Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

February 19, 2013

10 CFR 54.7

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Browns Ferry Nuclear Plant, Units 1, 2, and 3
Renewed Facility Operating License Nos. DPR-33, DPR-52, and DPR-68
NRC Docket Nos. 50-259, 50-260, and 50-296

Subject: **Response to Request for Additional Information Regarding BWRVIP-25 Core Plate Bolt Stress Analysis for BFN Units 1, 2, and 3 (TAC NOS. ME6615, ME6616, and ME6617)**

References:

1. Letter from TVA to NRC, "BWRVIP-25 Core Plate Bolt Stress Analysis," dated June 15, 2011 (ADAMS No. ML11171A037)
2. NRC Letter to TVA, "Browns Ferry Nuclear Plant, Units 1, 2, and 3, Request for Additional Information Related to Core Plate Bolt Stress Analysis (TAC NOS. ME6615, ME6616, and ME6617)," dated June 28, 2012 (ADAMS No. ML12108A088)
3. Letter from TVA to NRC, "Response to Request for Additional Information Regarding BWRVIP-25 Core Plate Bolt Stress Analysis for BFN Units 1, 2, and 3," dated October 25, 2012 (ADAMS No. ML12307A224)
4. NRC Letter to TVA, "Browns Ferry Nuclear Plant, Units 1, 2, and 3, Request for Additional Information Related to Core Plate Bolt Stress Analysis (TAC NOS. ME6615, ME6616, and ME6617)," dated January 18, 2013 (ADAMS No. ML13018A072)

On June 15, 2011, the Tennessee Valley Authority (TVA) submitted "BWRVIP-25 Core Plate Bolt Stress Analysis" for Browns Ferry Plant (BFN), Units 1, 2, and 3,

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(Reference 1) to complete a License Renewal Commitment. By NRC letter dated June 28, 2012 (Reference 2), TVA received a Request for Additional Information (RAI) regarding the BWRVIP-25 Core Plate Bolt Stress Analysis for BFN Units 1, 2 and 3. By letter dated October 25, 2012 (Reference 3), TVA provided the response to reference 3.

By NRC letter dated January 18, 2013 (Reference 4), TVA received a Request for Additional Information (RAI) regarding the BWRVIP-25 Core Plate Bolt Stress Analysis for BFN Units 1, 2 and 3. The NRC requested the response within 30 days, i.e., by February 17, 2013. Since February 17, 2013 is a Sunday and February 18, 2013 is a Federal Holiday, the response due date is no later than February 19, 2013.

The enclosure to this letter provides the TVA response to the January 18, 2013 NRC RAI.

This letter does not include any new regulatory commitments. Please direct any questions concerning this matter to Tom Hess at (423) 751-3487.

Respectfully,

Beth A. Wetzel, for

J. W. Shea
Vice President, Nuclear Licensing

Enclosures:

TVA Response to NRC Request for Information

cc (Enclosures):

NRC Regional Administrator – Region II
NRC Senior Resident Inspector – Browns Ferry Nuclear Plant
Alabama State Department of Public Health

Response to Request for Additional Information Regarding BWRVIP-25 Core Plate Bolt Stress Analysis for BFN Units 1, 2 and 3

TVA Response to NRC Request for Information

NRC Request for Additional Information (RAI) Question 1

Core plate bolts are prone to intergranular stress corrosion cracking (IGSCC). Since the visual examination currently performed at Browns Ferry Nuclear Plant cannot find IGSCC due to an accessibility issue, the licensee should address the potential extent of cracking that could occur in these bolts in its analysis. Clarify whether the core plate bolt stress analysis account for some portion of the core plate bolts being either completely or partially cracked due to IGSCC or irradiation assisted stress corrosion cracking. If this assumption is included in the analysis, describe how the cracking was accounted for in the analysis. If cracking was not accounted for in the stress analysis, provide a technical justification that demonstrates that cracking need not be considered in the analysis.

TVA Response

First, a justification must be made regarding the IGSCC resistance of the core plate bolts and the unlikelihood of any cracking. The history of non–welded Type 304 stainless steel material in the solution annealed condition has been excellent with no reported incidences of cracking, substantiating its high resistance to IGSCC initiation in BWR applications. All core plate bolts were fabricated in the solution annealed condition. All the threads were machined, given the size and uniqueness of the application and BFN's bolts were liquid honed to remove any burrs or residual surface roughness that could affect installation and reduce the potential for galling. Therefore, the microstructure is free of sensitization and free of bulk cold work that could have been introduced through processing prior to the final solution annealing heat treatment of the material. Moreover, BFN (like the rest of the domestic BWR fleet) is operating with an effective Hydrogen Water Chemistry (HWC) core environment in the core plate region. The units at BFN have implemented either classic Noble Metal Chemical Addition (NMCA) or On-line NobleChem™ (OLNC). This greatly increases confidence that SCC will not occur in the bolts during future operation. In essence, none of the three concurrent factors for SCC are present (material, environment, and stress): the core plate bolts are resistant due to solution annealing and thread manufacturing controls, the applied stresses are low with no weld residual stresses, and the effective HWC environment removes the environmental driver for SCC. The field experience as well as the specifications and processes used to make the core plate bolts support the SCC resistance of these annealed stainless steel components.

Now that a justification has been made for the IGSCC resistance of the bolts, the analyses can be discussed in more detail. Three scenarios (similar to the BWRVIP-25 Appendix A example) were analyzed in NEDC-33632P-R0. Scenarios 1 and 3 assumed that the aligner pins took no load. For these two scenarios, all of the core plate bolts were assumed functional (un-cracked) and all of the horizontal and vertical loads imparted to the core plate assembly were resisted by the bolts (for NEDC-33632P-R0, friction—provided by the bolted connection—also resisted horizontal loading). Scenario 2 assumed that the applied horizontal load was resisted by the aligner pins (for NEDC-33632P-R0, only two of the four aligner pins plus friction resisted horizontal loading).

None of the bolts resisted a horizontal load. With the conservatisms and available margins in each of the analyzed scenarios, the conclusions of NEDC-33632P-R0 stay valid even with postulated cracking in some of core plate bolts as analyzed below.

For Scenario 2, NEDC-33632P-R0 assumes the horizontal load is resisted by the shear capability of the aligner pins as well as friction at the rim-shroud interface. In this report, as in the BWRVIP-25 Appendix A example, none of the bolts have a shear or bending force imparted to them. They only have an axial load. In NEDC-33632P-R0, they only exist to resist vertical loads and maintain a preload (necessary for the friction to be present). Assuming 20% of the bolts were cracked would reduce the total applied preload to the core plate by 20%. This reduces the clamping force (and horizontal frictional resistance), increasing the shear stress in the aligner pins to the allowable limit listed in Scenario 2 of Table 7-1 in NEDC-33632P-R0. Two conservatisms (explained in Sections 5.7 and 6.3.2) in the analysis should still be considered. Only two of the four aligner pins were assumed to resist horizontal load. Assuming three of the four aligner pins resist load allows 45% of the bolts to be cracked and still meet ASME Code stress limits. Another conservatism is the coefficient of friction used. A more realistic value is double the value used in the analysis. Now with three aligner pins and a more realistic value for the coefficient of friction, 60% of the bolts could be cracked and the remainder would still provide enough clamping force such that the shear stress on the pins is below their allowable limit.

More simply, consider the horizontal load listed in Table 5-1 of NEDC-33632P-R0. Three aligner pins at the allowable shear stress can resist approximately 80% of the total horizontal load. Therefore, it would only take a few bolts to provide the friction, bolt shear, and bolt bending needed to resist the remaining 20% of the horizontal load (with the rest of the bolts assumed to be cracked). Nevertheless, it should be reiterated that no cracking is expected for these bolts.

NRC Request for Additional Information (RAI) Question 2

In the October 25, 2012, Request for Additional Information (RAI) response, the licensee presented the results of the analysis of the core plate bolts for Scenario 1 (defined in General Electric Report NEDC-33632P) and provided a justification for calculating the stresses in the core plate bolts using average horizontal and vertical forces. These results are presented in Figure 1 of the licensee's October 25, 2012, RAI response and include the effect of preload on the vertical forces applied to the core plate bolts; the horizontal load applied to the bolts was omitted for clarity. However, based on the information provided, the Nuclear Regulatory Commission staff is unable to determine whether the limiting core plate bolt(s) satisfy the allowable stress limits outlined in Table 4-1 of NEDC-33632P. Please provide a comparison of the calculated stresses in the limiting core plate bolt(s), depicted as the bolts to which the highest loads are applied in Figure 1 of the October 25, 2012, RAI response, to the stress limits provided in Table 4-1 of NEDC-33632P.

TVA Response

It is common practice to use the average stress by linear elastic analysis for ASME Code compliance evaluation for this situation, as demonstrated in the BWRVIP-25 Appendix A example. NEDC-33632-R0 applied the same methodology as the BWRVIP-25 Appendix A by using the average stress for the core plate bolt analysis. In addition to reasons mentioned previously, it should be noted that joint-to-fastener participation effects have been conservatively neglected and all vertical external loads were applied to the fasteners (core plate bolts). Therefore, the already-reduced variation (shown in NEDC-33779P-R1) will be further reduced (the vertical forces will be even closer to the average). This is because more than half (generally at least 90%) of an externally-applied load to a clamped joint will go into reducing the clamping load on the clamped components (the core plate rim in this case) with the remainder going into increasing the bolt load. Adding these details to the original calculations was not necessary to meet the stress limits.

Regardless, it can still be shown that individual bolt stresses are within the allowable stress limits. Using Figure 1 from NEDC-33779P-R1, one can estimate the maximum vertical variation in bolt forces (stresses) to be 11% greater than the average. Using Figure 7-2 from the original report (NEDC-33632P-R0), one can estimate the maximum horizontal variation to be 10% greater than the average. Now, in Table 7-1 of NEDC-33632P-R0 (which has a lower margin than Table 7-2), multiply the Mean P_m + P_b stress of Scenario 1 or 3 by 1.11 to cover both the horizontal and vertical variation. This 11% increase is still within the available margin of 21%.