TVA

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May 12, 2011

10 CFR 50.90

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

Browns Ferry Nuclear Plant, Unit 1
Facility Operating License No. DPR-33
NRC Docket No. 50-259

Subject: **Response to NRC Request for Additional Information Regarding a Request to Transition to AREVA Fuel (TAC No. ME3775)**

References:
1. Letter from TVA to NRC, "Technical Specification Change TS-473 - AREVA Fuel Transition," dated April 16, 2010
2. NRC Letter to TVA, "Browns Ferry Nuclear Plant, Unit 1 - Request for Additional Information Regarding a Request to Transition to AREVA Fuel (TAC No. ME3775)," dated March 28, 2011

On April 16, 2010, the Tennessee Valley Authority (TVA) submitted "Technical Specification Change TS-473 - AREVA Fuel Transition," (Reference 1) to the Nuclear Regulatory Commission (NRC) requesting approval of a license amendment to support using AREVA fuel in Unit 1 at Browns Ferry Nuclear Plant. On March 28, 2011, TVA received a Request for Additional Information (RAI) letter from the NRC (Reference 2) containing 18 questions related to Technical Specification Change TS-473. The NRC requested the responses within 45 days, i.e., no later than May 12, 2011.

Enclosure 1 to this letter provides the TVA responses to the 18 NRC RAI questions. Enclosure 1 also contains information that AREVA NP considers to be proprietary in nature and subsequently, pursuant to 10 CFR 2.390, "Public inspections, exemptions,

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requests for withholding," paragraph (a)(4), it is requested that this information be withheld from public disclosure.

Enclosure 2 contains the redacted version of Enclosure 1 with the proprietary material removed, suitable for public disclosure.

Enclosure 3 provides the affidavit supporting the request for withholding from public disclosure.

Additionally, TVA is sending a copy of this letter and non-proprietary enclosures to the Alabama State Department of Public Health.

This letter does not include any new regulatory commitments. Please direct any questions concerning this matter to Tom Matthews at (423) 751-2687.

I declare under penalty of perjury that the foregoing is true and correct.
Executed on the 12th day of May, 2011.

Respectfully,

R. M. Krich

Enclosures:

1. TVA Response to Request for Additional Information *(Proprietary)*
2. TVA Response to Request for Additional Information *(Non-Proprietary)*
3. Affidavit

cc (Enclosures):

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

Enclosure 2

Browns Ferry Nuclear Plant, Unit 1

Technical Specification Change TS-473 - AREVA Fuel Transition

TVA Response to Request for Additional Information
(Non-Proprietary)

Enclosure 2

Browns Ferry Nuclear Plant (BFN), Unit 1

Technical Specification (TS) Change TS-473 - AREVA Fuel Transition

TVA Response to Request for Additional Information *(Non-Proprietary)*

RAI I: Deleted

NRC Question

Question was deleted prior to issuance of final RAI Letter.

TVA Response:

No response required.

RAI II: Results – 0.25 ft^2 SF-BATT|BB Top-Peaked Axial

NRC Question 1

Explain what is causing [[ ]] immediately following the opening of the break.

TVA Response:

The Main Steam Isolation Valves (MSIVs) are assumed to begin closing at the initiation of the Loss of Coolant Accident (LOCA). The MSIV closing time is 5 seconds based on plant data. At this time steam line flow becomes 0 lbm/sec, and the system energy loss out of the break in the recirculation pump discharge line is less than the power generated in the core. Therefore, system pressure increases. The main steam relief valves open at 27 seconds and maintain the system pressure at approximately 1185 psia until High Pressure Coolant Injection (HPCI) flow starts at 65.4 seconds (Reference 1 Table 6.2). HPCI operation condenses steam in the reactor downcomer which causes the reactor pressure to begin decreasing.

NRC Question 2

Identify the reactor scram signal.

TVA Response:

The reactor scram is based on an MSIV position of 90% open with a 0.07 second delay based on plant data.

Enclosure 2

NRC Question 3

Explain whether main steam line isolation is modeled, the source of the isolation signal, the time of isolation, and the effect that steamline isolation has on the accident sequence.

TVA Response:

Main steam line isolation is modeled. Based on the EXEM BWR-2000 methodology, the MSIVs are assumed to begin closing at time zero (time of break). MSIV closure at time zero is considered a conservative assumption and initiation is not required from actual instrumentation signals for the methodology. The accident sequence for the limiting LOCA case is presented in Table 6.2 of Reference 1. The impact of the MSIV modeling on the LOCA sequence is described in the following discussion. Two LOCA cases are considered. These are:

Case 1 - The limiting Two Loop Operation (TLO) LOCA case presented in Reference 1. The MSIVs start closing at the time of break and are fully closed at 5 seconds.

Case 2 - The break size and key LOCA parameters are the same as the TLO limiting LOCA (0.25 ft^2 SF-BATT/BB Top-Peaked Axial). The MSIV closure is initiated by the L1 trip so steam line isolation occurs later in the LOCA event.

Modeling MSIV closure initiation at the time of break will result in higher system pressure during the initial 250 seconds of the LOCA event for the Case 1 LOCA compared to Case 2. The higher system pressure will result in higher break flow and increased mass loss from the reactor vessel. Scram will occur on MSIV position for Case 1 (0.5 seconds after break). Scram will occur on a level trip approximately 10 seconds after the start of the LOCA Case 2. The time of scram will not have a direct impact on the final Peak Cladding Temperature (PCT) result because all of the initial fuel rod stored energy will be removed to the coolant before fuel rod heatup begins at approximately 200 seconds.

The time of the L2 and L1 trips will be approximately the same for both cases. The break flow will be higher for Case 1, but this will be offset by the higher steam line flow in Case 2. Since the L2 trip times will be approximately the same, the HPCI start time will be approximately the same for each case. As the LOCA transient progresses, the break flow will become the dominant factor impacting the level change in the downcomer so the jet pumps will uncover much sooner for Case 1. Lower plenum flashing will occur later for Case 1 because the reactor vessel pressure will be higher.

The MSIVs will close at approximately 50 seconds for Case 2 based on the L1 trip. After HPCI flow starts, Case 1 will depressurize at a higher rate than Case 2. By 250 seconds the system pressures for the two cases will be approximately equal. After this time the depressurization rate will be similar for the two cases. Low Pressure Core Spray (LPCS) flow will start when the LPCS high pressure cutoff is reached at 304 psia, and this time will be approximately the same for the two cases. The LPCS event times in the scenario will not be sensitive to the MSIV modeling assumption.

LPCI is not available for the SF-BATT/BB cases so the analysis results are not sensitive to the Recirculation Discharge Isolation Valve (RDIV) event times in Table 6.2 of Reference 1. The Automatic Depressurization System (ADS) valves will open at 600 seconds for each case based on operator action, and the blowdown will end approximately 40 seconds after ADS is activated.

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] A sensitivity analysis was performed which confirms the conclusions presented in the above discussion.

NRC Question 4

The NRC staff's own analyses, as well as additional data gathered by the staff during the BFN power uprate reviews, have indicated that steady-state bundle exit void fractions are quite high. For core conditions matching the small break LOCA initial conditions, provide steady-state void fraction as a function of assembly elevation for a hot channel from XCOBRA and indicate the limiting plane analyzed in HUXY. Justify any significant discrepancies between XCOBRA and the RELAX/HUXY model.

TVA Response:

The initial void fraction at the limiting plane of the limiting LOCA case is 0.750 in the RELAX hot channel model. XCOBRA is used in the EXEM BWR-2000 LOCA methodology to determine the radial peaking factor and axial power shape for each initial power/flow state point analyzed in the LOCA break spectrum. XCOBRA provides the pressure distribution in the hot channel, but the XCOBRA void fractions are not directly used. The XCOBRA calculated void fraction for the limiting LOCA case state point at the limiting plane is 0.707. The RELAX and XCOBRA void fractions at the limiting plane differ because:

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Attachment 1 - Figure 1 shows the XCOBRA steady-state void distribution as a function of distance above the bottom of the active fuel for the limiting LOCA case hot channel. The RELAX limiting plane void fraction is included in the plot.

Enclosure 2

NRC Question 5

Provide a plot of upper plenum liquid mass with higher resolution from 0-10000 lb from the period between 300 seconds and the end of the transient. Provide similar plots (i.e., increased resolution at the region of interest) of liquid mass for the core average, bypass, and hot channel regions and the lower plenum.

TVA Response:

Attachment 2 - Figures 2 to 6 show upper plenum liquid mass, total core liquid mass, bypass region liquid mass, hot channel total liquid mass, and lower plenum liquid mass for the 300 to 650 second time interval of the limiting LOCA case. The y-axis on each plot has been adjusted to provide increased resolution.

NRC Question 6

Identify the primary sources of increased lower plenum liquid mass from 350-450 seconds.

TVA Response:

The primary source of increased lower plenum liquid mass is flashing from the intact recirculation line and HPCI flow through the jet pumps between 350 – 450 seconds. When flashing begins in the intact recirculation line, the water volume in the line expands forcing flow out the line. Some of the flow exits through the jet pump nozzle and then into the lower plenum increasing the lower plenum mass. After 450 seconds, LPCS flow through the bypass and core increases the lower plenum mass.

NRC Question 7

Provide a higher resolution plot of hot channel inlet flow rate from 350–500 seconds. Trace the zero line through the plot.

TVA Response:

Attachment 3 - Figure 7 shows hot channel inlet flow for the 350 to 500 second time interval of the LOCA. [

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Enclosure 2

NRC Question 8

*Explain the phenomena causing the [[
]] drop in temperature of the hot channel coolant. What are the sources and directions of liquid flow in this time period?*

TVA Response:

The lower plenum fills during the period between 200 to 450 seconds due to HPCI flow and flow from the recirculation discharge lines (see Comment 6). The hot channel flow oscillates around zero during the time interval between 200 to 400 seconds (see Comment 7). There is almost no liquid in the hot channel so steam is not generated in the hot channel. Upward hot channel steam flow could result in counter-current flow limiting (CCFL) at the upper tie plate location which would prevent LPCS from flowing into the hot channel. However, the analysis results show that there is insufficient steam generation to cause CCFL. LPCS flow begins at 352.6 seconds. [

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NRC Question 9

Explain what causes [[ ]] in the 50-75 second time frame.

TVA Response:

HPCI begins at 65.4 seconds. The cold (120°F) HPCI water condenses reactor steam resulting in decreasing pressure.

NRC Question 10

Justify the selection of fuel channel nodalization.

TVA Response:

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NRC Question 11

Provide information concerning the thermal hydraulic characteristics of the bypass region (mixture level, liquid mass, quality).

TVA Response:

The figures in Attachment 4 are provided to show the thermal hydraulic characteristics of the bypass region for the limiting LOCA case.

Figure 8 - Limiting TLO Recirculation Line Break Bypass Mixture Level
Figure 9 - Limiting TLO Recirculation Line Break Bypass Mixture Level (300 to 650 Seconds)
Figure 10 - Limiting TLO Recirculation Line Break Bypass Liquid Mass
Figure 11 - Limiting TLO Recirculation Line Break Bypass Quality
Figure 12 - Limiting TLO Recirculation Line Break Bypass Quality (300 to 650 Seconds)

RAI III: Results – Break Spectrum, SF-BATT|BA, Pump Discharge

NRC Question 1

Explain why the predicted peak central temperature (PCT) ***[[*** ***]]*** *interval for the mid-peaked spectrum.*

TVA Response:

The Appendix K conservatism of 300°F clad superheat can result in variability in trends between break sizes. Once the 300°F clad superheat occurs during blowdown, Appendix K requires that a return to nucleate or transition boiling does not occur until after blowdown when reflood has been achieved in the LOCA analysis. This criterion is conservative, since the conditions are not allowed to return to nucleate or transition boiling even if the 300°F clad superheat was for a very short duration. In the case where conditions reach superheat at a certain time such as for the **[** **]** break, a decrease or increase in break size such as the **[** **]** and **[** **]** breaks could result in the superheat criterion being reached at a different time. In this case both **[** **]** and **[** **]** breaks reached the criterion earlier, which causes a significant increase in PCT. The trends may be smoother if the Appendix K criterion was not used.

NRC Question 2

Explain similar trends on the top-peaked spectrum on the ***[[*** ***]]*** *interval, and on the* ***[[*** ***]]*** *intervals.*

TVA Response:

Similar to the discussion above, variability is due to the timing of Appendix K conservatisms of 300°F clad superheat for each particular break.

NRC Question 3

Provide plots analogous to Figures 6.1 – 6.19 for each of the break sizes identified in 1 and 2 above to reinforce the discussion. Also provide tabulated sequences of events.

TVA Response:

Plots and event tables for the cases requested are supplied in Attachment 5.

RAI IV: Results – Break Spectrum, SF-BATT|BB

NRC Question 1

Explain why the mid- and top-peaked power shape PCTs are inverted for the 0.45 ft² break. Provide plots for the [[ ]] breaks and justify the coarseness of the break spectrum. Also provide tabulated sequences of events.

TVA Response:

For the [ ] break reflood occurs before core spray has reached rated flow. Core spray penetration is less at the center for this case, which results in higher PCT than the top peak axial case. For the [ ] break and smaller breaks, the center of the core uncovers later which results in lower mid-peaked PCTs. For the [ ] break, reflood occurs after rated core spray for both the mid- and top-peaked cases with the top-peaked case taking longer to reflood which causes it to have a higher PCT.

The maximum PCT is 1973°F at 0.25 ft² while the breaks above [ ] all have significantly lower PCTs [ ] than the maximum PCT. Breaks larger than [ ] depressurize without the need of ADS and would produce PCT results similar to those calculated in Reference 1 Table 6.6. The PCTs for both the mid- and top- peaked power shape breaks below [ ] have smooth temperature trends. There is no reason to believe that any breaks above [ ] contain a higher PCT than the maximum temperature of 1973°F.

Plots and event tables for the cases requested are supplied in Attachment 5.

Enclosure 2

RAI V: Initial Conditions and Input Parameters

NRC Question 1

The emergency core cooling system fluid temperature has been reduced from 125°F in previous analyses to 120°F. Explain and provide a justification for this change.

TVA Response:

For the previous analysis, the emergency core cooling system fluid temperature was determined from suppression pool temperature versus time data following a LOCA at Extended Power Uprate (EPU) power. The 120°F value is more reasonable for non EPU LOCA analysis, and is also consistent with the value used in the current GEH LOCA analysis of record.

NRC Question 2

Provide a copy of ANP-2912(P) Revision 0, "Browns Ferry Units 1, 2 and 3 105 percent OLTP LOCA Parameters Document."

TVA Response:

Based on discussion with the NRC Staff, the requested AREVA Proprietary document was provided for review at the AREVA NP Bethesda Office. NRC Staff has reviewed the document. No additional response is required.

RAI VI: Fuel Thermal Conductivity Degradation

NRC Question

Explain whether and how the RODEX2 fuel centerline temperature inputs to the RELAX/HUXY analyses are corrected for issues identified in NRC Information Notice 2009-23, "Nuclear Fuel Thermal Conductivity Degradation." If they are not corrected, explain why not.

Enclosure 2

TVA Response:

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ATTACHMENTS

- Supporting information for TVA response to RAI II Question 4
- Supporting information for TVA response to RAI II Question 5
- Supporting information for TVA response to RAI II Question 7
- Supporting information for TVA response to RAI II Question 11
- Supporting information for TVA response to RAI III Question 3

REFERENCES

- ANP-2908(P), Revision 0, Browns Ferry Units 1, 2, and 3 105% OLTP LOCA Break Spectrum Analysis, AREVA NP, March 2010.
- [ ]

Attachment 1

Attachment 2

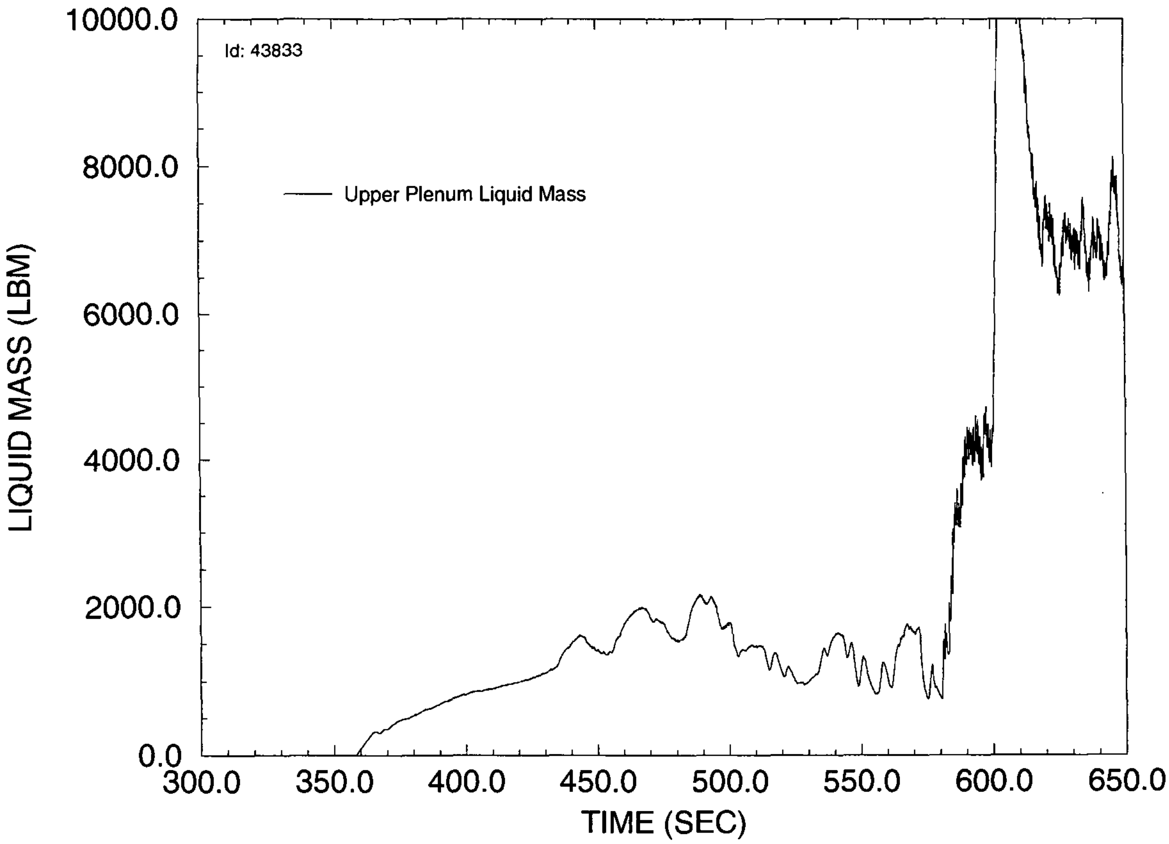

Figure 2 Limiting TLO Recirculation Line Break
Upper Plenum Liquid Mass (300 to 650 Seconds)

Attachment 2

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Attachment 2

Attachment 2

Attachment 2

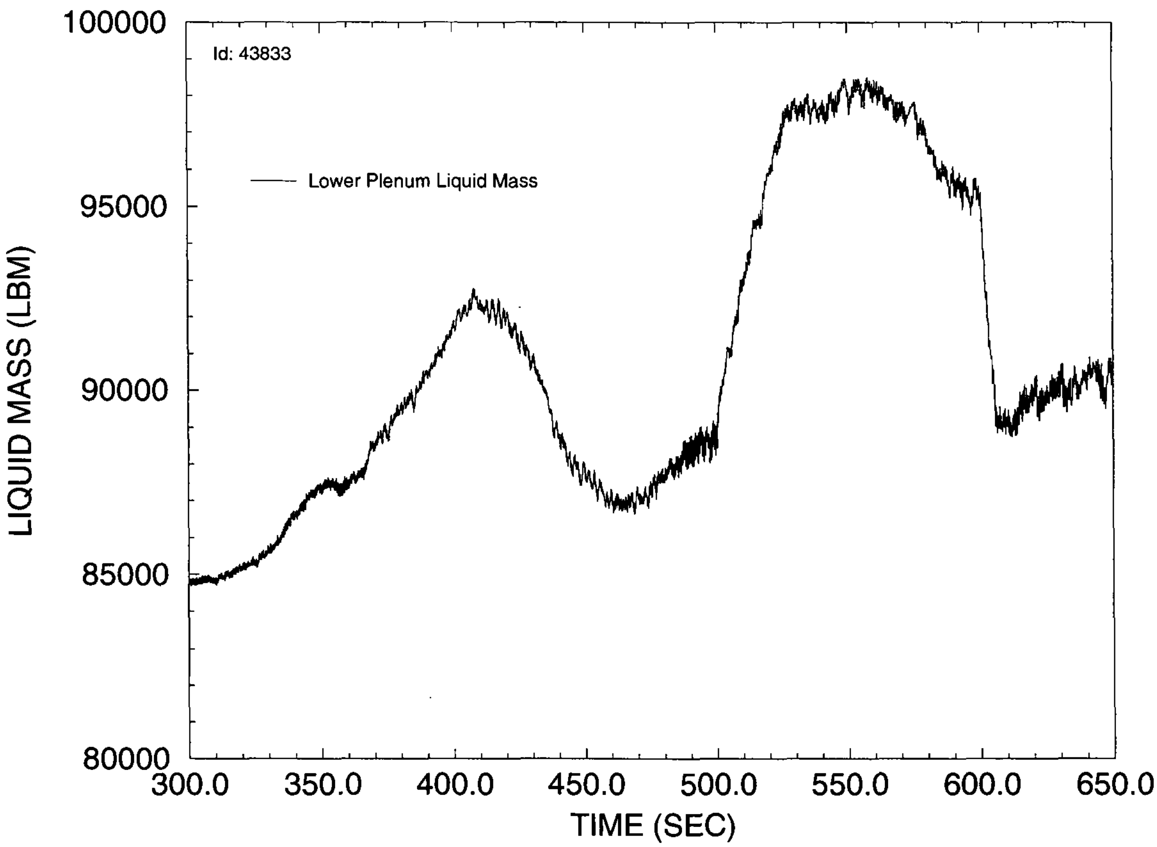

Figure 6 Limiting TLO Recirculation Line Break
Lower Plenum Liquid Mass (300 to 650 Seconds)

Attachment 3

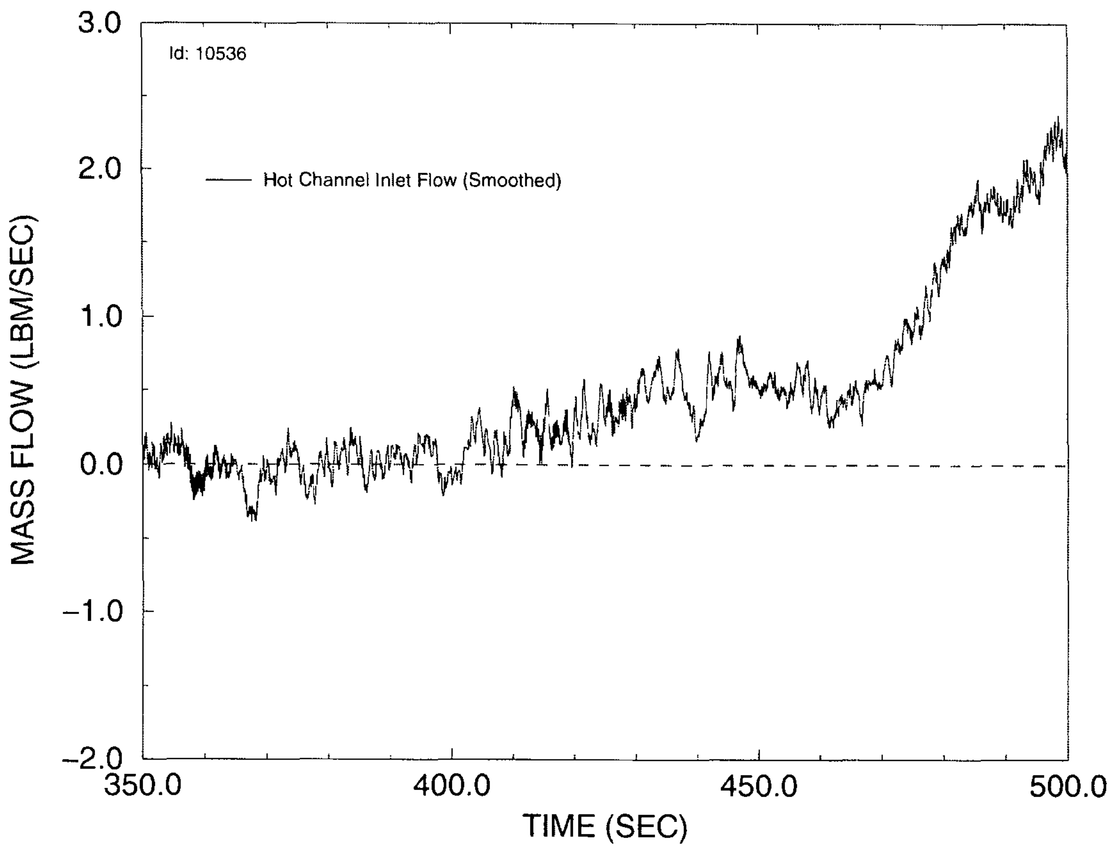

Figure 7 Limiting TLO Recirculation Line Break Smoothed Hot Channel Inlet Flow (350 to 500 Seconds)

Attachment 4

Attachment 4

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Enclosure 3

Browns Ferry Nuclear Plant, Unit 1

Technical Specification Change TS-473 - AREVA Fuel Transition

Affidavit

AFFIDAVIT

STATE OF WASHINGTON)
) ss.
COUNTY OF BENTON)

1. My name is Alan B. Meginnis. I am Manager, Product Licensing, for AREVA NP Inc. and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA NP to determine whether certain AREVA NP information is proprietary. I am familiar with the policies established by AREVA NP to ensure the proper application of these criteria.

3. I am familiar with the AREVA NP information contained in Enclosure 1 of the TVA Letter to USNRC entitled, "Response to NRC Request for Additional Information Regarding Amendment Request to Transition to AREVA Fuel (TAC NO. ME3775)," dated May 12, 2011 and referred to herein as "Document." Information contained in this Document has been classified by AREVA NP as proprietary in accordance with the policies established by AREVA NP for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA NP and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of proprietary information is made in accordance with 10 CFR 2.390. The information for which withholding from disclosure is

requested qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information."

6. The following criteria are customarily applied by AREVA NP to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA NP's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA NP.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA NP in product optimization or marketability.

(e) The information is vital to a competitive advantage held by AREVA NP, would be helpful to competitors to AREVA NP, and would likely cause substantial harm to the competitive position of AREVA NP.

The information in the Document is considered proprietary for the reasons set forth in paragraphs 6(b), 6(d) and 6(e) above.

7. In accordance with AREVA NP's policies governing the protection and control of information, proprietary information contained in this Document have been made available, on a limited basis, to others outside AREVA NP only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA NP policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

SUBSCRIBED before me this 12th day of May, 2011.

Susan K. McCoy
NOTARY PUBLIC, STATE OF WASHINGTON
MY COMMISSION EXPIRES: 1/10/12

SUSAN K. MCCOY
COMMISSION EXPIRES
NOTARY
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01-10-12
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