UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

Docket Nos. 50-259, 50-260,
and 50-296

March 19, 1992

Senior Vice President, Nuclear Power
Tennessee Valley Authority
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Dear Sir:

SUBJECT: BROWNS FERRY NUCLEAR PLANT UNITS 1, 2, AND 3 - NRC STAFF POSITION ON PROPOSED DUCTILITY RATIO DESIGN CRITERIA (TAC NOS. M80618, M80619, AND M80620)

This letter provides the NRC staff position which rejects application of a ductility factor or ratio of greater than one in the lower drywell and miscellaneous steel design criteria for the Browns Ferry Nuclear Plant (BFN), Units 1, 2, and 3. These criteria were submitted by the Tennessee Valley Authority (TVA) by letter dated June 12, 1991 (Reference 1). Following meetings and telephone conversations with the staff on this topic, the NRC issued a request for additional information (RAI). This request (Reference 2) documented staff questions with regard to the application of the ductility ratio as part of the proposed criteria. TVA provided its response to the staff's information request in Reference 3. The NRC staff evaluated this information and has provided the enclosed staff position.

In a safety evaluation dated July 26, 1988 (Reference 4), the staff approved interim criteria for the BFN Unit 2 restart. Subsequently, NRC inspections (Reference 5) documented staff acceptance of a ductility factor in design of Unit 2 structural steel outside the drywell. TVA states in its RAI response that these inspections explicitly accepted use of ductility ratios for the long-term steel design criteria. However, it is the staff's position that approval was not granted for the use of a ductility factor greater than one as a long-term design criterion for all structural steel at BFN. In addition, the staff concludes that the technical justification provided by TVA is not adequate to justify the acceptance of ductility ratios as part of the long-term structural steel design criteria.

Please note that while broad application of ductility ratios for structural steel design is not accepted, the staff recognizes there may be specific applications where plant modifications would be particularly difficult or would result in high personnel exposures. In such cases, the staff would consider a case-by-case application of a ductility factor greater than one. However, the staff expects new steel components will be designed such that a ductility factor greater than one is not required.





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The staff is continuing its review of the remainder of the proposed criteria. Please contact Joseph F. Williams, Browns Ferry Unit 3 Project Manager at (301) 504-1470 if you have any questions.

Sincerely,

Original signed by

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Enclosures:
1. References
2. Staff Position

cc w/enclosures:
See next page

| OFC | PDII-4/LA | PDII-4/PM | PDII-4/PM | PDII-4/D | DRPE:AD | ES | D |
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References

1. O. J. Zeringue to NRC Document Control Desk, "Browns Ferry Nuclear Plant (BFN) - Corrective Action Plan and Design Criteria for Lower Drywell Steel Platforms and Miscellaneous Steel," letter dated June 12, 1991.

2. J. F. Williams to Dan A. Nauman, "Request for Additional Information Regarding Browns Ferry Drywell and Miscellaneous Steel Design Criteria, Units 1, 2, and 3 (TAC NOS. M80618, M80619, AND M80620), letter dated December 12, 1991.

3. O. J. Zeringue to NRC Document Control Desk, "Browns Ferry Nuclear Plant (BFN) - Lower Drywell Steel Platforms and Miscellaneous Steel Seismic Criteria," letter dated February 6, 1992.

4. S. C. Black to S. A. White, "Interim Operability Criteria for the Seismic Design Program For the Browns Ferry Nuclear Plant, Unit 2 (TAC 00023, 00295, 00299, 00302)," safety evaluation dated July 26, 1988.

5. NRC Inspection Report No. 50-260/89-42, February 26, 1990.

ENCLOSURE 2

# NRC POSITION ON

# TVA PROPOSED BROWNS FERRY DUCTILITY RATIOS CRITERIA

## ISSUE

Whenever a structural member or element is subjected to elevated temperatures and its ends are constrained by such objects as a concrete wall or other unyielding elements, considerable compressive stresses are introduced within the member. Additional loading, such as from equipment weights or loads from an earthquake applied laterally, could then lead to failure, most likely in a beam-column type of instability failure mode.

Safety-related steel structures at the Browns Ferry Nuclear Plant (BFN) were not designed for load combinations recommended in the Standard Review Plan. As such, the Tennessee Valley Authority (TVA) committed to assess the effects of load combinations (including thermal loads) generated by design basis accident conditions on existing steel structures. Since some of these steel structures were constrained from free expansion due to thermal loads, TVA proposed to use a ductility approach (i.e., non-linear, inelastic response). TVA requested staff approval to use a ductility ratio of three for all BFN safety-related steel structures. This ductility ratio was calculated based on the ANSYS computer code non-linear option.

The staff reviewed and approved, for restart of Unit 2, a ductility ratio of three to be used for structural steel outside the drywell (NRC IR 50-260/89-42). TVA has currently proposed to extend the use of ductility ratios to all structural steel (i.e., inside and outside the drywell) and for all BFN Units (1, 2, and 3). The staff recently reviewed a similar proposal for Watts Bar and concluded that the use of ductility ratios was not acceptable because of a lack of technical justification. By letter dated December 12, 1991, the staff requested TVA to describe its technical basis for using ductility ratios at BFN in terms of physical test data and analytical demonstrations. TVA was also requested to describe how such ductility ratios were calculated, and the reliability of the calculational methodology.

By letter dated February 6, 1992, TVA responded to the staff's request for additional information. However, rather than providing the detailed technical basis requested by the staff, TVA attempted to justify its broad, multi-unit approach for using ductility ratios by describing a document trail in which the staff had presumedly already approved such an approach. In the following section titled "Background," the staff discusses the licensing basis history for this issue. The staff believes this history supports its present position on the use of ductility ratios at BFN.

## BACKGROUND

### Long-Term Design Criteria

By letter dated July 26, 1988, the staff issued a safety evaluation (SE) that approved interim operability criteria for both drywell steel platforms and miscellaneous steel for restart of Unit 2. However, in NRC Inspection Report (IR) 50-260/88-38, dated April 19, 1989, the staff discovered that in certain

applications TVA was using the design criteria from TVA design documents BFN-50-C-7100 through 7300, which had not been previously reviewed and approved by the staff. Although these design documents were designated by TVA as their long-term design criteria, the staff decided in NRC IR 50-260/89-29, dated September 20, 1989, to only review them for restart of Unit 2. The staff stated, in IR 50-260/89-29, that these "criteria could only be used if they were equivalent or more conservative than the interim operability criteria" previously accepted by the staff. Thus, in the context of interim use, the staff was merely confirming the suitability of TVA's proposed long-term criteria as an equivalent substitute for the interim operability criteria. The staff subsequently concluded in IR 50-260/89-29, "that the long-term criteria are more conservative than the interim operability criteria, and therefore the use of the long-term criteria for restart [of Unit 2] is acceptable."

It is obvious from NRC IR 50-260/89-29, that the staff did not perform a rigorous or detailed safety evaluation of the design documents TVA had designated as long-term (i.e., BFN-50-C-7100 through 7300). The staff intended to review these documents in much greater detail following Unit 2 restart. This intention was made clear in NRC IR 50-260/89-42, dated February 26, 1990, and NUREG-1232, Volume 3, Supplement 2, dated January 1991. Both of these documents requested TVA to submit for staff review its long-term criteria for drywell platforms and miscellaneous steel after restart of Unit 2. In fact, TVA's submittal dated June 12, 1991, "Corrective Action Plan And Design Criteria For Lower Drywell Steel Platforms And Miscellaneous Steel," reiterates and confirms the staff position that the design criteria previously approved by the staff were only for interim seismic qualification. TVA further acknowledged that:

"the final seismic qualification of the lower drywell steel platforms and miscellaneous steel at Browns Ferry will be accomplished in the following manner:

1. Obtain NRC acceptance of the design criteria for the lower drywell steel platforms and miscellaneous steel.

2. Evaluate and modify, as required, the lower drywell steel platforms and miscellaneous steel to meet the design criteria ..."

In this context, TVA formally submitted, as Enclosure 2 of the June 12, 1991 letter, its long-term design criteria (i.e., BFN-50-C-7100) to the staff for a detailed safety evaluation. These criteria were submitted by TVA to resolve several Unit 2 post-restart issues. Furthermore, since these criteria were "different [emphasis added] than the criteria used for restart of BFN Unit 2", they were also being submitted to support restart of Units 1 and 3.

Ductility Ratios

The staff first expressed its concerns with regard to the use of ductility ratios, as referenced in BFN-50-C-7100, in IR 50-260/89-29. In this IR, TVA was requested to justify its proposed use of an allowable ductility factor of 5 for thermal expansion of steel structures outside the drywell. In NRC IR 50-260/89-30, dated September 20, 1989, the staff agreed to review TVA's

documentation regarding ductility ratios, but stated "that a ductility factor of higher than 3 would not be acceptable because this is the limiting value that has previously been accepted by NRC, on a case-by-case basis." This statement means that the staff would consider accepting TVA's use of ductility ratios only for factors of three or lower, and then only for specific applications, not for broad, unrestricted uses. This interpretation is supported by the fact that all staff references to reviewing TVA's proposed use of ductility ratios were only in regard to thermal expansion of BFN Unit 2 steel structures outside the drywell, and only within the context of BFN Unit 2 restart. As such, the staff has clearly documented that its evaluation of TVA's use of ductility ratios was conducted within a very limited scope: thermal expansion of BFN Unit 2 structural steel outside the drywell to support restart.

NRC IR 50-260/89-42 closed out the staff's concerns regarding TVA's use of ductility ratios. The staff concluded that a ductility factor of three would be acceptable for discreet applications. As stated in IR 50-260/89-42, "In summary, the team concluded that TVA's thermal growth evaluation of the structural steel outside [the] drywell resolved all three [of the] team's concerns [which included ductility ratios] identified in IR 50-260/89-29, and the evaluation results and modifications are reasonable. This item (CSS-34) is closed." It was in this IR that the staff completed its review of ductility ratios with regard to restart of Unit 2.

After BFN Unit 2 restart, TVA submitted similar ductility ratios, via Enclosure 2 (BFN-50-C-7100) of the June 12, 1991 letter, for staff approval as part of its long-term criteria for post-restart of BFN Unit 2 and restart of BFN Units 1 and 3. This submittal proposed to expand the use of ductility ratios to all structural steel for all three units. Furthermore, it implies that ductility ratios of greater than three could be evaluated on a case-by-case basis. The staff concludes that TVA's proposal to use ductility ratios in unrestricted applications for all three units, and to consider ductility ratios greater than three are serious departures from the previously-approved criteria.

STAFF ASSESSMENT

After reviewing TVA's submittals of June 12, 1991 and February 6, 1992, the staff has determined that TVA has not provided sufficient technical justification to conclude that the broad application of ductility ratios for all Browns Ferry units is acceptable. However, the staff does recognize that under specific conditions, such as fully ductile failure modes, adequate margins of safety can be maintained through the use of ductility ratios on a case-by-case basis, but only when technically justified.

Consequently, the staff does not accept TVA's proposed use of ductility ratios as part of its long-term design criteria for BFN Units 1, 2, and 3 for the following reasons:

1. TVA did not provide adequate test data that can be used to validate the non-linear option of the ANSYS code.

2. No test data were provided to establish a basis for judging the available margins between the proposed ductility limits and the ductility corresponding to imminent failure.

3. Use of ductility ratios criteria alone is inadequate to address likely buckling failure modes.

4. Because of the uncertainties resulting from an inelastic analysis of the non-linear behavior of structures, the current staff design philosophy for structures carrying primary loads (e.g., static and seismic loads) is to generally limit allowable stresses to less than yield for load combinations including accident-induced loads. However, some localized yield is allowed for loads such as missile impact and impulsive loads.

STAFF POSITION

The ductility ratio approach proposed by TVA for the design and evaluation of structural steel for Browns Ferry is not acceptable. However, the staff recognizes that the BFN units are operating plants where construction has been completed, equipment is in place and some structural members are in highly radioactive areas. For these reasons, the staff would consider evaluating the use of ductility ratios, on a case-by-case basis, for any specific situations of extraordinary hardship, provided that a ductile failure mode is assured and margins against collapse are adequate.

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Date: March 19, 1992

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