September 15, 1997

Mr. Oliver D. Kingsley, Jr.
President, TVA Nuclear and
Chief Nuclear Officer
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, Tennessee 37402-2801

SUBJECT: ISSUANCE OF AMENDMENT ON TRITIUM PRODUCING BURNABLE ABSORBER ROD LEAD TEST ASSEMBLIES (TAC NO. M98615)

Dear Mr. Kingsley:

The Commission has issued the enclosed Amendment No. 8 to Facility Operating License No. NPF-90 for Watts Bar Nuclear Plant, Unit 1. This amendment is in response to your application dated April 30, 1997, as supplemented June 18, July 21 (3 letters), August 7 and 21, 1997. The proposed amendment would change the design features section of the Technical Specifications (TS) to provide for insertion of Lead Test Assemblies containing Tritium Producing Burnable Absorber Rods in the Watts Bar Nuclear Plant reactor core during Cycle 2. Specifically, the statement "For Unit 1, Cycle 2, Watts Bar is authorized to place a limited number of Tritium Producing Burnable Absorber Rod lead test assemblies into the reactor in accordance with Tennessee Valley Authority's application dated April 30, 1997, as supplemented June 18, July 21 (3 letters), August 7 and 21, 1997", would be added to TS 4.2.1, "Fuel Assemblies."

A copy of the safety evaluation is also enclosed. Notice of issuance will be included in the Commission's biweekly Federal Register notice.

Sincerely,

Original signed by:
Robert E. Martin, Senior Project Manager
Project Directorate II-3
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Docket No. 50-390

Enclosures: 1. Amendment No. 8 to NPF-90
2. Safety Evaluation

cc w/enclosures: See next page

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

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Docket No. 50-390

Enclosures: 1. Amendment No. 8 to NPF-90
2. Safety Evaluation

cc w/enclosures: See next page

Mr. Oliver D. Kingsley, Jr.
Tennessee Valley Authority

WATTS BAR NUCLEAR PLANT

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

TENNESSEE VALLEY AUTHORITY

DOCKET NO. 50-390

WATTS BAR NUCLEAR PLANT, UNIT 1

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 8
License No. NPF-90

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

   A. The application for amendment by Tennessee Valley Authority (the licensee) dated April 30 as supplemented June 18, July 21 (3 letters), and August 7 and 21, 1997, 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 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. NPF-90 is hereby amended to read as follows:

(2) Technical Specifications and Environmental Protection Plan

The Technical Specifications contained in Appendix A, as revised through Amendment No. 8 , and the Environmental Protection Plan contained in Appendix B, both of which are attached hereto, are hereby incorporated into this license. TVA shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan.

3. This license amendment is effective as of the date of its issuance, to be implemented no later than 30 days of its issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

Frederick J. Hebdon

Frederick J. Hebdon, Director
Project Directorate II-3
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Attachment:
Changes to the Technical Specifications

Date of Issuance: September 15, 1997

ATTACHMENT TO AMENDMENT NO. 8

FACILITY OPERATING LICENSE NO. NPF-90

DOCKET NO. 50-390

Revise the Appendix A Technical Specifications by removing the page identified below and inserting the enclosed page. The revised page is identified by the captioned amendment number and contains a marginal line indicating the area of change.

Remove Page	Insert Page
4.0-1	4.0-1

4.0 DESIGN FEATURES

4.1 Site

4.1.1 Site and Exclusion Area Boundaries

The site and exclusion area boundaries shall be as shown in Figure 4.1-1.

4.1.2 Low Population Zone (LPZ)

The LPZ shall be as shown in Figure 4.1-2 (within the 3-mile circle).

4.2 Reactor Core

4.2.1 Fuel Assemblies

The reactor shall contain 193 fuel assemblies. Each assembly shall consist of a matrix of Zircalloy or Zirlo fuel rods with an initial composition of natural or slightly enriched uranium dioxide (UO_2) as fuel material. Limited substitutions of zirconium alloy or stainless steel filler rods for fuel rods, in accordance with approved applications of fuel rod configurations, may be used. Fuel assemblies shall be limited to those fuel designs that have been analyzed with applicable NRC staff approved codes and methods and shown by tests or analyses to comply with all fuel safety design bases. A limited number of lead test assemblies that have not completed representative testing may be placed in nonlimiting core regions. For Unit 1, Cycle 2, Watts Bar is authorized to place a limited number of Tritium Producing Burnable Absorber Rod lead test assemblies into the reactor in accordance with TVA's application dated April 30, as supplemented June 18, July 21 (3 letters), and August 7 and 21, 1997.

4.2.2 Control Rod Assemblies

The reactor core shall contain 57 control rod assemblies. The control material shall be boron carbide with silver indium cadmium tips as approved by the NRC.

(continued)

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 8 TO FACILITY OPERATING LICENSE NO. NPF-90

TENNESSEE VALLEY AUTHORITY

WATTS BAR NUCLEAR PLANT, UNIT 1

DOCKET NO. 50-390

1.0 INTRODUCTION

By letter dated April 30, 1997, (Reference 1), as supplemented June 18, July 21, 1997 (3 letters), August 7 and 21, 1997, (References 2, 3, 4, 5, 6, and 7), the Tennessee Valley Authority (the licensee or TVA) submitted a request for changes to the Watts Bar Nuclear Plant, Unit 1 (WBN), Technical Specifications (TS). The requested amendment would change the design features section of the TS to provide for insertion of Lead Test Assemblies (LTAs) containing Tritium Producing Burnable Absorber Rods (TPBARs) in the WBN reactor core during Cycle 2. Specifically, the statement "For Unit 1, Cycle 2, Watts Bar is authorized to place a limited number of Tritium Producing Burnable Absorber Rod lead test assemblies into the reactor in accordance with TVA's application dated April 30, 1997 as supplemented June 18, July 21 (3 letters), August 7 and 21, 1997." would be added to Technical Specification 4.2.1, "Fuel Assemblies." TVA states that the purpose of the proposed amendment is to provide irradiation services to support U.S. Department of Energy (DOE) investigations into the feasibility of using commercial light water reactors to maintain the DOE inventory of tritium. The June 18, the three July 21 letters, and the August 7 and 21, 1997 letters provided clarifying information that did not change the initial proposed no significant hazards consideration determination.

TVA's application of April 30, 1997 incorporated the DOE technical report PNNL-11419, "Report on the Evaluation of the Tritium Producing Burnable Absorber Rod Lead Test Assembly," Revision 1, dated March 12, 1997 (Reference 8). The PNNL report is also referred to as the "DOE report" in this Safety Evaluation (SE). The report was prepared for DOE by the Pacific Northwest National Laboratory (PNNL). The report was first submitted to the Nuclear Regulatory Commission (NRC) for review pursuant to a Memorandum of Understanding between NRC and DOE. The results of the review of PNNL-11419 through Revision 1 are reported in the NRC staff report NUREG-1607, "Safety Evaluation Report related to the Department of Energy's proposal for the irradiation of lead test assemblies containing tritium-producing burnable absorber rods in commercial light-water reactors," May 1997, (Reference 9). The staff identified a number of areas in NUREG-1607 where additional information would be required. These areas were identified in response to

ENCLOSURE

TVA's application of April 30, 1997, in an NRC staff request for additional information (RAI) dated May 29, 1997. Following a meeting with the NRC staff on June 4, 1997, TVA responded to the May 29, 1997 RAI in a letter dated June 18, 1997. Following a further meeting with the NRC staff on July 3, 1997, TVA provided additional responses in three letters dated July 21, 1997 and in letters dated August 7 and 21, 1997. The NRC staff's evaluation reported in this Safety Evaluation therefore adopts and incorporates by reference the conclusions reported in NUREG-1607 and augments them with the conclusions of its review of TVA's application including the outstanding issues which had been identified in NUREG-1607.

2.0 EVALUATION

2.1 Reactor Systems

The NRC staff's reactor systems review included the TVA submittals, the DOE report, the Watts Bar Final Safety Analysis Report (FSAR), and the Watts Bar TS. The review focused on the open items identified in NUREG-1607.

This portion of the SE follows the format of the DOE report. The staff notes that Revision 1 of the DOE report was issued prior to the completion of the reload and thermal-hydraulic analyses for Cycle 2 of WBN. In this regard, the DOE report provided scoping studies of the nuclear and thermal-hydraulic design of a core with TPBARs installed. Those scoping studies were evaluated by the staff in NUREG-1607. This SE will evaluate the final reload safety evaluation (RSE) and the thermal-hydraulic analyses for Cycle 2 of WBN.

2.1.1 Tritium-Producing Burnable Absorber Rod Lead Test Assembly (LTA)

Section 2.1 of the DOE report, LTA Design Description, provides a description of the design features, materials, and operation of the TPBAR. The TPBAR LTA is designed to meet the operating requirements of a large four-loop Westinghouse reactor under Conditions I, II, III, and IV events, as defined in the Watts Bar Final Safety Analysis Report.[1]

The LTA consists of a Westinghouse hold-down assembly with eight TPBARs and sixteen thimble plugs as shown in Figure 2-1 of the DOE report. The TPBAR will be inserted into a fresh 17x17 Westinghouse standard fuel assembly which does not contain a control rod assembly. The external dimensions of the TPBAR are similar to those of the standard Westinghouse burnable poison rod assembly (BPRA) and the wet annular burnable absorbers (WABAs). The design characteristics of the TPBAR, the conventional BPRA, and the WABAs are compared in Tables 2-1 and 4-1 of the DOE report. Since the TPBARs are installed in the standard Westinghouse guide thimble, the diameter of TPBAR is similar to that of the BPRA and the WABA. With an overall length of 152.35 in. (387 cm) and the absorber's poison length of 142 in. (360.7 cm), the TPBAR

[1]Condition I - Normal Operation and Operational Transients
Condition II - Faults of Moderate Frequency
Condition III - Infrequent Faults
Condition IV - Limiting Faults

is physically more similar to the BPRA (rod length = 152.59 in. [387.6 cm], poison = 142 in. [360.7 cm]) than the WABA (rod length = 149.83 in. [380.6 cm], poison = 134 in. [340 cm]).

Based on the comparison of dimensions between the TPBAR, the conventional BPRA, and the WABA, and the use of standard Westinghouse design components for the LTA hold down assemblies, the staff concludes that TPBARs are similar in form to BPRAs and WABAs. The staff's evaluation as to whether the TPBAR is similar in function to the BPRA and the WABA is in Sections 2.2 and 2.3 of this safety evaluation, which relate to the nuclear design of the Watts Bar core and the thermal-hydraulic design of the TPBARs.

In Section 2.3, Surveillance Program, the DOE report states that a special LTA surveillance program is not planned since the LTAs will only be irradiated for one cycle. By letter dated June 18, 1997, TVA stated that the assembly average power of the TPBAR host assemblies will be monitored at the same frequency that the $F^N_{\Delta H}$ is monitored as required by WBN TS 3.2.2, Nuclear Enthalpy Rise Hot Channel Factor ($F^N_{\Delta H}$). Surveillance Requirement 3.2.2.1 requires that $F^N_{\Delta H}$ be monitored and verified to be within the limits specified in the Core Operating Limits Report (COLR) at a frequency of once after initial fuel loading and each refueling prior to thermal power exceeding 75 percent rated thermal power (RTP) and every 31 effective full power days (EFPD) thereafter. If the measured assembly average relative power value is exceeded, the reactor power would be reduced by 1.5 percent RTP from 100 percent RTP for each 1 percent that the host assembly power exceeds 1.40, which is the full power limit. Therefore, assembly average power will be reduced as power is reduced. In addition, the staff notes that TS 3.2.1, Heat Flux Hot Channel Factor ($F_Q(Z)$), TS 3.2.3, Axial Flux Difference, and TS 3.2.4, Quadrant Power Tilt Ratio, have requirements to monitor the power distribution limits at specified frequencies. On the basis of the TS requirements, the staff concludes that the Watts Bar surveillance program should be adequate to identify anomalies for one cycle of operation with TPBAR LTAs installed in the core.

Section 2.4.3 of the DOE report, Monitoring Program, states that no special testing or monitoring program is necessary. Standard start up tests, flux mapping, core activity monitoring, and power monitoring will be performed in conjunction with Watts Bar's procedures. As stated above, the staff concludes that conformance to TS 3.2, Power Distribution Limits, should be adequate to identify anomalies during Cycle 2.

2.1.2 Nuclear Design Description

Section 3 of the DOE report discusses the effects of the TPBAR LTAs in terms of nuclear design, power distribution, reactivity control, and the RSE. By letter dated June 18, 1997, TVA informed the staff that the Watts Bar Cycle 2 core will employ WABAs as a discrete burnable absorber instead of BPRAs. Since the TPBARs will replace some of the burnable poison rods in the reload core, the staff reviewed the Watts Bar Unit 1 RSE for Cycle 2. This section investigates whether the TPBARs have similar nuclear properties to WABAs, and whether the lithium based absorbers have any sensitivities to gaps or fabrication tolerances that need to be considered in the reload analysis. Section 2.2 also evaluates the Watts Bar Cycle 2 RSE.

Section 3.1 of the DOE report, Effects on Reactor Nuclear Design, states that the TPBAR LTAs will have minimal impact on the commercial core. Revision 1 of the DOE report proposed that mimicking, to the extent feasible, the behavior of BPRAs ensures that the TPBARs will have minimal impact on the overall core design. DOE also demonstrated such mimicking of behavior for WABAs. This would be accomplished by using a limited number of TPBARs in any one fuel assembly, using a limited number of LTAs in the core, and by placing LTAs in core regions which are not limiting with respect to core thermal-hydraulic performance. A comparison of the infinite medium multiplication factor (k_∞) for TPBARs and WABAs as a function of burn up is shown in Figure 3-1 of the DOE report. In this case, the close comparison between the these two designs is a general indication that other core design parameters are also similar. This analysis illustrates that differences are small enough to be accommodated within the range of core-to-core variations that are customarily handled in fuel cycle design. However, the scoping analysis, as discussed in NUREG-1607, did not provide a basis for assuring that all core design limits are satisfied. Accordingly, further information was requested by the staff, as discussed in the following paragraph.

By letter dated May 29, 1997 (Reference 10), the staff requested additional information regarding the reactivity characteristics of the TPBAR in comparison to BPRAs. As stated above, WBN Cycle 2 will employ WABAs as a discrete burnable absorber. Based on this information, a reactivity characteristic comparison to BPRAs was not necessary. However, the staff did review a comparison of preliminary core designs for two burn-up windows that bracket the estimated burn-up for a core with TPBARs and WABAs versus a core design utilizing only WABAs (Reference 3). The model with TPBARs had four assemblies which contained 104 integral fuel burnable absorber (IFBA) fuel rods and eight TPBAR rods, while the model with WABA rods had four assemblies which contained 104 IFBA rods and four WABA rods. The comparison illustrated that the model with TPBARs had a slightly lower $F^N_{\Delta H}$ per assembly than the model with only WABAs. In addition, Figure 1 in Reference 2 illustrates that the WABA reactivity worth is slightly greater at the beginning of the core life and slightly less at the end of cycle. This is based on ^{10}B having a larger absorption cross section relative to ^{6}Li and a smaller number density of ^{10}B in a WABA relative to the number density of ^{6}Li in a TPBAR. Figure 1 of Reference 2 also shows the physical differences in the burn up characteristics of the lithium versus the boron absorbers and demonstrates that the design of the TPBAR is within the range of reactivity behavior that occurs over a normal cycle. Based on the two preliminary cases presented, the staff concludes that the TPBARs should have a negligible effect on global parameters such as moderator temperature coefficient. The core power distribution is relatively unaffected by the presence of the TPBARs. This point is justified by the analysis of two cores that are identical except for the presence of four WABA assemblies in place of four TPBAR LTAs. The flux maps show negligible change in flux shape.

In Section 3.2 of the DOE report, Effects on Power Distribution, the sensitivity of flux peaking on pellet gaps and fabrication tolerances is evaluated. Revision 1 of the DOE report states that the impact of TPBARs on overall power distribution will be similar to that of BPRAs and WABAs currently used in pressurized water reactors (PWRs). TPBAR absorber pellets are contained in pencils which are stacked in a column in the TPBAR. The interfaces between the pencils result in gaps between segments of absorber pellet material. Each gap produces a small local axial power peak in the adjacent fuel rods. Gaps are affected by manufacturing tolerances, temperature, and irradiation. The peak pellet gap is calculated with DORT, a discrete ordinate transport code; the maximum gap was calculated to be less than 400 mils. This method should accurately represent the effect of an absence of absorber on the surrounding fuel pins. The effect of a 400-mil gap in the absorber pellet stack results in a relatively small local power peak of 4.5 percent in the surrounding fuel pins.

The original DOE report discussed a 300-mil gap with a small local power peak of 4.5 percent. Based on this information, the staff requested TVA to provide an analysis of the effect of a 400-mil gap in the absorber pellet stack to demonstrate that a local power peak of 4.5 percent in the surrounding fuel pins will be the maximum achieved. In response to this question, TVA stated that a number of factors affecting peaking were included in the calculation besides the change in gap dimension at the time that Revision 1 of the DOE report was prepared. While increasing the gap would tend to increase the peak, other changes such as the reduction in ^{6}Li enrichment would decrease the peak. The net result of all changes was that the same peaking factor of 4.5 percent was reported for the 400-mil gap in Revision 1 as for the 300-mil gap reported in the original DOE report. Based on this information, the staff concludes that this response adequately addresses the concern.

An analysis of fabrication tolerances using the WIMS-E model assessed the effect of variations in TPBAR dimensional tolerances, ^{6}Li loading tolerances, and impurity specifications. Power peaking due the TPBAR fabrication tolerances was less than 1 percent. This peaking is small compared to other flux perturbation effects. Since it is a WBN TS requirement that the LTA assemblies will not be placed in peak locations, the staff believes that peaking effects of less than 1 percent caused by fabrication tolerances are not likely to exceed fuel design limits.

Section 3.3 of the DOE report, Effects on Control Requirements, discusses the overall reactivity contribution of ^{6}Li in the LTA and its similarity to that of regular burnable absorber rod assemblies. The staff noted that the most significant difference in the behavior of the TPBAR is the decay of tritium to a strong absorber, ^{3}He. As discussed in the January 22, 1997 public meeting, the effect of tritium decay during a long shutdown near the end of a cycle might result in more negative reactivity in the TPBARs than a comparable WABA or BPRA.

By letter dated May 29, 1997, the staff requested that the reload analysis include an assessment of the maximum negative worth of the TPBAR LTAs near the end of cycle following a long shutdown rather than the usual beginning-of-life case. TVA performed an additional analysis to assess the effect of ^{3}H decay into ^{3}He for a case near end of cycle. To perform the analysis, it was necessary for the licensee to select a hypothetical shutdown time and duration of shutdown. The shutdown is assumed to occur at 80 percent burn up and to last for 90 days. These are reasonable values for assessing the effect of ^3H decay. The result is a slight reduction in the power in the TPBAR host assembly from 1.198 to 1.191, and a slight increase in the hot channel assembly peak of a non-TPBAR host assembly from 1.390 to 1.391. On the basis of this analysis, the staff concludes that ^3H decay has a negligible impact on core power distribution.

Section 3.4 of the DOE report, Changes in Reload Safety Analysis, discusses the change in the standard suite of NRC-approved Westinghouse core analysis codes (PHOENIX/ANC) to account for the presence of the TPBAR in the core. The staff approved the Westinghouse Topical Report WCAP-11596, "Qualification of the PHOENIX-P/ANC Nuclear Design System for Pressurized Water Reactor Cores," for use by letter dated May 17, 1988 (Reference 11).

Westinghouse and TVA have proposed changes to the NRC-approved ANC and PHOENIX-P codes which would model the depletion of ^6Li in the TPBARs, the decay of ^3H, and the production/depletion of ^3He. The new version of the NRC-approved PHOENIX-P code, called PHOENIX-L, was documented in a report by letter dated March 12, 1997 (Reference 12). An additional letter from Westinghouse is included as an enclosure in Reference 3 and further clarifies the calculation method. Westinghouse's PHOENIX-L code is used to calculate the nodal cross sections. The core power distributions are then calculated using a special version of the advanced nodal code (ANC-L). Both codes have minor modifications from the approved versions, PHOENIX-P and ANC.

The verification testing of PHOENIX-L and ANC-L consisted of a set of generic test problems and a set of version-specific test problems. The generic test problems are standard cases that have been run under the previous versions. Comparing the results from the current and previous versions shows that the code changes, as intended, have had no impact on previous results. Therefore, the method of solution and data for the other isotopes in the materials library were not inadvertently changed. The version-specific tests exercise the new material features and balance equations. The code changes discussed above only add the data necessary to represent the TPBAR materials. The method of solution is already validated. Consequently, the staff concurs that for these minimal changes, the verification has been adequate.

On August 21, 1997 (Reference 7), TVA submitted the RSE for Cycle 2 for staff review. Cycle 2 will employ eighty fuel assemblies which will contain fresh IFBA coated UO_2 fuel pellets. The IFBA fuel pellets are identical to other fresh fuel pellets except for the addition of a thin boride coating on the cylindrical surface of the pellet along the central portion of the fuel stack length. The fuel rod design evaluations for Cycle 2 were performed using NRC-approved models and methodologies, WCAP-12610-P-A, WCAP-10851-P-A, WCAP-10125-P-A, and WCAP-14297-A (References 13, 14, 15, and 16). The nuclear kinetics parameters for Cycle 2 are within the range of those in Cycle 1. The shutdown margin available meets the minimum required.

The RSE demonstrates that the TPBAR LTAs do not have any adverse effect on the thermal-hydraulic design of the Cycle 2 core. The staff notes that some available departure from nucleate boiling ratio (DNBR) margin has been allocated to address DNBR penalties due to rod bow and potential RCS flow anomaly. However, additional DNBR margin has been assessed for Cycle 2 in the "Steamline Break Coincident with RCCA Withdrawal at Power" analysis. TVA evaluated the core kinetics characteristics, control rod worths, and core peaking factors with respect to accident analysis input parameters. The Cycle 2 reload parameters were found to be acceptable with respect to the applicable safety analyses. Based on this information, the staff concludes that the nuclear and thermal-hydraulic design of Cycle 2 with TPBAR LTA inserted into the reload core is acceptable. The staff also concludes that the results of the transient and accident analyses are acceptable.

2.1.3 TPBAR Thermal and Hydraulic Design

Section 4 of the DOE report addresses the impact of the TPBAR LTA on the WBN reactor core thermal-hydraulic design. The DOE report stated that the thermal-hydraulic analysis of the TPBAR design was performed by hand calculations and MATHCAD software. This analysis was available for staff audit at Pacific Northwest National Laboratory (PNNL). The staff performed an audit of the TPBAR thermal-hydraulic analysis (Reference 17) on July 8 and 9, 1997. The following discussion provides the details of the audit at PNNL.

The TPBAR channel analysis evaluates the coolant temperatures in the subchannel formed by the TPBAR and its surrounding eight fuel pins. Heat is generated in the fuel pins by fission, in the TPBARS primarily through the $^{6}Li(n,\alpha)^{3}H$ transmutation reaction, in the structural materials (guide tubes and end plugs) by gamma heating, and in the coolant by gamma heating and neutron thermalization. The TPBAR is cooled by the reactor coolant flow in the annulus between the fuel assembly's control rod guide tube and the TPBAR. Adequate cooling is required to ensure that the materials do not exceed their temperature limits which could result in structural failure of the TPBAR and relocation of the components. Boiling in the annulus could result in thermal-hydraulic instability and considerable increase in TPBAR temperature. Consequently, the thermal design criteria ensure that boiling does not occur in the guide tube annulus. This condition is assured by two criteria: that temperature of the bulk coolant in the guide tube annulus must be less than the coolant saturation temperature and that the clad temperature of the TPBAR must be less than the temperature for the onset of subcooled nucleate boiling.

The calculation is primarily a thermal calculation since the hydraulic parameters in the guide tube annulus channel were provided by Westinghouse. The TPBAR and fuel rod powers are given as surface heat fluxes. The calculation determines the bulk fluid temperature from an energy balance and the TPBAR surface temperature from the solution of a set of simultaneous equations for a one-dimensional, radial heat transfer from the TPBAR and other structural metal into the coolant in the guide tube annulus. The film temperature coefficient is calculated using the Dittus-Boelter heat transfer correlation. The clad superheat correlation for the onset of nucleate boiling is evaluated using the Thom correlation.

The channel is divided into 45 axial nodes. The purpose of the axial noding is to provide a means for assessing the effect of non-uniform surface heat flux on the onset of nucleate boiling criterion. The number of nodes should provide more than adequate spatial discretization for assessing the temperature distribution effects.

One calculation that may be particularly important for consideration in the design analysis is the heat transfer in the dash pot region of the TPBAR guide tube. The guide tube coolant enters primarily through slots in the sides of the guide tube near the top of the dash pot region. The total flow above these slots is given by Westinghouse. However, a small fraction of the total flow enters through a hole in the bottom of the guide tube. The flow through this hole, called the screw hole, was not provided by Westinghouse. An estimate of this flow is the only hydraulic calculation in this analysis. The flow cools the lower end plug and dashpot regions. Conservative estimates of both power, flow, and heat transfer formulation are made in this region. Although the maximum temperatures occur at the outlet of the core, the analysis shows a significant local peak in the lower end plug/dashpot region.

The staff questioned whether a flow blockage in the screw hole, which might reduce the flow in the dashpot region to the point that the boiling limits are exceeded, was considered. The staff notes that flow blockage was considered in the thermal and hydraulic design of the WABA rods. As discussed in the staff's safety evaluation report (SER) on the "Westinghouse Wet Annular Burnable Absorber Evaluation Report," dated August 9, 1983 (Reference 18), Westinghouse has imposed the following requirements to achieve the WABA thermal and hydraulic design.

(1) The maximum absorber temperature shall not exceed 1200°F during normal operation (Condition I) or an upset Condition II malfunction occurrence.

(2) Stagnant coolant or dry-out shall not occur for the WABA in the hottest channel with a plugged thimble screw hole.

(3) The core bypass flow through the guide thimble tubes shall be limited to assure that sufficient coolant flow is provided to the fuel rod channels to meet fuel and thermal hydraulic design criteria.

Since a flow blockage could be postulated to occur, the staff requested Oak Ridge National Laboratory (ORNL) to perform an independent calculation to confirm the PNNL calculations in general, and to assess the impact of a flow blockage in the dashpot region. The analysis, given in Appendix A, assumed a 90 percent flow blockage in the dashpot region. For this case, the temperature increases about 10°F over the normal case. The cooling by conduction through the guide tube wall to the reactor coolant at the inlet of the core provides an adequate cooling mechanism. Based on these results, the staff concludes that flow blockage of the screw hole does not have significant effects on the cooling of the dashpot region. The staff also concludes that the TPBAR thermal-hydraulic design criteria are very similar to the design criteria of the WABAs.

The staff notes that the core design for Watts Bar Cycle 2 depends on the Cycle 1 burn up. Operating considerations could affect the exact final burn up in Cycle 1 and hence the Cycle 2 core design calculations. The thermal analysis does not depend directly on the core design. The thermal design calculation is a limiting calculation that determines the maximum power that the TPBAR host assembly can safely remove. The thermal performance analysis with significant conservatism in the parameter estimate and formulation of equations indicates that the TPBAR is adequately cooled for any power up to an assembly peak of 1.46 which represents significant margin over the core design limit of 1.40.

The inputs into thermal design performance are conservatively adjusted for the variability or uncertainty to ensure that the calculated thermal performance is conservative with respect to the true performance. The tolerances for parameter variation are either added to or subtracted from the nominal value of the parameter so that the calculation uses a conservative value. The calculation does not use a statistical combination of the tolerances. Uncertainties for the operating conditions use the same error tolerances for Conditions I and II that Westinghouse has used. The manufacturing tolerances for the TPBARs are used for the dimensional variability. The uncertainties in heat transfer correlations and the heat transfer formulation are assumed to be 10 percent for each.

In addition to using conservative estimates in the parameters, the calculation method has approximations to the heat transfer formula that give a conservative result. For example, all the heat generated in the TPBAR, guide thimble, and direct heating of coolant is considered to be generated in the TPBAR. Thus, the heat flux at the surface of the TPBAR includes all the heat generation terms. This approximation gives a higher estimate for the bulk fluid temperature because some fraction of the heat generated in the guide tube would be conducted to the coolant outside the guide tube. It also gives a higher TPBAR surface temperature since more heat is assumed to pass through the surface than actually does. The purpose of the approximation is to avoid the difficult calculation of the heat transfer in the guide tube.

Another example of a conservative approximation in the method is using the outlet pressure to evaluate the water properties throughout the channel. Since the outlet pressure is the lowest pressure that is possible for the channel and the saturation temperature decreases as pressure goes down, using the outlet pressure is a conservative approximation. The advantage of the approximation is that it avoids calculating the actual pressure drop in the annulus.

The calculation method assumes that the peak TPBAR power occurs at the same time as the peak fuel assembly power. Since the TPBAR absorber is depleted over the fuel cycle, the TPBAR power peak is at the beginning of the fuel cycle while its host fuel assembly power peak occurs at the end of the cycle. Assuming the highest TPBAR reaction rate coincident with the limiting host fuel assembly peak is thus conservative.

Water property evaluations are used to determine various properties of the coolant as functions of the pressure and enthalpy. The water property routines include saturation temperature, subcooled temperature, specific volume, thermal conductivity and viscosity as a functions of enthalpy and pressure. The properties are evaluated using high order polynomials taken from the VIPRE code (Reference 19). The VIPRE polynomials are not certified for use by the NRC so the calculation file includes a verification of the accuracy of the routines for the conditions under which they are used in this evaluation. The verification consists of evaluating the functions at three points in the range of temperature and pressure conditions at which the TPBARS operate and comparing the result to the ASME steam tables. For deviations that are significant with respect to the ASME, the largest observed difference is applied in the conservative direction. The staff notes that the applied difference is not necessarily in the direction of the observed deviation. Therefore, when the property is used in the calculation file, the uncertainties bias the result in the conservative direction. Where the errors are small (0.2 - 0.3 percent), no correction is applied.

The output of the calculation is the maximum power that can be generated in the assembly without exceeding either the bulk boiling or clad superheat criterion in the guide tube coolant. This calculation is performed for Condition I and Condition II events. The plant conditions used in the analysis are the standard for safety analysis cases. The design criterion is that the maximum allowable assembly power, the lower of Condition I and Condition II cases, must be greater than the total assembly power peaking limit for Watts Bar Nuclear Plant of 1.40 (Reference 6). That is, the TPBAR heat removal capability may not be the limiting thermal design consideration. Since the allowable TPBAR maximum heat removal capacity is greater than the total assembly power peaking limit of 1.40, the thermal performance limits are met. The staff notes that there is some additional conservatism in the comparison because the core design limit applies to the highest fuel assembly in the core and the TPBAR host assembly is always well below the peak assembly because the negative worth of the TPBAR suppresses the power in that assembly. Therefore, the capability to remove the heat generated by the TPBAR and its structural materials without boiling has been very conservatively demonstrated by this calculation. Based on these results, the staff can conclude that the thermal limits will not be exceeded in the WBN Cycle 2 core design.

By letter dated May 29, 1997, the staff requested that TVA provide additional documentation to show that the MATHCAD model is conservative. As discussed above, the staff has established that conservative inputs and assumptions were used in the thermal-hydraulic evaluation of the TPBAR. These inputs and assumptions were used in equations which were evaluated by the MATHCAD software. MATHCAD is a numerical evaluation program and equation editing program combined. The program's equation editing features present the formulas which are being evaluated in a readable, typeset format. The computation program evaluates the formulas according to the usual rules of mathematics. MATHCAD file is self-documenting because it requires no special knowledge of MATHCAD or any programming language to follow the calculation. MATHCAD is useful for calculations that might previously have been done by hand and has some significant advantages over a hand calculation. It is easier to check than a hand calculation because documentation and evaluation are in fact the same and are not subject to a transcription error. Also, it is easier to revise since the user can edit an input or formula then let MATHCAD re-evaluate the results. The program has security features that permit the calculation to be locked preventing unauthorized or unintentional alteration. And, since the printed output is typeset, the text is more legible than a hand documented calculation. MATHCAD also has some capability for normal text editing so that explanations can accompany the formulas. The TPBAR thermal-hydraulic calculation is an appropriate type of analysis to perform with MATHCAD. As stated above, the MATHCAD model contains several conservative estimates and approximations, and therefore, the staff concludes that the MATHCAD model is conservative.

2.1.4 Operational Impacts of LTAs

Section 6 of the DOE report addresses the operational impacts of TPBAR LTAs with respect to normal operations, refueling operations, off-normal events and accidents. As noted above in section 1.0, the staff adopts and incorporates by reference its evaluation in NUREG-1607. This section of the SE evaluates the operational events from NUREG-1607 which required further review by the staff.

Section 6.2 of the DOE report states that 150 hours after reactor shutdown, the heat load of each LTA is less than 0.024 kW (3 W per pin). The total heat load to the spent fuel pool from all four LTAs after irradiation should not increase from normal assemblies with BPRAs or WABAs and should be within the capability of the Watts Bar spent fuel pool cooling system. By letter dated May 29, 1997, the staff requested TVA to provide quantitative information with respect to this matter for the WBN. Watts Bar's current maximum design spent fuel pool heat load with one of two trains of cooling available is 32.6×10^6 BTU/hr. The estimated heat load of the 4 LTAs (32 TPBARs) is approximately 0.001 percent of the maximum design heat capacity of the Watts Bar spent fuel pool. However, the calculational references were not provided. ORNL performed a simple calculation which would confirm the heat generation rate given in the response. The rate can be estimated based on the amount of tritium produced, the decay rate and the energy released per decay. The decay constant, and energy per decay can be found in *Nuclides and Isotopes* (Reference 20). According to Section 6.3.3.1 of the DOE report, the TPBARs are designed to contain 1.2 grams of tritium at the end of the irradiation cycle. The decay heat rate can be calculated from the following equation.

$$\textit{Decay Heat Rate} = (M_t/m_w)\, A_v \lambda E_\lambda$$

where:

M_t = Mass of tritium = 1.2 g/rod x 32 rods = 38.4 g
m_w = Molecular weight of tritium = 3 g/gmoles tritium
A_v = Avogadro's Number = 6.023×10^{23} atoms/gmole
λ = Decay constant = $\ln(2)/T_{½}$ = 1.786×10^{-9} (decays/atom)/s
E_λ = Energy per decay = 0.0183 MeV x 1.6×10^{-13} J/MeV = 2.976×10^{-15} Joules/decays

Decay heat rate = 41 Watts

The resulting decay heat rate is about half the value of the decay heat rate indicated in the report (328 BTU/hr = 96 W) but is a reasonable estimate.

This calculation neglects activation products other than tritium decay. It provides adequate substantiation of the fact that the decay heat power level in the TPBARs is very low compared to decay heat from the spent fuel. On the basis of the information provided, the staff concurs with the conclusion that the contribution of the TPBARs to decay heat load is negligible.

Section 6.3.4 of the DOE report, Inadvertent Loading and Operation of an LTA in an Improper Position, states that LTA loading errors are precluded by the Watts Bar administrative procedures which are in place to prevent fuel assembly and burnable poison misloading. These procedures include confirmation of the final core configuration via video tape. The DOE report states that in the unlikely event the LTA is loaded in the wrong location, the resulting power distribution will be detectable by the in-core moveable detector system or the core power distribution perturbation will be within the specified fuel design limits.

The staff concurs that administrative procedures for verifying fuel loading provide a high degree of protection to prevent core misloadings. However, the purpose of this analysis is to verify that misloading the TPBAR LTA to a limiting location is within the limits of the safety analysis report. By letter dated May 29, 1997, the staff requested TVA to submit information evaluating the consequences of loading the LTA in the limiting assembly in the core. TVA submitted this information by letter dated July 21, 1997 and also submitted its final core design as part of its RSE on August 21, 1997. In addition, as noted above in section 2.1.3, the staff audited the licensee's thermal-hydraulic analysis at PNNL. In the proposed core design for the TPBAR irradiation, the TPBARs cause the assembly in which they are located to produce much less power than the core design limit. Further, the heat transfer analysis, as discussed in section 2.1.3, has shown that the TPBAR would be adequately cooled if it were in an assembly that produces more power than the core design limit. On the basis of the information provided, the staff concludes that misloading TPBARs into the wrong fuel assembly will not result in the TPBAR itself being insufficiently cooled.

Consideration has been given to the effect on the fuel assemblies that are involved in the misloading to assure that the change in the flux distribution does not cause the fuel assemblies to exceed their thermal design limit. In this case, TVA's letter dated July 21, 1997, stated that the FSAR demonstrates that such core loading errors and resulting power distribution effects are either within the analytical uncertainties of the core design or will be detected by the incore flux mapping system. The staff agrees that the reliance on the existing safety analysis and the similarity of the TPBARs to the conventional burnable absorbers is sufficient to conclude that the fuel assemblies are adequately protected. The staff has reviewed the RSE and other supporting documentation which shows that the worth of the specific TPBAR is in the range of worth of conventional burnable absorber rods that have been previously approved and that the reactivity worth is a valid basis for determining the effect of misloading a TPBAR LTA on fuel assembly power would be similar to misloading a conventional burnable absorber.

Section 6.3.5 of the DOE report, Anticipated Transient Without Scram (ATWS), discusses the TPBAR LTA impact on ATWS events. The DOE report states that the

TPBARs could effect the reactivity assumptions of the ATWS analysis, although this effect would be minimal due to the ^{6}Li cross-section. Because the TPBARs are designed to mimic the neutronic behavior of conventional poison rod assemblies, the TPBARs should not have an impact on the existing ATWS neutronics analysis. However, the staff was unable to conclude in NUREG-1607 that the TPBARs will have minimal impact on the ATWS neutronics analysis, based on the information which had been presented by DOE. By letter dated May 29, 1997, the staff requested TVA to provide information with respect to this matter for the Watts Bar Unit 1 ATWS analysis for Cycle 2.

By letter dated June 18, 1997, TVA responded to this concern stating that the response of the reactor to an ATWS event is affected by the moderator temperature coefficient (MTC). The range of preliminary designs of a core containing TPBARs presented in Reference 3 results in a lower boron concentration than the reference safety analysis case for the ATWS event described in the WBN FSAR. The lower boron concentration results in a more negative MTC. On the basis of the information provided, the staff concludes that the lower MTC results in a less severe ATWS event and that the reference ATWS analysis is conservative with respect to an ATWS event for the core containing TPBAR LTAs.

2.1.5 Reactor Systems - Conclusion

The staff has reviewed TVA's TS amendment request which would allow insertion of four TPBAR LTAs into the WBN Cycle 2 core. The areas of the review included the current WBN surveillance program, the nuclear and thermal-hydraulic design of the TPBARs and the Cycle 2 core, and the transient and accident analyses of Cycle 2 with the TPBAR LTAs installed. On the basis of the staff's review, the following conclusions are made.

1. Conformance with WBN TS, specifically TS 3.2, Power Distribution Limits, should be adequate to identify anomalies with the TPBAR during Cycle 2.

2. The neutronic and mechanical characteristics of the TPBAR have been designed to be similar to conventional burnable poison assemblies.

3. The TPBAR LTAs do not result in an increase of consequences of any credible accident or failures.

4. Introducing four (4) LTAs into non-limiting core locations presents minimal risk to the health and safety of the public.

2.2 Materials Engineering

This portion of the SE provides a summary of the materials engineering related open items from NUREG-1607, as identified by number in the May 29, 1997 RAI. Some of the design details for the LTAs are classified and were submitted separately by DOE to the NRC staff.

Question 1 - Cladding and Top and Bottom End Plugs

> The LTA cladding and top and bottom end plugs were designed consistent with the methodology of the American Society of Mechanical Engineers (ASME) Code, Section III, Division I, Subsection NG, Article 3220, 1995. The staff requested that TVA show that the design limits of Article 3220 are satisfied. The staff also requested that TVA submit a relief request for the use of the 1995 Edition of the code since the NRC staff has not endorsed the 1995 Edition.

TVA's Response to Question 1.

TVA submitted a response to Question 1 as an attachment to a TVA letter dated June 18, 1997. After discussion at the July 3, 1997 meeting with the staff, TVA submitted a revised response to this question on July 21, 1997. The TPBARs are not considered to be ASME Code Class I, II, or III components. The methodology used to calculate the design stress limits follows the methods described in the ASME Code, Subsection NG. The stresses applied to the structural members under the specified design operating conditions are within the limits in Subsection NG-3000 with the exception of the stresses produced by a large break loss-of-coolant-accident (LOCA) and the external pressure limits of NG-3133. The stress limits given in the 1995 Edition of Subsection NG have not changed from the 1989 Edition.

NRC Staff's Evaluation

The staff has concluded that using the stress limits found in ASME Code, Subsection NG is an acceptable method for designing the TPBARs. Not meeting the limits for a large break LOCA and not meeting the limits for external pressure in NG-3133 does not result in unacceptable conditions, as discussed in detail in NUREG-1607. Since the TPBARs are not ASME Code components, and since the stress limits in Subsection NG-3000 have not changed from the 1989 Edition to the 1995 Edition, the staff concludes that a request for relief for the use of the 1995 ASME Code is not required.

Question 2. Use of ASTM Standard A 771 for Purchase of Cladding

> The DOE report does not address the conformance of the design with 10 CFR Part 50, Appendix B and NQA-1 because the cladding was ordered to conform to ASTM A 771. Reliance on ASTM A 771 for the purchase of the cladding does not satisfy the requirements of 10 CFR Part 50, Appendix B. The quality assurance program described in ASTM A 771 needs to be supplemented to include conformance with NQA-1 and 10 CFR Part 50, Appendix B.

TVA's Response to Question 2.

Activities associated with the fabrication of the TPBARs are performed under the PNNL Project Quality Assurance Program which complies with 10 CFR 50, Appendix B, and ANSI/ASME NQA-1.

NRC Staff's Evaluation

The staff finds that since the TPBARs are fabricated under PNNL's Quality Assurance Program that complies with 10 CFR Part 50, Appendix B and ANSI/ASME NQA-1, that it is acceptable to use ASTM A-771 for the purchase of the cladding.

Question 3 - Effects of Thermal Cycling on TPBAR Components and Quality Standards to Address them.

> DOE's report does not address the effects of thermal cycling during postulated design-basis accidents (DBAs) on the materials, particularly on the cladding and the aluminide barrier.

TVA's Response to Question 3.

Thermal cycling and the resultant clad fatigue during normal and transient operating conditions are addressed in DOE's report, PNNL-11419, Revision 1, (March 1997). Information on the cladding barrier coating was provided to the staff in a classified response.

NRC Staff's Evaluation

The staff has reviewed the report and the classified information and agrees there is reasonable assurance of the cladding and the cladding barrier surviving one operating cycle. The effect of a DBA on the cladding and aluminide barrier was determined experimentally and the cladding and aluminide barrier remained intact with no apparent damage.

Question 4 - Metal-Metal Interactions Occurring During a LOCA

> No discussion has been given about possible metal-metal interactions during design basis accidents that could result in the formation of intermetallic phases. There is also no discussion on temperature limits for metal-metal and intermetallic interactions.

TVA's Response to Question 4.

As discussed in DOE's report, the TPBAR is calculated to reach the design stress at 1500°F due to the loss of material strength combined with the high internal gas pressure at 1500°F. The classified Technical Report identifies the lowest eutectic temperature and it is substantially above 1500°F.

NRC Staff's Evaluation

The staff agrees, as stated in NUREG-1607, that the TPBAR will reach the design stress at 1500°F. The staff has reviewed the classified report and has independently verified the conclusions by looking at relevant phase diagrams that no metal-metal, intermetallic, or eutectic temperatures will be encountered at temperatures up to 1500°F.

Question 5. Demonstration that the MATHCAD Model is Conservative

> Section 2.2.5 of the DOE report summarizes the analytical models used to calculate TPBAR operating parameters. The software used to calculate the TPBAR performance parameters is MATHCAD. DOE states that the models may contain large uncertainties for some situations. TVA is requested to submit additional documentation to show that the MATHCAD model is conservative when it is used to calculate TPBAR temperatures and pressures. This documentation could consist of results obtained for other applications using MATHCAD and compared with actual operating service.

TVA's Response to Question 5.

Conventional equations were used for heat transfer and established material properties were used in MATHCAD. Principal uncertainties were addressed by using conservative assumptions. Where possible, corroborating test data were used to support the assumptions. Details of the specific analytical assumptions were provided in the classified report.

NRC Staff's Evaluation

The staff has reviewed the classified report and agrees that conventional equations were used for heat transfer and that established material properties were used. It also appears that conservative assumptions have been used for thermal properties and heating rates. The analysis methods and conservative assumptions should account for the uncertainties in the analysis as it relates to the LTA demonstration. The staff recommends that as DOE gathers additional post-irradiation examination data, the MATHCAD results be compared to actual results to further confirm that, even with the large uncertainties in the MATHCAD results, they remain conservative for the production phase of DOE's tritium program.

Question 12. Weld Qualification Procedure

> On the basis of the information in Section 5.3 of the DOE report, the staff concludes that the weld qualification procedure for TPBARs is deficient. Since the TPBAR is considered safety-related, the welder qualification and weld process specification must conform to the requirements of Section IX of the ASME Code, as well as to additional requirements of the construction code, owners specifications, and the additional requirements for special processes of NQA-1 and the Westinghouse quality assurance (QA) program. The DOE report does not address which construction code will be used for welder qualification and weld process specifications. ASTM E2 is no longer an approved standard; it was replaced in 1982 by ASTM E883. ASTM E883 describes how to conduct metallographic examinations, and its use for examining these welds needs to be described in more detail. Therefore, TVA must supplement the welding procedure described in Section 5.3.1.5 of the DOE report to address these concerns before the staff can conclude that TPBAR LTA irradiation in the WBN reactor is acceptable.

TVA's Response to Question 12 (as excerpted from the July 21, 1997 response to Question 1).

The specification for TPBAR end plug welding utilizes criteria that are equivalent to or exceed the applicable requirements of Section IX of the ASME Code, Part QW and Section III, Article NG-5000. The TPBAR end plug welding specification contains requirements and criteria for: the qualification of welds, welding operators, the procedures that will be employed, welding equipment, examination and inspection requirements, testing, nondestructive examination, destructive testing, essential variables, and records. The TPBAR end plug weld examinations include: radiographic, visual, dimensional, metallographic, and helium leak testing.

NRC Staff's Evaluation

The staff concurrs that the licensee's welding procedure meets or exceeds the applicable requirements of Sections III and IX of the ASME Code based on a review of the licensee's submittal and an inspection conducted at PNNL (NRC Inspection Report 99900541/97-01). The staff's inspection at PNNL included a review of the procedures and a review of the method for implementing the procedures. During the inspection, a problem was encountered with the welding of the end caps to the cladding that resulted in an entrapped bubble in the weld. A design change was implemented and the revised procedure eliminated the formation of bubbles. Based on this inspection, the staff concluded that the procedures were adequate and were properly implemented, and that further supplementation of the procedure is not necessary.

Question 13. Non Destructive Examination (NDE)

> DOE states that the cladding and end plugs are tested in conformance with applicable codes and standards. Table 5-5 of the DOE report notes the NDE techniques and applicable standards used during TPBAR fabrication. The staff concludes that, since the TPBAR is being classified as safety-related and is being produced to the criteria of Section III of the ASME Code, the NDE techniques and applicable standards should conform to the requirements of Section III, or an alternative to the requirements must be submitted to the NRC for approval under Title 10 of the Code of Federal Regulations, Section 50.55a (10 CFR 50.55a). Since DOE states that the TPBARs are being designed to the 1995 edition of the code, the staff concludes that the NDE techniques performed by PNNL and by subvendors should be qualified to the requirements of Section XI, Appendix VIII or to an acceptable alternative proposed under 10 CFR 50.55a.

TVA's Response to Question 13 (as excerpted from the July 21, 1997 response to Question 1).

The specification for TPBAR end plug welding utilizes criteria that are equivalent to or exceed the applicable requirements of Section IX of the code, Part QW, and Section III, Article NG-5000. The LTA TPBAR end plug welding specification contains requirements and criteria for: the qualification of welds, welding operators, the procedures that will be used, welding equipment, examination and inspection requirements, testing, nondestructive examination, destructive testing, essential variables, and records. The TPBAR end plug weld examinations include: radiographic, visual, dimensional, metallographic, and helium leak testing.

NRC Staff's Evaluation

The staff conducted an inspection at PNNL and was satisfied that the end cap welding NDE program is adequate and conforms to the requirements of 10 CFR Part 50, Appendix B and is properly implemented. The DOE report referenced a 1995 Edition of the ASME Code, which has not yet been endorsed by the staff, but which in pertinent part is identical to the most recent staff endorsed version of the Code (1989). However, since the TPBARs are not ASME code components, it will not be necessary to request relief from the requirements of the code pursuant to 10 CFR 50.55a. Accordingly, this issue is closed.

Conclusion

All of the issues identified in the materials engineering area of the NRC staff's review have been addressed acceptably. Accordingly these items are considered to be closed as they pertain to the LTA demonstration project.

2.3 Quality Assurance

2.3.1 Background

The staff has completed its review of TVA's submittals including DOE's report, PNNL-11419, and its supplement related to the Tritium Target Qualification Program (TTQP). Additionally, the staff has completed its inspection efforts at PNNL's facilities, located at Hanford, Washington, and the results have been documented in NRC Inspection Report 99900541/97-01, dated August 14, 1997. Although this inspection report identified several instances where PNNL failed to properly implement its Quality Assurance (QA) plan, these nonconformances were satisfactorily addressed by PNNL during the course of the inspection and they were documented as closed in the report. Notwithstanding the identification of these nonconformances, the staff has concluded that the licensee's QA program, including the programs of its vendors, is adequate. This SE documents the resolution of the specific RAIs and the basis for the staff's conclusion that the TPBAR LTA quality assurance program conforms to the requirements of 10 CFR Part 21 and Appendix B of 10 CFR Part 50.

2.3.2 Evaluation

The staff has completed its review of TVA's Submittal along with the QA provisions described in Sections 2.4.1, 2.4.2 and 7 of report PNNL-11419. As stated above, subsequent to the initial submittal of this report on December 4, 1996, the staff forwarded an RAI to DOE in order to seek clarification on specific issues pertaining to the establishment and maintenance of appropriate quality provisions for the TPBAR LTAs. The responses provided by DOE on January 21, and February 14, 1997, asserted that the TPBARs did not perform a safety-related function and that they were, therefore, considered to be non-safety related. However, the report indicated that PNNL would voluntarily apply 10 CFR Part 21 provisions and their QA program to these items which they considered met the requirements of 10 CFR Part 50, Appendix B. By letter dated February 13, 1997, the staff conveyed to DOE its position that the TPBARs were part of a basic component, and that, as such they were subject to the provisions of 10 CFR Part 21 and the quality assurance requirements of 10 CFR Part 50, Appendix B.

In response to the staff's position regarding the safety classification of the TPBARs, PNNL forwarded a revised response to the staff's RAI on March 7, 1997, which stated that, "Due to their association with reactor fuel assemblies, the TPBARs are considered to be a part of a basic component as defined in 10 CFR Part 21. The TPBAR is important to safe and reliable operation, requiring the design and fabrication of TPBARs to be accomplished under a QA program that complies with the requirements of 10 CFR Part 50, Appendix B. The appropriate QA and 10 CFR Part 21 requirements have been applied to the individual subcomponents of TPBARs to an extent commensurate with their importance to safety, and consistent with provisions of 10 CFR Part 50, Appendix B, Criterion II, Quality Assurance Program."

The staff reviewed this response and determined that although PNNL acknowledged that the TPBARs were part of a basic component, the initial question, related to identifying the specific components in the TPBAR LTAs that are considered safety-related, remained unanswered. Therefore, RAI Items 1 and 2 remained open pending the resolution of this issue with DOE/PNNL.

As a follow-up to this issue the staff conducted an initial inspection at PNNL, during the week of April 28 through May 2, 1997. As a result of this inspection effort it was determined that although the TPBARs were characterized as being subject to the requirements of Appendix B, there was no apparent correlation between the safety classification described in TVA's Nuclear Quality Assurance Plan, TVA-NQA-PLN89-A, Revision 6, which describes the necessary provisions for safety-related items, and PNNL's "importance factors" described in procedure TTQP-1-046, Revision 0.

Subsequent to a June 4, 1997, public meeting between the NRC and TVA, the staff provided further amplification on the specific safety function of the TPBARs in a letter to Mr. O.D. Kingsley (TVA) from Mr. F.J. Hebdon dated, June 14, 1997. This letter underscored the NRC's position that the fuel and control rod assemblies were considered basic components subject to 10 CFR Part 21 that, by definition, were designed and manufactured under a QA program that complied with the requirements of 10 CFR Part 50, to Appendix B, and that parts thereof (e.g., burnable poison rods and TPBARs) were similarly regarded because of their safety function. The letter further stated that the NRC has always considered burnable poison rods in their entirety to be safety-related and that as such, this position included the TPBARs in their entirety (e.g., end plugs, getter, cladding, plenum spring, etc.).

On July, 3, 1997, the staff again met, in a public forum, with representatives from TVA, PNNL, DOE, and Westinghouse to discuss the safety classification of the TPBAR components. During this meeting, TVA provided the staff with revised information related to the TPBAR component importance factors and the safety functions of items within the LTAs.

During the weeks of July 7 through July 18, 1997, the staff performed follow-up inspections at PNNL's Hanford facilities. The results of these inspection activities were subsequently documented in NRC Inspection Report 99900541/97-01, dated August 14, 1997. Based on the results of this inspection, the staff determined that the governing procedural controls contained in TTQP-1-046, Revision 3, had been revised to reflect the safety functions of the TPBAR components. These safety functions included recognition that the TPBARs perform as burnable absorber rods and that these components are an essential element of a reactor core design. The procedure also stated that "The presence and location of the absorber rods, in conjunction with the soluble boron and control rods, determine the appropriate level of reactivity to keep the reactor in a safe state. TPBARs have no active reactivity control function but do have passive reactivity characteristics. Therefore, the TPBAR LTAs are an integral part of the reactivity control system and are safety-related." TTQP-1-046, Revision 3, further stated that "Because the TPBAR LTAs perform a safety-related function, the 10 CFR Part 50, Appendix B, quality assurance program and 10 CFR Part 21 are applied to the design, procurement, fabrication, assembly and handling of the TPBAR LTAs." With respect to the structural integrity of these components the staff determined that, TTQP-1-046 had been revised to state that the TPBARs must maintain their mechanical integrity in order to ensure the location of the absorber within the TPBARs. Based on the review of the revised safety classifications of the TPBAR components described in Table 1 of TTQP-1-046, the staff concluded that RAI Items 1 and 2 had been acceptably resolved and these items were closed.

Item 3 of the RAI requested a consolidated description of the QA program controls that would govern the design fabrication, testing and installation of the LTAs. PNNL's response stated that in accordance with Tennessee Valley Authority's Nuclear Quality Assurance Plan (TVA-NQA-PLN89-A), TVA contractually required PNNL and Westinghouse to establish, and maintain a QA program that meets the requirements of 10 CFR Part 50, Appendix B. The response further stated that PNNL maintained primary responsibility for the design and fabrication of the TPBARs in accordance with their project QA plan described in ETD-003, Revision 2.

Corresponding QA program information contained in Revision 1 to DOE's report stated that in addition to being the fuel system supplier for TVA, Westinghouse would qualify PNNL as an approved supplier for the design and fabrication of lead test assemblies in accordance with Westinghouse's Quality Management System (QMS), Revision 1. This qualification process included evaluation of the PNNL Project Quality Assurance Plan and its implementation for compliance with 10 CFR Part 50, Appendix B, and ASME NQA-1 Basic and Supplementary Requirements as delineated in the Westinghouse QMS.

The staff considered the documented response acceptable. However, implementation verification of PNNL's QA program related to the design and fabrication of TPBAR LTAs was specifically evaluated during the NRC's inspection of PNNL's facilities, and the results were documented in Inspection Report 99900541/97-01, dated August 14, 1997. Based on the results of this inspection effort it was determined that the project QA plan described in ETD-003, Revision 3, and the implementing QA program procedures adequately incorporated the requirements of Appendix B to 10 CFR Part 50. Therefore, RAI Item 3 is considered closed.

Items 4, 12, 17 and 18 of the RAI requested a definition of the contractual relationship among the participants described in Figure 7-1 of PNNL-11419, and for a description of the methods that would be used by TVA to provide QA oversight of PNNL, Westinghouse, and sub-suppliers. Additionally, the staff questioned if Appendix B audits, surveillances, and inspections would be conducted by TVA.

PNNL's response stated that Battelle, as the operator of Pacific Northwest National Laboratory (PNNL), is procuring irradiation and technical support services from TVA and nuclear computer code modification services from Westinghouse Electric Corporation. Furthermore, it was stated that (1) TVA is procuring QA oversight (including qualification of PNNL as a supplier), engineering, and technical support services from Westinghouse and (2) that TVA has contractually imposed 10 CFR Part 50, Appendix B and 10 CFR Part 21 on PNNL and Westinghouse. The response to the RAI also indicated that TVA, as licensee of the facility, is responsible for ensuring appropriate technical and quality requirements are established and complied with prior to insertion of the LTAs into the reactor core. These activities are to be accomplished in accordance with TVA's established QA Program.

The RAI response stated that the final supplier of the completed LTAs to Watts Bar would be Westinghouse, who was identified as an approved supplier for TVA. Additionally, it was stated that Westinghouse had been contracted by TVA to provide QA oversight of PNNL in accordance with their Quality Management System (QMS) and that Westinghouse oversight activities included the following aspects:

a. Performance of a supplier qualification audit to evaluate PNNL's compliance with 10 CFR Part 50, Appendix B and ANSI NQA-1, Basic and Supplementary Requirements.

b. Oversight of PNNL manufacturing operations and PNNL control of subcontractor quality processes.

c. Providing TVA with a report summarizing the adequacy of the implementation of PNNL's QA program, prior to insertion of the LTAs into the core.

The RAI response further stated that PNNL would furnish Westinghouse with certified subcomponents (TPBARs), and that Westinghouse would complete the fabrication, certification, and delivery of the LTAs to TVA. TVA's acceptance of the LTAs, as stated, would include receipt inspection in accordance with their established QA Program.

The documented response provided by PNNL regarding the contractual relationship between the participants described in Figure 7-1 of the report and TVA's QA oversight of PNNL, Westinghouse, and sub-suppliers was acceptable. Therefore, RAI Items 4, 12, 17 and 18 were administratively closed. Verification of implementation of these oversight functions, which affect safety-related activities, was evaluated during the NRC's inspection of PNNL facilities, and the results were documented in Inspection Report 99900541/97-01, dated August 14, 1997. Based on the results of this inspection effort it was generally determined that appropriate programmatic controls had been established with respect to the requirements of 10 CFR Part 21 and Appendix B of 10 CFR Part 50 and that external audits of PNNL had been performed by both Westinghouse and TVA. Therefore, RAI Items 4, 12, 17 and 18 are considered closed.

With respect to RAI Items 5 and 13, the staff requested a current copy of PNNL's QA program that implemented ASME NQA-1, 1989, as well as a description of how TVA's quality requirements which conform to ANSI N45.2 series standards, as endorsed NRC Regulatory Guides, were transmitted to Westinghouse and PNNL.

In addition to forwarding the response to the staff's question concerning corollaries between ASME NQA-1-1989 edition and ANSI N45.2 series standards, DOE provided an informational copy of PNNL's Tritium Target Qualification Project (TTQP) Quality Assurance Plan, ETD-003, Revision 2. In providing this document DOE stated in their letter that "The governing quality assurance requirements for this project are embodied in the NRC accepted plans of TVA-Watts Bar and Westinghouse, and therefore we are not requesting NRC review and approval of this plan." The staff acknowledged DOE's statement regarding the preeminence of the governing QA provisions in both TVA's and Westinghouse's QA program descriptions. However, the requirements of 10 CFR Part 50, Appendix B, Criterion IV, state in part that "....applicable regulatory requirements, design basis, and other requirements which are necessary to assure adequate quality are suitably included in or referenced in the documents for procurement of material, equipment, and services, whether purchased by the applicant or by its contractor or its subcontractor." Furthermore, Criterion IV states that "To the extent necessary, procurement documents shall require **contractors or subcontractors** [emphasis added] to provide a quality assurance program consistent with the pertinent provisions of this appendix."

Although DOE specified that NRC review and approval of PNNL's QA plan was not requested, the fact that PNNL was identified as maintaining primary responsibility for the design and fabrication of the TPBARs established that the evaluation of their QA program would constitute an integral component in the NRC's review of the TPBAR LTA program as applied to CLWRs. To that end, the staff continued to evaluate the QA program controls associated with the implementation of 10 CFR 50, Appendix B requirements during the NRC's inspection of PNNL facilities, and the results were documented in Inspection Report 99900541/97-01, dated August 14, 1997. Based on the results of this inspection effort it was concluded that the project QA plan described in ETD-003, Revision 3, and the implementing QA program procedures adequately incorporated the requirements of Appendix B to 10 CFR Part 50. Therefore, RAI Items 5 and 13 are considered closed.

RAI Items 6 and 7 requested a description of PNNL's QA program and vendor controls which would provide audit, oversight and acceptance criteria for component and service suppliers utilized by PNNL for design and fabrication of TPBAR LTAs.

In response to these questions, PNNL stated that their project QA plan required procurements to include appropriate quality requirements and that specified component and service suppliers are subject to PNNL QA oversight. PNNL also stated that quality requirements are established commensurate with the importance to safety of the item or service being provided. The RAI response further stated that suppliers are required to submit QA control plans to PNNL for review and approval, and that their oversight included pre-award surveys, periodic audits, in-process monitoring, source inspections, and receipt inspection of delivered products.

The docketed responses provided to RAI Items 6 and 7 were considered acceptable and the programmatic aspects of these issues were closed. The implementation of PNNL's audit and oversight of component and service suppliers as well as the evaluation of procurement requirements imposed on vendors were evaluated during the NRC's inspection of PNNL. The results of the staff's inspection efforts were documented in Inspection Report 99900541/97-01, dated August 14, 1997. Based on the results of this inspection effort it was generally concluded that the project QA plan EDT-003, Revision 3, and the implementing QA procedures adequately addressed the requirements of Appendix B, related to audit and oversight of component and service suppliers and that appropriate quality provisions had been contractually imposed on vendors. Therefore, RAI items 6 and 7 are considered closed.

Item 8 of the RAI requested clarification regarding the treatment of commercial grade items that were not manufactured in accordance with 10 CFR Part 50, Appendix B QA requirements or the PNNL QA program for use in the TPBARs. The staff also requested a description of the process employed by PNNL to determine the acceptability of those items (i.e. commercial grade item dedication).

PNNL's response reiterated that TVA had contractually imposed compliance with 10 CFR Part 50, Appendix B and 10 CFR Part 21 on PNNL and Westinghouse. PNNL further stated that any components received that did not comply with the requirements specified in the procurement documents were considered nonconforming and would be handled in accordance with their corrective action program. PNNL also stated that items were determined to be acceptable by appropriate combinations of testing, source inspection, review of supplier quality control plans, review of supplier documentation, and receipt inspection. In conclusion PNNL stated that the methods used were appropriate to the characteristics to be verified.

Based on the review of PNNL's response to RAI Item 8, the staff determined that inadequate information had been provided to resolve this issue. Specifically, the response failed to address the essential programmatic elements that are necessary for the dedication of commercial grade items including the processes associated with the identification and verification of "critical characteristics." Therefore, this item remained open pending the staff's evaluation of PNNL's commercial grade item dedication program.

During the conduct of follow-up evaluations at PNNL, which were documented in Inspection Report 99900541/97-01, dated August 14, 1997, the staff examined the procurement activities for selected critical component parts of the LTAs. Based on the results of this review the team identified concerns with the records related to procurement and dedication of the stainless steel material for the TPBAR cladding tubes and end-plugs. These concerns constituted a nonconformance. However, PNNL responded with prompt corrective actions, which included revising the controlling procedure and correcting the associated material reverification record. As a result of these corrective actions the staff concluded that PNNL had adequately addressed the nonconformance and the programmatic aspects of this issue. Therefore, RAI Item 8 was closed.

Item 9 of the RAI requested a description of the management assessments and QA audits performed by PNNL's regulatory compliance and QA organizations to verify the effectiveness of the PNNL QA program implementation.

PNNL's response stated that their project QA plan established requirements for periodic audits and management assessments. To date, PNNL stated that they had conducted four management assessments related to QA plan implementation in the areas of overall program adequacy and implementation, training, records, and design. PNNL further stated that fabrication activities had only recently commenced, and that supplier QA oversight activities were underway. PNNL indicated that additional management assessments and QA audits would be performed during the remainder of the project to ensure compliance with the project QA plan, including fabrication. In addition, PNNL stated that TVA required Westinghouse to perform QA oversight activities and provide a report to the utility regarding the adequacy of PNNL's QA program.

The response provided to RAI Item 9 was regarded as acceptable and this issue was considered closed. The adequacy of PNNL's management assessments and QA audits were subsequently evaluated during the NRC's inspection of PNNL facilities, and the results were documented in Inspection Report 99900541/97-01, dated August 14, 1997. Based on staff's examination of PNNL's internal audit program it was determined that, contrary to the requirements of Criterion XVIII, "Audits," of Appendix B, to 10 CFR Part 50, not all aspects of the QA program had been audited. Although, this deficiency had been previously identified during an internal assessment conducted in May 1996, the team concluded that inadequate corrective actions had been implemented in that no audits had been performed during 1997 and none were scheduled to occur until after project completion.

Subsequent to the identification of this nonconformance, PNNL initiated a corrective action report (CAR) 97-010. The team reviewed PNNL's documented corrective actions taken to resolve this deficiency and to prevent recurrence. Based on the review of the response to CAR 97-010, which included procedural changes, development of an enhanced audit plan, and an impact evaluation to address the lack of formal audits, the staff concluded that appropriate corrective actions had been implemented in response to this nonconformance. An enhanced audit plan was developed and was found to be satisfactory. PNNL's susequent audit disclosed no significant adverse findings. Therefore, RAI Item 9 is considered closed.

Items 10, 11, and 15 of the RAI requested a description of the PNNL verification processes used to assure that the TPBARs conform to design specification requirements as well as a delineation of design responsibilities and interface controls.

In response to these items PNNL stated that their project QA plan established requirements for source inspections, receipt inspections, review of supplier documentation, as well as in-process and final acceptance inspections. PNNL also stated that in-process and final acceptance inspections are specified in their Manufacturing and Quality Plan (MAQP). The MAQP, as described in PNNL's response, was reviewed and administratively approved by Westinghouse to ensure provisions for appropriate criteria are established. Furthermore, PNNL stated that the control of design information within each organization was established by procedures in accordance with each organization's quality program. Transmittal of information between TVA, Westinghouse and PNNL organizations was via designated organizational points of contact.

Relative to the performance of design reviews and design verification activities PNNL stated that they were responsible for the design of the TPBARs and that project procedures controlled the documentation and independent review of analyses and calculations by the PNNL design team. In addition, PNNL stated that a series of design reviews by independent design review boards had been initiated in accordance with a project design review plan. The design review plan as stated by PNNL included phased reviews by personnel with appropriate experience and expertise.

The responses provided to RAI Items 10, 11, and 15 were regarded as acceptable and these issues were administratively closed. The implementation of PNNL's design interface controls and design verification process for confirming specification requirements, were evaluated during the NRC's inspection of PNNL's facilities. The results of these inspection efforts were documented in Inspection Report 99900541/97-01, dated August 14, 1997. In order to confirm (1) the adequacy of PNNL's design interface controls and (2) that design specification requirements were properly maintained, the staff reviewed the TTQP design verification program. This review included the examination of the current MAQP, selected design calculation packages and procurement documents related to TPBAR components. As a result of this review, issues which constituted a nonconformance were identified relative to the maintenance of design specification requirements for procured lithium aluminate pellets. Specifically, these issues involved inadequacies in the specified sampling plan used to verify critical characteristics related to the pellets. Subsequent to the identification of this nonconformance, PNNL developed corrective actions, which included revising the applicable inspection/test instructions and documenting the basis for the sample sizes used to accept the pellets. Based on the evaluation of these corrective actions the staff concluded that PNNL had adequately addressed the technical and programmatic aspects of this issue and the noncompliance was administratively closed in the inspection report. Based on reviews conducted in this area, the staff concluded that an adequate design control process had been established and implemented for the TTQP. Accordingly, RAI Items 10, 11, and 15 are considered closed.

Item 14 of the RAI requested the identification of the Westinghouse quality program (such as the NRC-approved Quality Management System) that would be applied to activities associated with the LTAs.

PNNL's response to this issue indicated that Westinghouse would apply their Quality Management System (QMS) and implementing procedures to Westinghouse activities associated with the LTAs, including QA oversight.

The response provided to RAI Item 14 was determined to be acceptable and this issue was considered closed.

Item 16 of the RAI requested a description of how nonconforming conditions would be reported by suppliers to client organizations. Additionally, the staff requested information on how the client organizations would evaluate those nonconforming conditions.

In response to this issue PNNL stated that they address the reporting of nonconforming conditions through a formal mechanism established in the PNNL procurement quality system. PNNL also stated that procurement documents require that a supplier submit a "Contractor Nonconformance Request" (CNR) documenting any nonconforming condition tendered for acceptance of a variance from PNNL specifications. As indicated in PNNL's response the supplier must describe the deficient condition, recommend a disposition and provide a justification. PNNL further stated that the supplier must submit the CNR for PNNL's review and approval and that the recommended supplier disposition may be approved, modified or disapproved by PNNL. During the review of the CNR, PNNL stated that they would make a determination regarding the type of verifications that were necessary to assure that CNR disposition had been completed correctly. PNNL maintained that LTA-related nonconformance reports, whether generated by PNNL or a PNNL supplier would be made available to Westinghouse and TVA as part of the process. Furthermore, PNNL stated that TVA reserved the right to review and concur in all repair and use-as-is dispositions of nonconformances with the utility requirements. In conclusion PNNL stated that the reporting and posting requirements of 10 CFR Part 21, imposed on PNNL by TVA and Westinghouse, would be followed and passed to subvendors as appropriate.

The response provided to RAI Item 16 was considered acceptable and this issue was administratively closed. The implementation of PNNL's program controls related to nonconforming conditions reported by suppliers to client organizations was evaluated during the NRC's inspection of PNNL facilities, and the results were documented in Inspection Report 99900541/97-01, dated August 14, 1997. Based on the results of this inspection effort it was generally concluded that the project QA plan EDT-003, Revision 3, and the implementing QA procedures provided appropriate controls related to the documentation and disposition of nonconforming conditions for products and services. Therefore, RAI Item 16 is considered closed.

Item 19 of the RAI requested a description of the processes that will be utilized by Westinghouse (e.g. receipt inspection, dimensional and configuration verification, and material verification) to verify that the

TPBARs conform to Westinghouse technical requirements prior to assembly in LTAs.

In addition to the response provided to RAI Item 4, PNNL stated that Westinghouse would review PNNL's supporting documentation certifying the TPBAR was built in accordance with the design requirements and utility's quality requirements. As stated in the response, Westinghouse would also provide unique TPBAR identification for traceability, and would perform receipt inspection in accordance with their approved procedures.

The response provided to RAI Item 19, in conjunction with the staff's review of Section 2.4.1 of PNNL-11419, Revision 1, was determined to be acceptable and this issue was closed.

Item 20 of the RAI requested a description of the processes that would be utilized by TVA (e.g., receipt inspection, dimensional and configuration verification, and material verification) to confirm that LTAs were suitable for installation in the Watts Bar Unit 1 core.

In response to this issue PNNL stated that Section 6.2 of the report discussed existing TVA procedures for receipt inspection of fuel and fuel components and that these procedures would be used to receive the LTAs. PNNL further stated that this receipt inspection process, in conjunction with utility and Westinghouse assessments of TPBAR design and fabrication activities, and the successful completion of a reload safety evaluation, would confirm that the LTAs were suitable for installation in the core.

The response provided to RAI Item 20, in conjunction with the staff's review of Section 2.4.2 of PNNL-11419, Revision 1, was determined to be acceptable and this issue was closed.

Item 21 of the RAI requested clarification as to whether Westinghouse special processes, in this instance welding, had been re-qualified as necessary to account for differences in TPBAR material from that typically used in LTA assemblies.

In response to this issue PNNL stated that special process procedures (including welding) would be developed and qualified by PNNL and were, therefore, not considered to be re-qualified Westinghouse special processes. The special process controls, however, would be subject to oversight by PNNL QA. Special processes would be identified and key parameters defined in the MAQP and the MAQP would be reviewed and administratively approved by Westinghouse.

Based on the review of PNNL's response to RAI Item 21, the staff determined that inadequate information had been provided to resolve this issue. Therefore, this item remained open pending the staff's future evaluation of PNNL's manufacturing and quality plan related to the production of TPBARs

During the conduct of follow-up evaluations at PNNL, which were documented in Inspection Report 99900541/97-01, dated August 14, 1997, the staff examined PNNL's process controls related to welding qualification, performance and inspection. As a result of these inspection efforts, which included observation of welding processes, examination of radiography results and review of the completed welding qualification report, no adverse findings were identified and it was determined the PNNL had developed and implemented appropriate welding process controls. Therefore, RAI Item 21 is considered closed.

2.3.3 Quality Assurance - Conclusions

Based on the review of TVA's submittal and the associated inspection results, all of the staff's RAIs related to the adequacy of the QA provisions for controlling the design, procurement, fabrication, assembly and handling of the TPBAR LTAs have been adequately resolved. Accordingly, the staff has concluded that PNNL's QA controls for the TTQP conforms to the requirements of 10 CFR Part 21 and Appendix B of 10 CFR Part 50.

3.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Tennessee State official was notified of the proposed issuance of the amendment. The State official, Mr. Michael Mobley, submitted comments by letter dated September 3, 1997, stating as follows:

> ... In my letter of May 30, 1997, to Mark Lesser I expressed my concern about the introduction of DOE manufactured components into the reactor core without adequate assessemnt of their worthiness. I noted that it cannot be assumed that these items will meet commercial nuclear standards.
>
> In your letter of August 7, 1997, you state in response to this concern that this would be part of the NRC's ongoing review. This issue is still of great concern to the State of Tennessee. Our concern is heightened by the apparent speed with which the manufacturer of the Lead Test Assemblies received approval as a manufacturer of safety related equipment. It was our understanding that this was an arduous process. Has the manufacturer actually been approved? How often has this level of approval has been granted on such a short time line?

NRC Staff Response

The NRC staff would agree with the State's concern that it cannot be assumed, absent an NRC staff review, that the TPBARs would meet NRC regulatory requirements for insertion into the WBN during Cycle 2. Accordingly, the staff has reviewed TVA's proposal extensively, as discussed in the Safety Evaluation presented above. The proposal to insert four LTAs into WBN for Cycle 2 has been found to be acceptable.

The State's concern with the time period in which the review has been accomplished appears to be based on the date of TVA's submittal, which was April 30, 1997. However, as noted in the Safety Evaluation above, the staff's review of DOE's proposal regarding insertion of TPBARs into a commercial light water reactor began over eight months ago, in December 1996, with the receipt of the submittal from DOE. Thus, considerable staff review resources had been expended and the staff's review of DOE's submittal had progressed substantially prior to receipt of TVA's site-specific application. In addition, with respect to approval of the TPBAR manufacturer, the staff has conducted an extensive inspection and review of TPBAR manufacturing activities performed by TVA's vendors, including PNNL. As discussed in the above SE, the staff has concluded that activities involved in the manufacture of the TPBAR LTAs have been acceptably performed.

4.0 ENVIRONMENTAL CONSIDERATION

Pursuant to 10 CFR 51.21, 51.32 and 51.35, an environmental assessment and finding of no significant impact was published in the *Federal Register* on September 11, 1997 (62 FR 47835). In this finding, the Commission determined that issuance of this amendment would not have a significant effect on the quality of the human environment.

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 Contributors: K. Kavanagh, J. Davis, R. Latta

Date: September 15, 1997

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Appendix A: Audit Calculation in Support of the Review of Report Number TTQP-1-038 Revision 3, "TPBAR Thermal Performance"

This appendix documents an audit calculation to verify independently the TTQP-1-038 calculations. Based on this review and the audit calculation, the staff concurs with the main conclusion of the report, which is that the TPBAR maximum allowed power is greater than 9.675 kW when operated in an assembly with a hot channel (an eight-rod sub-channel surrounding the TPBAR guide tube) rise factor lower than 1.4917. This TPBAR maximum allowed power bounds the expected maximum TPBAR power of 7.83 kW.

ORNL's review of the TTQP-1-038 calculations indicates that the methodology used is technically correct and its implementation appears to be free of errors except for the calculation of the dash pot flow as noted below. The treatment of errors and uncertainties is adequate.

The review produced two areas of concern:

(1) The mass flow rate in the dash pot area is overestimated by more than 200 percent because of an apparent error in the calculation of the friction coefficient. PNNL calculated a dash-pot flow of 2.96 percent of the total guide tube flow based on a laminar friction coefficient in the screw hole. The audit calculation indicates that the Reynolds number in the screw hole region with a 2.96 percent flow is greater than 15,000, indicating that a turbulent-flow friction factor is required. With this flow, a screw-hole pressure drop of 12 psi is estimated, which cannot be supported by the core pressure drop. The calculations indicate that the dash-pot flow is 1.34 percent.

The calculated flow of 1.34 percent is lower than the "conservative" assumption of 2 percent used in the report; thus the dash pot temperatures are higher than calculated in TTQP-1-038. The audit calculation has evaluated the effect of the reduced dash-pot flow and shown that it does not affect the report conclusions since the limiting temperatures occur at the outlet of the guide tube under all conditions.

(2) A second area of concern is the fact that the TTQP-1-038 report did not address partial flow-blockage conditions. To resolve this concern, ORNL performed a scoping calculation assuming a 90 percent flow blockage (i.e., with only 10 percent of nominal flow). This calculation indicates that a severe (90 percent) flow blockage only results in approximately a 10°F penalty. This is caused by the fact that the linear heat generation rate (LHGR) in the TPBAR is approximately one order of magnitude smaller than a fuel pin (0.75 W/ft maximum LHGR for the TPBAR versus 5.45 W/ft LHGR for the average fuel pin). With this low LHGR, the TPBAR heat can be dissipated by conduction to the fuel sub-channel coolant.

A summary of some of the audit calculation results is shown in Figures 1 through 3. Figure 1 shows the calculated TPBAR annulus and fuel sub-channel coolant temperatures for Condition I with a 148 percent assembly peaking factor and a 165 percent hot pin peaking factor next to the TPBAR. These calculated temperatures agree well with the numbers documented in TTQP-1-038. The calculated temperatures are below the maximum acceptable value of 650°F. The audit calculation shows temperatures slightly lower than those reported in TTQP-1-038 because they do not reflect all the uncertainties included in TTQP-1-038. In that sense, the audit calculations are best estimate for the given conditions.

Figure 2 studies the sensitivity to different axial power distributions. The Condition I power shape is shown along with a uniform and a cosine distributions. As it can be observed, the outlet temperatures are fairly insensitive to power distribution. The temperature in the dash pot is very sensitive to the assumed power distribution in the dash pot, but this temperature is not limiting under any realistic power shape. Thus, the staff concludes that the conclusions in TTQP-1-038 can be generalized to all expected axial power shapes.

Figure 3 shows the result of a sensitivity study to flow blockage. For this calculation, ORNL assumed than only 10 percent of the nominal flow exists in both the dash pot and the upper section of the guide tube. As observed, the annulus temperature increases as heat must be conducted to the fuel sub-channel through the guide tube cladding. For this calculation, ORNL assumed the Condition I axial power shape, which has low power generation at the edges; for this reason, the delta temperature is decreased at the guide tube outlet (less heat must be conducted), and the temperature "penalty" due to a 90 percent flow reduction is only of the order of approximately 10°F. Note that the dash-pot temperature does not change significantly because most of the dash-pot heat is conducted to the fuel sub-channel though the guide-tube cladding. This is the reason why the error in estimated dash-pot flow (1.34 percent as opposed to 2.96 percent) does not affect the report conclusions.

In conclusion, ORNL review of TTQP-1-038, Revision 3, and the audit calculations confirm the thermal design calculation and indicate that the TPBAR should satisfy all thermal-hydraulic design requirements even accounting for flow blockage.

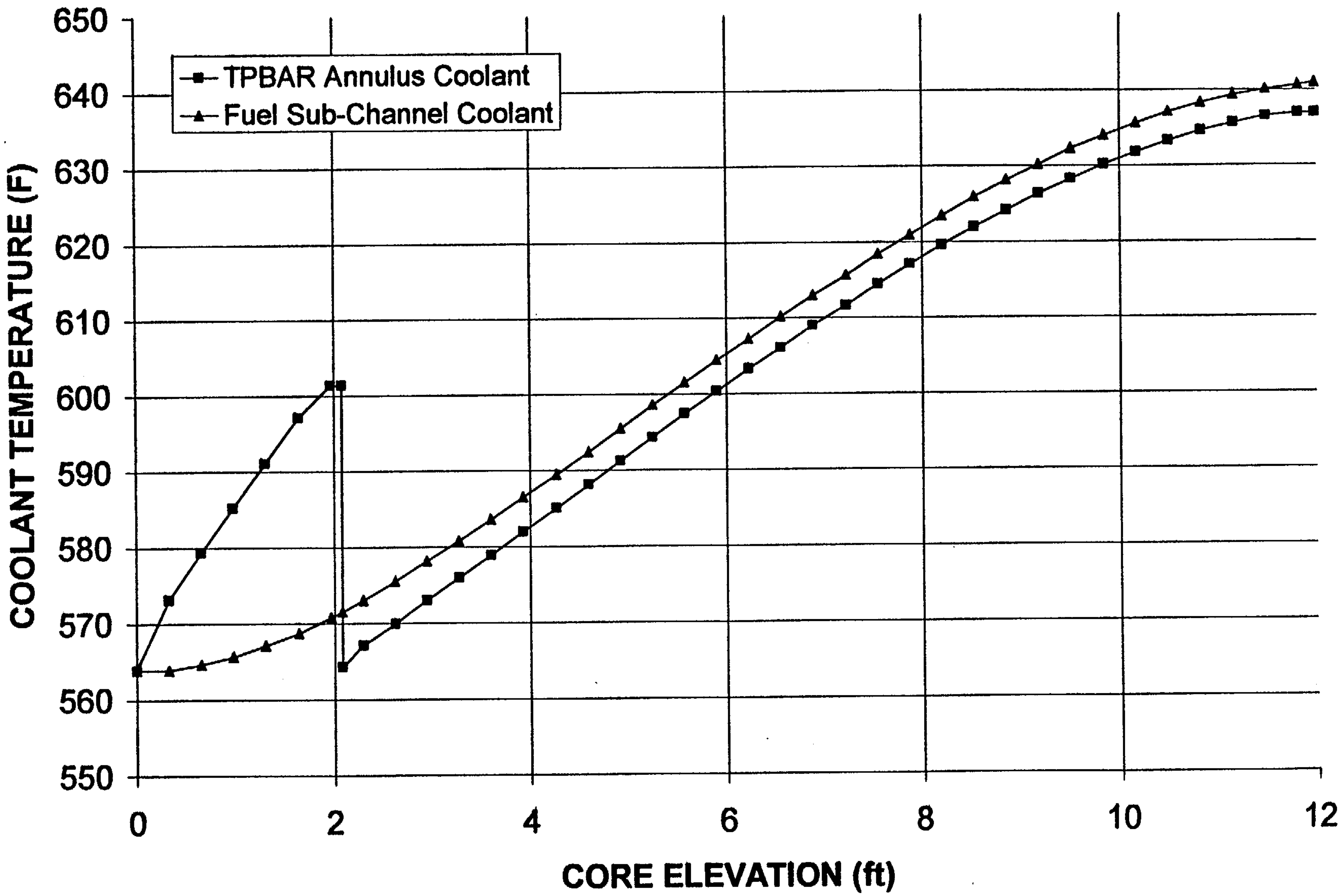

Figure 1. Calculated coolant temperature for fuel sub-channel and TPBAR annulus for "Condition I" assuming a 148% assembly peaking factor.

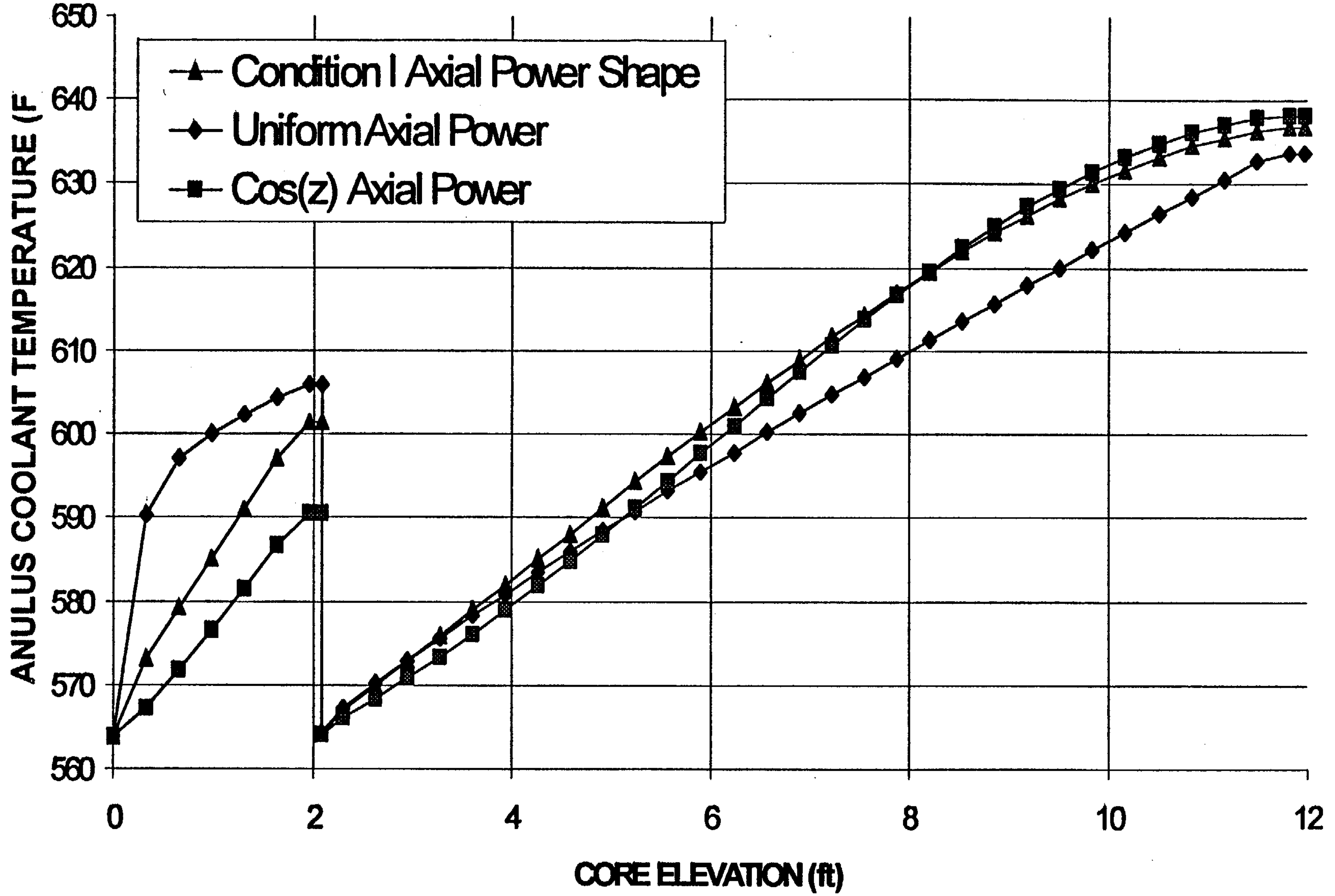

Figure 2. Calculations with different power shapes show relatively-low sensitivity of limiting conditions to the actual axial power shape.

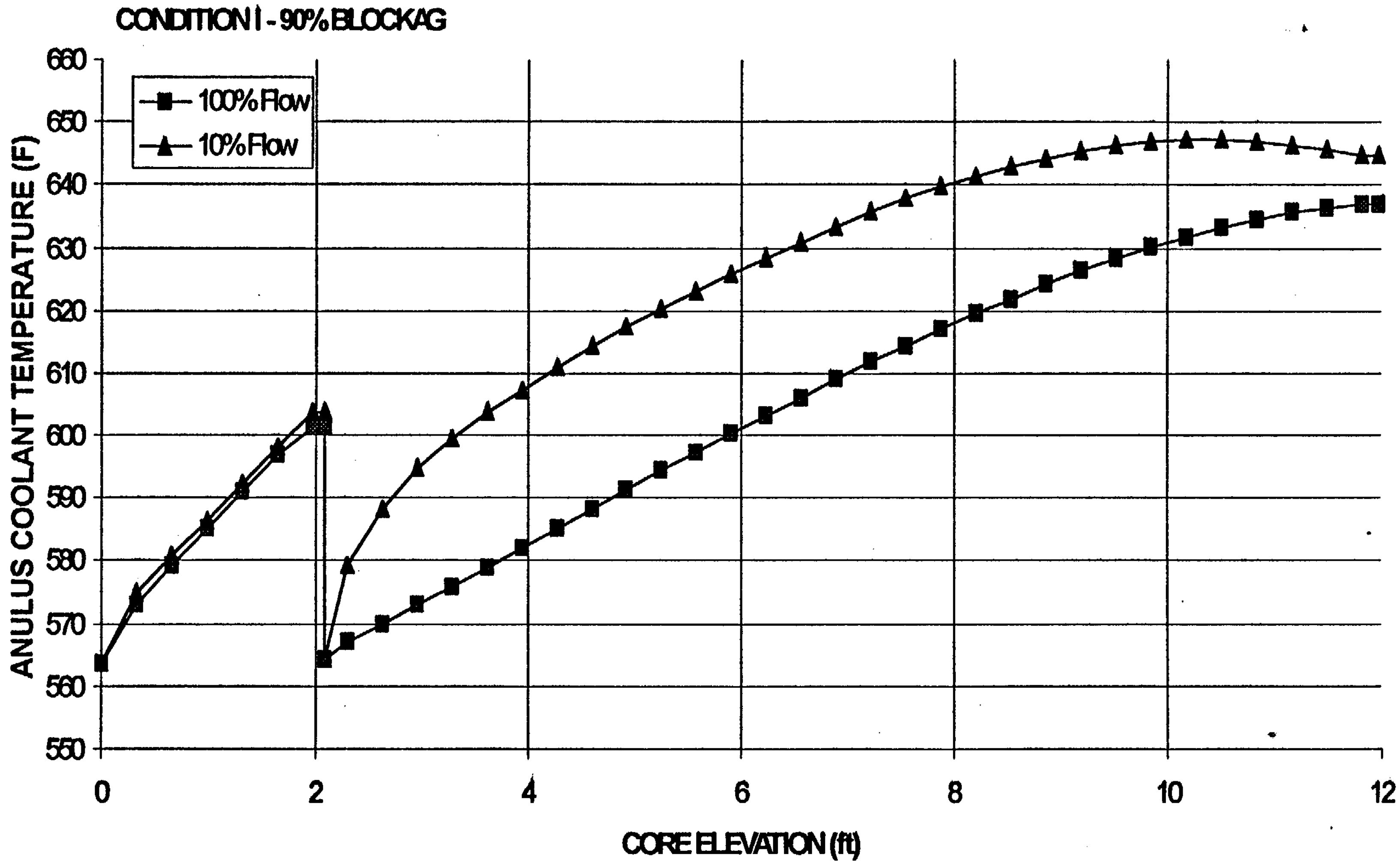

Figure 3. Thermal coupling between TPBAR and fuel sub-channel is large. TPBAR heat can be dissipated by conduction even with a 90% blockage.