July 26, 2006

Mr. Karl W. Singer
Chief Nuclear Officer and
Executive Vice President
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

SUBJECT: BROWN FERRY NUCLEAR PLANT, UNIT 1 - ISSUANCE OF AMENDMENTS REGARDING UPDATE OF PRESSURE-TEMPERATURE CURVES (TAC NO. MC5373) (TS 428)

Dear Mr. Singer:

The Commission has issued the enclosed Amendment No. 256 to Facility Operating License No. DPR-33 for the Browns Ferry Nuclear Plant (BFN), Unit 1. This amendment is in response to your application dated December 6, 2004, as supplemented by letter dated June 16, 2005. This amendment revises the pressure-temperature limit curves for BFN, Unit 1.

A copy of the Safety Evaluation is also enclosed. Notice of Issuance will be included in the Commission's biweekly *Federal Register* notice.

Sincerely,

/RA/

Margaret H. Chernoff, Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-259

Enclosures: 1. Amendment No. 256 to
License No. DPR-33
2. Safety Evaluation

cc w/enclosures: See next page

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TENNESSEE VALLEY AUTHORITY

DOCKET NO. 50-259

BROWNS FERRY NUCLEAR PLANT UNIT 1

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 256
License No. DPR-33

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Tennessee Valley Authority (the licensee) dated December 6, 2004, as supplemented by letter dated June 16, 2005, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is amended by changes to the Technical Specifications as indicated in the attachment to this license amendment and paragraph 2.C.(2) of Facility Operating License No. DPR-33 is hereby amended to read as follows:

   (2) Technical Specifications

   The Technical Specifications contained in Appendices A and B, as revised through Amendment No. 256, are hereby incorporated in the license. The licensee shall operate the facility in accordance with the Technical Specifications.

3. This license amendment is effective as of its date of issuance and shall be implemented within 60 days from the date of issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

/RA/

L. Raghavan, Chief
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Attachment: Changes to the Technical Specifications

Date of Issuance: July 26, 2006

ATTACHMENT TO LICENSE AMENDMENT NO. 256

FACILITY OPERATING LICENSE NO. DPR-33

DOCKET NO. 50-259

Replace Page 3 of Renewed Operating License DPR-33 with the attached Page 3.

Replace the following pages of the Appendix A Technical Specifications with the attached revised pages. The revised pages are identified by amendment number and contain marginal lines indicating the areas of change.

REMOVE	INSERT
3.4-26	3.4-26
3.4-28	3.4-28
3.4-29	3.4-29
----	3.4-29a
----	3.4-29b
----	3.4-29c

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 256 TO FACILITY OPERATING LICENSE NO. DPR-33

TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT, UNIT 1

DOCKET NO. 50-259

1.0 INTRODUCTION

By letter dated December 6, 2004, as supplemented by letter dated June 16, 2005, the Tennessee Valley Authority (TVA, the licensee) submitted a request for changes to the Browns Ferry Nuclear Plant (BFN), Unit 1, Technical Specifications (TS). The proposed amendment would revise the pressure-temperature (P-T) limits to provide new limits that are valid to 12 and 16 effective full-power years (EFPY). The June 16, 2005, letter provided clarifying information that did not change the initial proposed no significant hazards consideration determination.

2.0 EVALUATION

2.1 Regulatory Evaluation

The Nuclear Regulatory Commission (NRC) has established requirements in Title 10, *Code of Federal Regulations* (10 CFR), Part 50, to protect the integrity of the reactor coolant pressure boundary in nuclear power plants. The NRC staff evaluates the P-T limit curves based on the following NRC regulations and guidance: Appendix G to 10 CFR Part 50; Generic Letter (GL) 88-11, "NRC Position on Radiation Embrittlement of Reactor Vessel Materials and Its Impact on Plant Operations"; GL 92-01, " Reactor Vessel Structural Integrity," Revision (Rev.) 1; GL 92-01, Rev. 1, Supplement 1; Standard Review Plan (SRP) for the Review of Safety Analysis Reports for Nuclear Power Plants (NUREG-0800), Section 5.3.2; Regulatory Guide (RG) 1.190, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence." Appendix G to 10 CFR Part 50 requires that P-T limit curves for the reactor pressure vessel (RPV) be at least as conservative as those obtained by applying the methodology of Appendix G to Section XI of the American Society of Mechanical Engineers (ASME) Code. GL 88-11 advised licensees that the NRC staff would use RG 1.99, "Radiation Embrittlement of Reactor Vessel Materials," Rev. 2, to review P-T limit curves. RG 1.99, Rev. 2, contains methodologies for determining the increase in transition temperature and the decrease in upper-shelf energy resulting from neutron radiation. GL 92-01, Rev. 1, requested that licensees submit their RPV data to the NRC staff for review. GL 92-01, Rev. 1, Supplement 1, requested that licensees provide and assess data from other licensees that could affect their RPV integrity evaluations. These data are used by the NRC staff as the basis

for the review of P-T limit curves. SRP Section 5.3.2 provides an acceptable method of determining the P-T limit curves for ferritic materials in the beltline of the RPV, based on the linear elastic fracture mechanics methodology of Appendix G to Section XI of the ASME Code. RG 1.190 contains methodologies for determining the best-estimate neutron fluence experienced by materials in the beltline region of light-water reactor pressure vessels, as well as for determining the overall uncertainty associated with those best-estimate values.

Appendix G to 10 CFR Part 50 requires that P-T limit curves for the RPV be at least as conservative as those obtained by applying the methodology of Appendix G to Section XI of the ASME Code. The most recent version of Appendix G to Section XI of the ASME Code, which has been endorsed in 10 CFR Part 50.55a, and, therefore, by reference in Appendix G to 10 CFR Part 50, is the 2001 Edition through the 2003 Addenda of the ASME Code. This edition of Appendix G to Section XI incorporates the provisions of ASME Code Cases N–588 and N–640. In addition, Appendix G to 10 CFR Part 50 imposes minimum head flange temperatures when system pressure is at or above 20 percent of the preservice hydrostatic test pressure.

The basic parameter of the methodology specified in Appendix G to Section XI of the ASME Code is the stress intensity factor (K_I), which is a function of the stress state and flaw configuration. Appendix G requires a safety factor of 2.0 on stress intensity factors resulting from reactor pressure during normal and upset operating conditions, and a safety factor of 1.5 for hydrostatic testing curves. Appendix G to Section XI of the ASME Code also requires a safety factor of 1.0 on stress intensity factors resulting from thermal loads for normal and upset operating conditions, as well as for hydrostatic testing. The methods of Appendix G postulate the existence of a sharp elliptical surface flaw in the RPV that is normal to the direction of the maximum stress. This flaw is postulated to have a depth that is equal to one quarter of the RPV beltline thickness and a length equal to one and a half times the RPV beltline thickness. The critical locations in the RPV beltline region for calculating heatup and cooldown P-T limit curves are the 1/4 wall thickness (1/4T) and 3/4 wall thickness (3/4T) locations, which correspond to the maximum depth of the postulated inside surface and outside surface defects, respectively.

Appendix G to Section XI of the ASME Code methodology requires that licensees determine the adjusted reference temperature (ART or adjusted RT_{NDT}) at 1/4T and 3/4T locations. The ART is defined as the sum of the initial (unirradiated) reference temperature (initial RT_{NDT}), the mean value of the adjustment in reference temperature caused by irradiation (ΔRT_{NDT}), and a margin (M) term. The ΔRT_{NDT} is a product of a chemistry factor (CF) and a fluence factor. The CF is dependent upon the amount of copper and nickel in the material and may be determined from tables in RG 1.99, Rev. 2, or from surveillance data. The fluence factor is dependent upon the neutron fluence at the maximum postulated flaw depth. The margin term is dependent upon whether the initial RT_{NDT} is a plant-specific or a generic value and whether the CF was determined using the tables in RG 1.99, Rev. 2, or surveillance data. The margin term is used to account for uncertainties in the values of the initial RT_{NDT}, the copper and nickel content, the fluence, and the calculational procedures. RG 1.99, Rev. 2, describes the methodology to be used in calculating the margin term.

2.2 Technical Evaluation

2.2.1 Licensee Evaluation

Pursuant to 10 CFR 50.90, the licensee has submitted a request to the NRC staff for the approval of TS change regarding the revised P-T limit curves for BFN, Unit 1. The proposed P-T limit curves were developed in accordance with 10 CFR Part 50 Appendix G requirements, Section XI of the ASME Code, 1995 Edition, 1996 Addenda, and Section XI of the ASME Code Case N–588, and Code Case N–640, for establishing the P-T limit curves. Section XI of the ASME Code Case N–588 allows the usage of circumferentially oriented postulated defects in circumferential welds. Section XI of the ASME Code Case N–640 permits application of the lower bound plane strain fracture toughness equation (K_{IC} equation) as the basis for establishing the P-T limit curves in lieu of using the lower bound crack arrest fracture toughness equation (i.e., the K_{IA} equation, which is based on conditions needed to arrest a dynamically propagating crack). The licensee, in its submittal, stated that it will use the NRC staff approved Section XI of the ASME Code Cases N–588 and N–640, and Section XI of the ASME Code, 1995 Edition, 1996 Addenda, which was endorsed in 10 CFR 50.55a for the development of P-T limit curves.

The licensee stated that the heatup and cooldown P-T limit curves at a given EFPY apply for both 1/4T and 3/4T locations. Thermal gradient tensile stresses exist in the inner RPV wall during cooldown period and in outer RPV wall during heatup period. As a conservative simplification, the thermal gradient stress at the 1/4T location is assumed to be tensile for both heatup and cooldown, thereby resulting in the approach of applying the maximum tensile stress at the 1/4T location. The licensee stated that this approach is conservative because radiation effects cause the allowable toughness at 1/4T to be less than that at 3/4T for a given metal temperature.

The licensee stated that part of the analysis involved in developing P-T limit curves is to account for radiation embrittlement effects in the beltline region. The method used to account for radiation embrittlement is described in RG 1.99, Rev. 2. In addition to the beltline considerations, limits related to nonbeltline discontinuities such as nozzles, penetrations, and flanges influence the construction of P-T limit curves. The nonbeltline limits are based on generic analyses that are adjusted to the maximum RT_{NDT} for the applicable vessel components. Curves were included to allow monitoring of the vessel bottom head and upper vessel regions, separate from the beltline region, to help minimize heating requirements prior to pressure testing.

The licensee submitted ART calculations and P-T limit curves valid for up to 12 and 16 EFPY for BFN, Unit 1. For the RPV of BFN, Unit 1, the licensee determined that the most limiting material at the 1/4T and 3/4T locations is the lower intermediate shell plate axial welds. The ART value, the neutron fluence, and the ΔRT_{NDT} values at the 1/4T location of the limiting axial weld for BFN, Unit 1 are given below:

EFPY	Neutron Fluence (n/cm^2)–E > 1 MeV	ΔRT_{NDT} (^{0} F)	ART (^{0} F)
12	3.6×10^{17}	35	101
16	4.89×10^{17}	41	112

2.2.2 NRC Staff Evaluation

The licensee requested a two-step process. The first step will implement P-T limit curves at 12 EFPY in BFN, Unit 1, and upon their expiration the second step will implement 16 EFPY in BFN, Unit 1, to the end of its original license. This process requires NRC staff preapproval of the second set of P-T limit curves and the related TS changes. Furthermore, this process will eliminate resubmittal of TS changes related to the second step. The NRC staff finds this two-step process acceptable, provided at the time of implementation of the second step, the licensee will assure that the P-T limit curves and associated TS changes related to the second step remain valid.

The NRC staff has reviewed the fluence methodology that was implemented by the licensee for the BFN, Unit 1 and concludes that the methodology complies with the requirements of RG 1.190, and therefore is acceptable. Since the BFN, Unit 1 has been in shutdown mode for an extended period, the assumed operating time is much greater than the anticipated actual time of operation. The peak fluence values are calculated based on the extended power uprate conditions for the entire operating history, without taking credit for shutdown mode for the extended period. Therefore, the licensee's peak fluence calculations are very conservative. The NRC staff determined that the licensee's proposed peak vessel fluence of 7.06×10^{17} n/cm^2 (E > 1 MeV) at the end of the original license period (16 EFPY) is conservative and acceptable.

Appendix G to 10 CFR Part 50 requires the use of Appendix G to Section XI of the ASME Code, and defines the acceptable Editions and Addenda of the Code, which is endorsed in 10 CFR 50.55a. Part 50.55a of 10 CFR endorses Editions and Addenda of Section XI of the ASME Code up through the 2001 Edition and 2003 Addenda. The licensee, in its submittal, stated that it will use the Section XI of the ASME Code Cases N–588 and N–640 and Section XI of the ASME Code, 1995 Edition, 1996 Addenda. This is equivalent to using the NRC staff approved 2001 Edition through 2003 Addenda of the Section XI of the ASME Code, which incorporates the provisions of Section XI of the ASME Code Cases N–588 and N–640.

The NRC staff performed an independent calculation of the ART values for the limiting beltline material using the methodology in RG 1.99, Rev. 2. Based on these calculations, the NRC staff verified that the licensee's limiting material for the RPV is the lower intermediate shell plate axial welds. The NRC staff's calculated ART values for the limiting material agreed with the licensee's calculated ART values.

The NRC staff evaluated the licensee's P-T limit curves for the beltline region by performing independent calculations using the methodology referenced in the ASME Code (as indicated by SRP 5.3.2), and verified that the licensee's proposed P-T limit curves satisfy the requirements in Paragraph IV.A.2 of Appendix G of 10 CFR Part 50. The P-T limit curves apply to both heatup and cooldown and for both 1/4T and 3/4T locations. The licensee stated that the thermal gradient stress at the 1/4T location is assumed to be tensile for both heatup and cooldown, thereby resulting in the approach of applying the maximum tensile stress at the 1/4T location. The NRC staff has verified thermal stress intensity K_{It} values at 1/4T and 3/4T locations for the heatup period and concludes that the absolute K_{It} values at 1/4T location are always larger than K_{It} values at 3/4T location during the heatup period. Therefore, the licensee's methodology of using K_{It} values at 1/4T locations for both heatup and cooldown P-T

limit curves is acceptable. In addition, the NRC staff independently generated P-T limit curves for normal operations and hydrostatic test pressures to the specified EFPYs. By comparing the independently generated P-T limit curves with the licensee's curves, the NRC staff determined that the licensee's proposed P-T limit curves meet the requirements of Appendix G to Section XI of the ASME Code, 1995 Edition, 1996 Addenda, and Section XI of the ASME Code Cases N–588 and N–640. Therefore, the NRC staff determined that the licensee's proposed beltline P-T limit curves were acceptable.

In addition to beltline materials, Appendix G of 10 CFR Part 50 also imposes a minimum temperature at the closure head flange based on the reference temperature for the flange material. Section IV.A.2 of Appendix G states that when the pressure exceeds 20 percent of the preservice system hydrostatic test pressure, the temperature of the closure flange regions (highly stressed by the bolt preload) must exceed the reference temperature of the material in those regions by at least 120 EF for normal operation and by 90 EF for hydrostatic pressure tests and leak tests. The NRC staff has determined that the proposed P-T limits have satisfied the requirement for the closure flange region during normal operation and inservice leak and hydrostatic testing.

The NRC staff has reviewed the licensee's method of establishing the bolt-up temperature using the limiting initial RT_{NDT} for the closure flange region + 60 EF or the lowest service temperature (LST) of the bolting materials, whichever is greater. The limiting initial RT_{NDT} for the closure flange region is 23.1 EF, which is represented by the electroslag weld materials in the lower intermediate shell plate axial welds. The LST of the closure studs is 70 EF. Therefore, the bolt-up temperature of 83EF (60 + 23) is acceptable.

The P-T limit curves for the nonbeltline region (upper vessel and bottom head) were conservatively developed for a BWR [boiling-water reactor]/6 with nominal inside diameter of 251 inches. The analysis is considered appropriate for TVA since the plant specific geometric values are bounded by the generic analysis for large BWR/6. The generic value was adapted to the conditions at BFN using plant-specific RT_{NDT} values for the RPV.

The bottom head thermal transient and pressure stresses were developed using the limiting normal and upset conditions and generic BWR/6 dimensions. The NRC staff finds this methodology of establishing P-T limit curves for the bottom head conservative and acceptable. Under certain conditions, the minimum bottom head temperature can be significantly cooler than the beltline or closure flange region. To account for these circumstances, individual temperature limits for the bottom head were established. The NRC staff reviewed the P-T limit curves for the bottom head, and concluded that the licensee's evaluation for the bottom head curves is acceptable because the licensee developed the P-T limit curves for the bottom head by using BWR/6 vessel stress values, which are higher than those in the BFN, Unit 1, vessel.

Upper vessel curves were developed to allow monitoring of the upper vessel independent of the beltline and bottom head. The upper vessel region P-T limits were based on analysis of the feedwater nozzle and beltline regions. The K_I for the feedwater nozzle during pressure test conditions was computed using the methods from Welding Research Council (WRC) Bulletin 175 with the geometry from a feedwater nozzle. Appendix G to Section XI of the ASME Code indicates that the methods from WRC Bulletin 175 provide acceptable methods for analyzing the inside corner of a nozzle and cylindrical shell for elastic stresses due to internal pressure. This method of analysis proposed by the licensee for the upper vessel and feedwater nozzle will satisfy Appendix G to 10 CFR Part 50.

In summary, the NRC staff found the application of the generic BWR/6 analysis to the nonbeltline region P-T limit curves at the TVA facility acceptable.

2.3 Summary

The NRC staff concludes that the proposed P-T limits curves for each of the pressure tests, core not critical and core critical conditions; the separate P-T limit curves for the upper vessel, beltline, and bottom head satisfy the requirements in Appendix G of 10 CFR Part 50. Based on the information provided in the licensee's submittal, the proposed P-T limit curves may be incorporated into the TVA Technical Specifications.

3.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Alabama State official was notified of the proposed issuance of the amendment. The State official had no comments.

4.0 ENVIRONMENTAL CONSIDERATION

The amendment changes a requirement with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20 and changes surveillance requirements. The NRC staff has determined that the amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendment involves no significant hazards consideration, and there has been no public comment on such finding (70 FR 2899). Accordingly, the amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b) no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendment.

5.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

Principal Contributor: G. Cheruvenki
L. Lois

Date: July 26, 2006

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cc:

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