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O. J. "Ike" Zeringue
Vice President, Browns Ferry Operations

JUL 31 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) - RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING DESIGN CRITERIA FOR LOWER DRYWELL STEEL PLATFORMS AND MISCELLANEOUS STEEL (TAC NOS. M80618, M80619, AND M80620)

Reference: NRC letter, dated July 13, 1992, Safety Evaluation and Request for Additional Information Regarding Browns Ferry Nuclear Plant Units 1, 2, and 3 Design Criteria for Lower Drywell Steel Platforms and Miscellaneous Steel

This letter provides TVA's response to the referenced request for additional information regarding the design criteria for lower drywell steel platforms and miscellaneous steel. An item by item response to each request is provided as Enclosure 1 to this letter. TVA requests a Supplemental Safety Evaluation Report be issued to document the resolution of these open items as each item is resolved.

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A summary list of commitments contained in this letter is provided as Enclosure 2. If you have any questions, please contact R. R. Baron, Manager of Site Licensing, at (205) 729-7570.

Sincerely,

O. J. Zeringue

Enclosures
cc (Enclosures):
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ENCLOSURE 1
BROWNS FERRY NUCLEAR PLANT (BFN)
LOWER DRYWELL PLATFORMS AND MISCELLANEOUS STEEL CRITERIA

The cover letter to the NRC's July 13, 1992 Safety Evaluation Report (SER) and Request for Additional Information lists four open items that require TVA's response. Listed below is TVA's response to each open item.

NRC Request:

1. As noted in the enclosed SE Section 2.2, the staff does not agree that TVA has demonstrated compliance with the FSAR requirements for steel design. First, application of a ductility ratio is not permitted by the FSAR. Second, the shear stress limit of 0.52 F_y proposed in the criteria submitted on June 12, 1991 is greater that the FSAR limit of 0.4 F_y. TVA has not provided a justification for this increased limit. TVA should justify the increased shear stress limit, as noted in SE Section 2.5.3. TVA has stated that the FSAR will be revised to reflect changes in the steel design criteria. This revision and the associated justification will be reviewed by the staff when it becomes available.

TVA Response:

Ductility -

The original FSAR loading combinations did not include thermal loads for steel structures and there are no statements in the BFN FSAR that would prohibit the use of ductility to accommodate the effects of thermal conditions. TVA has evaluated the changes to its steel design criteria under the provision of 10 CFR 50.59 and voluntarily upgraded its design criteria and loading combinations to explicitly address thermal conditions and to use the concept of ductility to relieve thermal loads. This upgraded design criteria provides specific methods to address Standard Review Plan (SRP) Section 3.8.4, which states, in part: "... thermal loads can be neglected when it can be shown that they are secondary and self-limiting in nature and where the material is ductile."

TVA and NRC met on April 30, 1992 to discuss the methodology used to evaluate effects of thermal growth of steel structures. As documented in the NRC's May 12, 1992 meeting notes, the NRC staff requested that TVA perform, and the NRC review, further analysis of structures effected by thermal conditions following a postulated pipe break. TVA agreed to develop a plan to perform this analysis and submitted this plan by TVA letter to NRC, dated July 20, 1992. NRC also documented in its meeting notes that TVA would not have to perform any physical testing or verification of the ANSYS computer program.

TVA continues to pursue its proposed plan for the resolution of the thermal growth issue. TVA will prepare a summary of the calculations used to address the thermal growth issue and will also perform linear analyses for those structural configurations that exhibit the highest level of thermally induced stress. A summary report will be submitted to NRC and the supporting calculations made available for NRC review at TVA's Rockville office by September 30, 1992.

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(CONTINUED)

Shear Stress Limit -

The shear stress limit of 0.52 F_y is provided to ensure a margin similar to the 0.9 F_y limit on tension and bending stresses. Commentary Section 1.5.1.2 of the American Institute of Steel Construction (AISC) 8'th edition states shear yield stress is frequently taken as:

$$\frac{F_y}{\sqrt{3}}$$

$$Thus, \quad \frac{0.9\,F_y}{\sqrt{3}} = 0.52\,F_y.$$

This allowable is in accordance with, or more conservative than, standard industry practice. An illustration of the margin provided by this shear stress limit with respect to industry practice is described below.

The use of a shear stress limit of 0.52F_y for DBE load combinations is within the bounds of acceptable practice permitted under the AISC Code. Section 1.5.1.2 of the AISC's 8'th Edition of Manual of Steel Construction provides shear allowables. A shear allowable of 0.4F_y is the basic allowable on cross-sectional area effective in resisting shear. It is used for service level loads and for the OBE at BFN. Section 1.5.6 of the same code states that the allowable stress may be increased one third above the values otherwise provided when produced by wind or seismic loading, acting alone or in combination with the design dead and live loads. Considering a one third increase on the basic allowable for DBE loading combinations with wind or seismic loads results in an allowable shear stress of:

$$1\,\frac{1}{3} \times 0.4F_y = 0.533F_y$$

The shear stress limit of 0.52F_y for DBE load combinations that is specified in BFN's steel design criteria is therefore more conservative that the 0.533F_y allowed by the AISC.

The stress allowables specified in SRP Section 3.8.4 for DBE load combinations are 1.6 times the allowables of normal loading combinations. This results in an allowable shear stress of:

$$1.6 \times 0.4F_y = 0.64F_y$$

The shear stress limit of 0.52F_y for DBE load combinations that is specified in BFN's steel design criteria is therefore more conservative that the 0.64F_y allowed by the SRP.

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The 0.52 F_y value is consistent with the allowable used for the evaluation/design of other commodities at BFN. For example, the NRC's July 16, 1992 SER on the Browns Ferry seismic design criteria for HVAC duct and their supports states that the shear stress limit of 0.52F_y for DBE load combinations is acceptable. The SER further states that this stress limit is in accordance with, or more conservative than, current industry practices.

FSAR Revisions -

TVA letter to NRC, dated July 23, 1992, transmitted Revision 9 of the Updated Browns Ferry Final Safety Analysis Report. The FSAR has been updated to reflect the steel design criteria. TVA will further enhance FSAR Table 12.2-16 to more clearly describe stress allowables for drywell platforms.

NRC Request:

2. In the enclosed SE Section 2.4, TVA is requested to clarify the criteria to state that the absolute sum of dynamic forces will be used versus evaluation of dynamic force phase relationships. The staff feels this request is consistent with previous TVA commitments.

TVA Response:

TVA will clarify the criteria to state that the various dynamic reactions from attached systems, such as piping, HVAC, and cable trays, are combined on an absolute sum basis.

NRC Request:

3. SE Section 2.5.1 requires TVA to clarify the FSAR with regard to circumstances where the upper stress limit should be applied.

TVA Response:

TVA will further enhance FSAR Table 12.2-16 to more clearly describe stress allowables for drywell platforms.

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(CONTINUED)

NRC Request:

4. SE Section 2.5.2 states the staff does not accept 0.9 of the critical buckling stress, since this limit provides insufficient margin. TVA is requested to submit a lower limit for staff review which demonstrates acceptable margin.

TVA Response:

TVA's design criteria specifies a 1.5 increase in the basic AISC stress allowables for the DBE load combination. However, in no case shall allowables exceed 90 percent of critical buckling for axial compression. The 0.9 F_{CR} (Factor of Safety = 1.11) is only approached for very short compression members for which buckling is not a concern. This allowable is in accordance with, or more conservative that, standard industry practice.

The allowables for columns are demonstrated by the following examples. Note that 0.9 F_{CR} is approached only for columns of very short length. As column length increases, the allowable stress is rapidly reduced to 0.78 F_{CR}. The example column has an allowable stress of 0.88 F_{CR} at a 7.25 inch length. The allowable stress is reduced to 0.81 F_{CR} at a 48 inch length and declines to 0.78 F_{CR} at a length of 101.33 inches. The factor of safety against critical buckling ranges from 1.11 for the short column, up to 1.28 for the longer column. These factors of safety are consistent with those used for tension and bending members for the DBE loading combination. It has also been observed in physical tests that columns exhibit post-buckling strength and do not fail abruptly in compression. The relationship between a 1.5 increase in basic AISC stresses and 0.9 F_{CR} is shown graphically in Figure 1.

The following examples assume a W6x25 main member, constructed from A36 steel, with an r_{MIN} of 1.52. Using K = 2.1, $K\,l/r < C_c$, with C_c = 126 (Reference AISC 8th Edition, Section 1.5.1.3).

1. Length = 7.25 inches

   $K\,l/r$ = 2.1 (7.25) / 1.52 = 10.0 Using $K\,l/r$ = 10

   AISC allowable = 21.16 ksi (AISC 8th Edition, Table 3-36)

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For the DBE condition, Attachment F of TVA's design criteria allows a 1.5 increase. Therefore, $F_A = 1.5\ (21.16) = 31.74$ ksi

$$F_{CR} = [1 - \frac{(K\frac{l}{r})^2}{2\,C_c^2}]\,F_y = [1 - \frac{10^2}{2\,(126)^2}]\,36 = 35.89\ ksi$$ (AISC Eq. 1.5-1 without Factor of Safety)

Factor of Safety = 35.89/31.74 = 1.13

Note for evaluation purposes, compute 0.9 F_{CR}

0.9 F_{CR} = 0.9 (35.89) = 32.30 ksi

Compare to 1.5 F_A

1.5 F_A = 31.74 ksi ← Controlling

2. Length = 48 inches

$K\,{}^{l}/_{r}$ = 2.1 (48) / 1.52 = 66.3 Using $K\,{}^{l}/_{r}$ = 67

AISC allowable = 16.74 ksi (AISC 8th Edition, Table 3-36)

For the DBE condition, Attachment F of TVA's design criteria allows a 1.5 increase. Therefore, $F_A = 1.5\ (16.74) = 25.11$ ksi

$$F_{CR} = [1 - \frac{(K\frac{l}{r})^2}{2\,C_c^2}]\,F_y = [1 - \frac{67^2}{2\,(126)^2}]\,36 = 30.91\ ksi$$ (AISC Eq. 1.5-1 without Factor of Safety)

Factor of Safety = 30.91/25.11 = 1.23

Note for evaluation purposes, compute 0.9 F_{CR}

0.9 F_{CR} = 0.9 (30.91) = 27.82 ksi

Compare to 1.5 F_A

1.5 F_A = 25.11 ksi ← Controlling

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(CONTINUED)

For $K_l/r > C_c$

3. Length = 101.33 inches

   K_l/r = 2.1 (101.33) / 1.52 = 139.99 Using K_l/r = 140

   AISC allowable = 7.62 ksi (AISC 8th Edition, Table 3-36)

   For the DBE condition, Attachment F of TVA's design criteria allows a 1.5 increase. Therefore, F_A = 1.5 (7.62) = 11.43 ksi

   $$F_{CR} = \frac{\pi^2 E}{(K\frac{l}{r})^2} = \frac{(3.14)^2 29000}{140^2} = 14.59\ ksi$$ (AISC Eq. 1.5-2 without Factor of Safety)

   Factor of Safety = 14.59/11.43 = 1.28

   Note for evaluation purposes, compute 0.9 F_{CR}

   0.9 F_{CR} = 0.9 (14.59) = 13.13 ksi

   Compare to 1.5 F_A

   1.5 F_A = 11.43 ksi ← Controlling

The factor of Safety against buckling ranges from 1.13 to 1.28 for these examples.

CONCLUSION

It is TVA's understanding that the proposed steel design criteria is acceptable to the NRC Staff except for the open items identified in the NRC's July 13, 1992 SER. TVA's plan for resolving the thermal growth issue was submitted for Staff review by letter, dated July 20, 1992. TVA's proposed use of the ductility ratio concept is compatible with the SRP philosophy of self-limiting and ductile materials, and is more conservative than the SRP since a upper bound of 3 was established on the allowable ductility ratio. The remainder of the open items are addressed in this submittal.

TVA's steel criteria is conservative and consistent with past TVA commitments. TVA requests a Supplemental SER be issued to document the resolution of these open items as each item is resolved.

ALLOWABLE STRESSES

FOR COMPRESSION MEMBERS OF 36 KSI YIELD STRESS STEEL
BROWNS FERRY NUCLEAR PLANT DESIGN CRITERIA

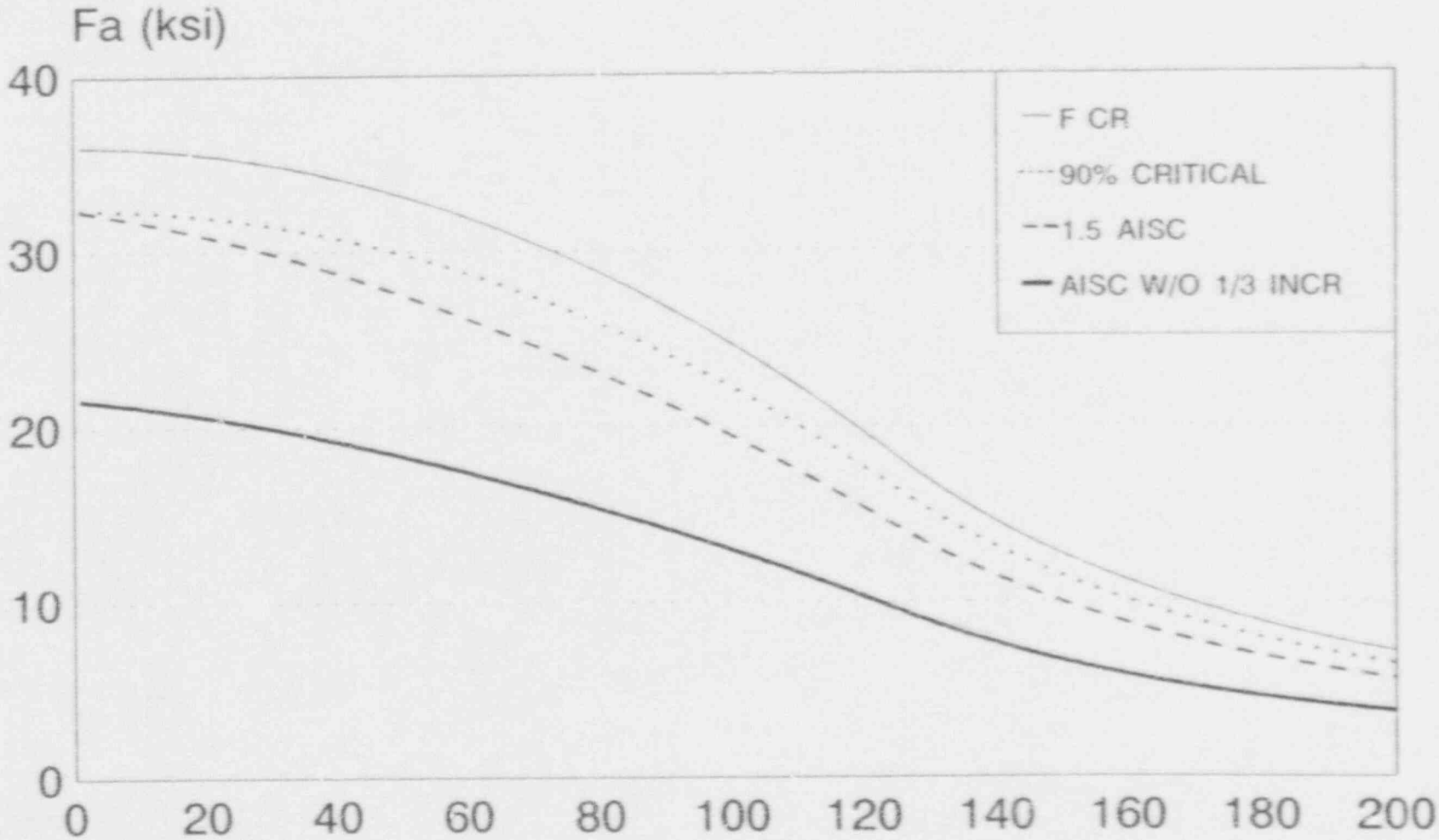

Figure 1

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ENCLOSURE 2
BROWNS FERRY NUCLEAR PLANT
SUMMARY OF COMMITMENTS

TVA will:

1) TVA will further enhance FSAR Table 12.2-16 to more clearly describe stress allowables for drywell platforms.

2) TVA will clarify the criteria to state that the various dynamic reactions from attached systems, such as piping, HVAC, and cable trays, are combined on an absolute sum basis.