 1, Section 2.2.3.1, NRC accepted use of the SRSS method in conjunction with El Centro earthquake response spectra and use of absolute summation method in conjunction with Housner spectra.

4. NRC Question

"Confirm that the proposed long-term seismic design criteria does not deviate from the current design basis as described in the UFSAR. Discuss the basis for any deviations."

TVA Response

The criteria developed for the HVAC seismic qualification does not violate any commitments for HVAC ductwork and supports as described in the BFN FSAR.

5. NRC Question

"Describe the methodology and basis used for evaluating seismic anchor movement effect."

TVA Response

When duct is routed from one building to another the differential seismic movements of the two buildings must be considered. If the magnitude of the movements is significant, and the duct is not protected by an in-line flexible connection, then a seismic anchor movement analysis is performed. In this analysis, the maximum seismic movements of the buildings at the appropriate structural mass points are assumed to act out of phase to each other and a pseudo static load case simulating this situation is run. The results from this seismic anchor movement analysis are then combined with the seismic inertia loads.

6. NRC Question

"Clarify the use of "restoring force methodology" mentioned in the proposed criteria. Describe how the effective spring constant was derived and applied."

TVA Response

Restoring force methodology utilizes the pendulum restoring effects of rod hangers. For small displacements, the restoring force is proportional to the displacement and is oppositely directed, thus providing some lateral stiffness to the rod-hung systems. The stiffness, k, is given as k=W/L, where W is the total dead weight on the rods and L is the rod length.

7. NRC Question

"Provide an example on the use of the missing mass correction factor in the evaluation of seismic response."

TVA Response

The computer codes used at BFN to dynamically analyze HVAC duct account for the "missing mass" by determining the modal contributions of the mass of the system, for all modes below the 20 hertz cut off frequency, and then obtaining the "missing mass" as the difference between these contributions and the actual mass. The maximum building accelerations for the applicable elevation are then applied to this "missing mass". Finally, these results are combined with those from the modal analysis by the square root of the sum of the squares method.

8. NRC Question

"Provide an example of a buckling evaluation for HVAC ductwork. Also, provide the AISC criteria to be used for buckling evaluations associated with HVAC ducts and supports."

TVA Response

The TVA tests conducted on duct of both the companion angle and the pocket lock construction demonstrated that ducts have considerable capability of sustaining high dynamic loads without significant adverse local buckling affects. TVA performed a buckling evaluation of 22 representative rectangular duct sections for the effects of vacuum pressure, axial compression, bi-axial bending, and torsion. The evaluation criterion was based on the American Iron and Steel Institute Specification for the Design of Cold Formed Steel Structural Members and was documented in a TVA design calculation. The evaluation method and results were reviewed by NRC and accepted for BFN Unit 2 cycle 5 restart in NRC Inspection Report No. 50-260/89-42. Since the General Design Criteria BFN-50-C-7104 bending allowable for rectangular ducts is the same as was used in the pre-restart local buckling evaluation, the calculation methodology is applicable for the long-term buckling qualification of duct.

Duct stress for axial compression from dead weight and design basis earthquake (DBE) load combination will be verified not to exceed 90 percent critical buckling. This evaluation will be based on the AISC methodology for beam buckling for axial compression.

Evaluation of duct support members for buckling shall be in accordance with the AISC Specification (Sections 1.5 and 1.6) with increase stress allowables not to exceed 90 percent critical buckling (P_{cr}) for axial compression under loading conditions of dead weight and DBE seismic loads. P_{cr} will be based on Section 2.4 of the AISC Specification.

9. NRC Question

"Could the conservative assumptions (i.e., effective moment of inertia, test based damping, and frequency correction factor) made by TVA, when integrally applied in the evaluations, adversely affect a realistic assessment of the seismic demands on HVAC at BFN?"

TVA Response

Testing has demonstrated that the percent damping for companion angle and pocket lock duct is approximately 7% and 9%, respectively. For design purposes, 7% is conservatively used for both types of duct constructions.

The frequency correction factors were derived from a comparison of calculated natural frequencies using beam theory versus the natural frequencies measured during testing. The beam theory equation used for calculating the first mode natural frequencies is:

$$f_n = \frac{\pi}{288} \sqrt{\frac{12\ EIg}{wL^4}}$$

where E = Young's modus (lb/in^2)

I = effective moment of inertia SMACNA four corner method (in^4)

g = gravitational constant ($386\ in/sec^2$)

w = duct weight per foot (lb/ft)

L = support spacing (ft)

Frequency correction factors are applied to respective duct systems in the dynamic analyses to better correlate the dynamic characteristics of these systems with those observed in the tests in order to obtain more realistic analytical results. Duct stresses are then conservatively calculated using the SMACNA four corner effective moment of inertia method.

The results of each of these items used in the manner described above is representative of actual behavior observed during testing. Each item as considered helps to make the analytical model more closely match the actual behavior.

10. NRC Question

"Only the safe shutdown earthquake was considered by TVA. Why wasn't the operating basis earthquake (OBE) also considered as called for in the UFSAR?"

TVA Response

Seismic testing by TVA in 1979 of representative rectangular duct samples using seismic acceleration factors equivalent to OBE levels determined that 7 percent damping is appropriate for duct analysis. Since the DBE loads are based on 7 percent damping, they are twice the OBE loads.

Design criteria BFN-50-C-7104 requires an evaluation of duct and supports for Design Basis earthquake (DBE) loads, with an allowable duct bending stress increase of 1.5. The corresponding allowable stress increase for piping subjected to a DBE loading condition is 1.8. In addition, the OBE stress allowables would be bounded by the relatively small range between 24 percent for normal condition and 36 percent for DBE loading combination of duct material yield stress. Consequently, it was concluded that functionality of the duct and supports was not adversely affected by not requiring evaluation of the OBE loading condition.