Tennessee Valley Authority, Post Office Box 2000, Decatur, Alabama 35609-2000

July 21, 2006

TVA-BFN-TS-431
TVA-BFN-TS-418

10 CFR 50.90

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Stop OWFN, P1-35
Washington, D. C. 20555-0001

Gentlemen:

In the Matter of	)	Docket Nos. 50-259
Tennessee Valley Authority	)	50-260
	)	50-296

BROWNS FERRY NUCLEAR PLANT (BFN) - UNITS 1, 2, AND 3 - TECHNICAL SPECIFICATIONS (TS) CHANGES TS-431 AND TS-418 - EXTENDED POWER UPRATE (EPU) - RESPONSE TO ROUND 6 REQUEST FOR ADDITIONAL INFORMATION (TAC NOS. MC3812, MC3743, AND MC3744)

By letters dated June 28, 2004 (ADAMS Accession No. ML041840109) and June 25, 2004 (ML041840301), TVA submitted applications to the NRC for EPU of BFN Unit 1 and BFN Units 2 and 3, respectively. On June 26, 2006, the NRC staff issued the Round 6 requests for additional information (RAIs) (ADAMS Accession Nos. ML061730002 and ML061680003 for BFN Unit 1 and BFN Units 2 and 3, respectively). By letter dated July 6, 2006, TVA provided a partial response to questions regarding General Electric fuel methods that support BFN Unit 1's EPU.

Enclosure 1 to this letter provides responses to sixteen of the RAI questions. TVA is preparing responses to the remaining nine Round 6 RAI questions, which will be provided to the NRC in the near future.

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NRC RAI questions APLA.23/25 (Unit 1/Units 2 and 3), ACVB.37/35, ACVB.39/37, ACVB.40/38, ACVB.41/39, ACVB.42/40, ACVB.49/47, ACVB.56/54, and ACVB.58/56 request detailed information pertaining to analyses associated with crediting available containment overpressure to ensure adequate net positive suction head (NPSH) for the low pressure emergency core cooling system (ECCS) pumps during analyzed events. TVA requires further time to prepare these responses due to the issues discussed during the June 28, 2006, meeting as further clarified during the telephone conference call held on July 19, 2006. TVA is revising certain analyses and associated calculations to resolve these issues and is planning periodic meetings and phone calls with the NRC staff to provide results as they are generated. TVA will provide the response to the RAI questions following the completion of the remaining analyses.

TVA has determined that the additional information provided by this letter does not affect the no significant hazards considerations associated with the proposed TS changes. The proposed TS changes still qualify for a categorical exclusion from environmental review pursuant to the provisions of 10 CFR 51.22(c)(9).

No new regulatory commitments have been made in this submittal.

If you have any questions regarding this letter, please contact me at (256)729-2636.

I declare under penalty of perjury that the foregoing is true and correct. Executed on this 21ST day of July, 2006.

Sincerely,

William D. Crouch

William D. Crouch
Manager of Licensing
and Industry Affairs

Enclosures:

1. Response to Round 6 Requests for Additional Information
2. BFN EPU Containment Overpressure (COP) Credit Risk Assessment

cc: (see page 4)

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ENCLOSURE 1

TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN)
UNITS 1, 2, AND 3

TECHNICAL SPECIFICATIONS (TS) CHANGES TS-431 AND TS-418 - EXTENDED POWER UPRATE (EPU) - RESPONSE TO ROUND 6 REQUESTS FOR ADDITIONAL INFORMATION (TAC NOS. MC3812, MC3743, AND MC3744)

RESPONSES TO REQUEST FOR ADDITIONAL INFORMATION

This enclosure provides TVA's response to sixteen of the NRC staff's June 26, 2006, Round 6 Requests for Additional Information (ADAMS Accession Nos. ML061730002 and ML061680003 for BFN Unit 1 and BFN Units 2 and 3, respectively). Because the same information was requested for all BFN units, the responses to the two sets of NRC Round 6 RAIs are combined below for all three BFN units. The following numbering of the RAI questions and responses corresponds to Unit 1, followed by Units 2 and 3 in the format of "(x/y)."

NRC RAI APLA.22/24

It is recognized that the need to have containment accident pressure for emergency core cooling system (ECCS) net positive suction head (NPSH) should be based on a realistic analysis consistent with current probabilistic risk assessment (PRA) practices, as contrasted to a deterministic, design-basis calculation that employs excessive conservatism. Discuss which typical PRA accident sequences realistically require containment accident pressure in order to ensure that the ECCS pumps remain functional. This should include sequences currently modeled in the Browns Ferry PRA models or similar sequences, not currently modeled, that could be risk-significant if containment accident pressure is necessary and not available. This should also consider realistic fire scenarios, such as those considered in the Individual Plant Evaluation of External Events for Severe Accident Vulnerabilities study.

TVA Response to RAI APLA.22/24

Each of the BFN PRAs was reviewed in detail to specifically determine the initiation events resulting in a suppression pool temperature increase that adversely impacts maintaining adequate NPSH for the RHR and Core Spray pumps. This review identified

four initiating events meeting this criterion: LOCA, ATWS, SBO, and stuck open main steam relief valve (MSRV).

As discussed in the TVA replies to NRC Request ACVB.29 (refer to TVA letters to NRC dated March 7, 2006; ADAMS ML060720248 and ML060680583 for Unit 1 and Units 2 and 3, respectively), the stuck open MSRV event is bounded by the LOCA.

Events outside the scope of the BFN PRA were also reviewed regarding the associated suppression pool heatup. This review identified that the Appendix R event results in an elevated suppression pool temperature. Therefore, the events within the scope of review for adequate availability of COP were LOCA, ATWS, SBO, and Appendix R.

NRC RAI APLA.24/26

For each accident sequence in [NRC Request APLA.23/25] above, estimate the risk associated with the need for that accident pressure (i.e., the risk above the level that would exist if the ECCS pumps could function satisfactorily without the need for containment accident pressure). While a realistic core damage frequency and large early release frequency are the desired metrics for this risk estimate, the licensee may utilize sensitivity studies, bounding analyses or qualitative arguments, where appropriate, provided all conclusions are substantially supported by the discussion.

TVA Response to RAI APLA.24/26

For the ATWS and SBO events, BFN has completed an evaluation to determine the risk impact of utilizing containment overpressure (COP) to satisfy the NPSH requirements for the RHR and core spray pumps. This evaluation was accomplished in accordance with the guidelines contained in RG 1.174, Revision 1, and used the BFN Unit 1 Probabilistic Risk Assessment (PRA) internal events model (including internal flooding). This model was revised previously to account for the core damage frequency (CDF) and large early release frequency (LERF) changes due to crediting COP during the large LOCA events. Refer to TVA's March 23, 2006, letters to the NRC (ADAMS ML060880460 and ML060880395 for Unit 1 and Units 2 and 3, respectively).

The evaluation determined that the change in CDF and LERF is very small when crediting COP for the RHR and core spray pumps during the ATWS and SBO events. The BFN report for COP credit risk assessment is provided as Enclosure 2. The report

concludes that the use of COP to satisfy the NPSH requirements for the RHR and core spray pumps (during large LOCA, ATWS, and SBO events) represents a very small change in CDF (2.4E-08/yr.) and LERF (2.4E-08/yr.).

For fire events not modeled in the BFN PSA, a qualitative evaluation of realistic postulated fires shows that it is unlikely that fire damage would result in the need for containment overpressure to maintain adequate NPSH for the ECCS pumps. Each of the three BFN units is segregated into five distinct areas regarding the effects for a postulated fire. These five areas are the control room, reactor building, turbine building, Units 1 and 2 diesel generator building, and Unit 3 diesel generator building. The fire protection design includes physical separation between these areas that provides reasonable assurance a realistic fire in one area will not propagate to another area. The fire protection system provides detection and suppression specifically designed, based on the contents of the area, to limit the extent of damage from a realistic fire. The consideration of a postulated fire has also provided for a design approach within each area that physically separates redundant and diverse trains of ECCS equipment so the propagation of a postulated fire affecting more than one train of equipment is remote. For a postulated fire, successful mitigation regarding NPSH for ECCS pump operation is accomplished by any one of the following scenarios:

1) using the balance of plant equipment to dissipate the reactor heat (results in no suppression pool temperature increase),

2) using two or more RHR pumps and associated RHRSW pumps in the suppression pool cooling mode of operation (suppression pool temperature is maintained low enough that containment overpressure is not required), or

3) adequate containment overpressure is maintained by containment isolation.

For a postulated fire in the control room, each of the units has a backup control system specifically designed, constructed, and operated to provide isolation of control room electrical circuits. The backup control system assures operation of adequate onsite AC and DC power systems and a dedicated train of equipment to shutdown the reactor, depressurize the reactor, and maintain reactor vessel water level. Two RHR pumps and associated RHRSW pumps are provided with backup control for

suppression pool cooling. With two RHR pumps in the containment cooling mode of operation, the suppression pool temperature is maintained low enough to maintain adequate NPSH for the operating ECCS pumps without containment overpressure.

For a postulated fire in the reactor building, the offsite AC power and associated control power systems needed to operate the balance of plant equipment remain available. This balance of plant equipment provides reactor pressure control and decay heat removal with the turbine control system, and reactor vessel water level control with the feedwater/condensate control systems. The availability and utilization of the balance of plant equipment avoids addition of heat to the suppression pool and the need for containment overpressure. A fire in the reactor building could adversely impact components associated with the operation of the main steam isolation valves (MSIVs), potentially resulting in closure of one or more MSIVs. If the fire extends to the point that one of the MSIVs in each of the four steam lines is closed, the impact would be isolation of the reactor vessel from the condenser.

The fire protection system provides detection and suppression specifically designed, based on the contents of the reactor building, to limit the extent of damage from a realistic fire. The consideration of a postulated fire has also provided for a design approach within the reactor building that physically separates redundant and diverse trains of ECCS equipment. A minimum number of main steam relief valves (MSRVs) would be available to reduce reactor vessel pressure and allow the concurrent use of the condensate system to maintain reactor vessel water level. This combination of equipment would avoid the need for containment overpressure.

For a postulated fire in the turbine building, the control room and reactor building contain the equipment required to support reactor shutdown. This fire could adversely impact the availability of offsite AC power. However, the control room and reactor building contain the equipment for supplying onsite AC and DC power for the ECCS. In this case, at least two RHR pumps and associated RHRSW pumps would be available for suppression pool cooling. With two RHR pumps in the containment cooling mode of operation, the suppression pool temperature is maintained low enough to ensure adequate NPSH for the operating ECCS pumps without containment overpressure.

For a fire in either diesel generator building, normal power would remain available to all three units. The condenser would

be available as a heat sink and the reactor feedwater system would be available to supply water to the reactor vessel. The availability and utilization of the balance of plant equipment avoids addition of heat to the suppression pool and the need for containment overpressure.

NRC RAI ACVB.38/36

The current Updated Final Safety Analyses Report Table 14.6-4 shows a higher drywell volume for Case 3, the limiting case for drywell pressure and temperature, than for Cases 1, 2 and 4. Discuss why there is a larger drywell volume assumed for this case, and whether the same assumption is made for the extended power uprate (EPU).

TVA Response to RAI ACVB.38/36

A range of drywell volumes was specified for the BFN containment analyses. The limiting (more conservative) volumes were chosen for the different containment analyses. For the short-term DBA-LOCA analyses, performed in support of the hydrodynamic loads assessment, a smaller drywell volume produced limiting results. For the analyses performed to establish a peak drywell pressure, the larger drywell volume produced limiting results. The short-term containment analyses, performed for the EPU, were also performed considering this range of drywell volumes. The EPU short-term DBA-LOCA containment analyses, performed to establish the peak drywell pressure, used a volume of 171,000 ft^3, whereas the analyses performed in support of the hydrodynamic evaluations used the smaller volume of 159,000 ft^3.

Basis for Use of Smaller (159,000 ft^3) Drywell Volume in Hydrodynamic Loads Evaluations

A smaller drywell volume produces a higher initial drywell pressurization rate, which results in a higher pool swell load. A smaller drywell volume also results in a higher drywell-to-wetwell pressure difference, which results in a higher vent mass flux and therefore a higher vent thrust load and a higher condensation oscillation load.

Basis for Use of Larger (171,000 ft^3) Drywell Volume to Calculate Peak Drywell Pressure

The peak drywell pressure is controlled by the break flow into the drywell and the vent flow out from the drywell. The break flow into the drywell is controlled by the critical break flow

from the vessel, which is independent of the drywell pressure conditions. However, the vent flow out from the drywell is controlled by the drywell-to-wetwell pressure difference. A higher wetwell pressure forces a higher drywell pressure to maintain the flow out from the drywell.

The peak drywell pressure occurs after the vents have cleared and a significant portion of the drywell non-condensible mass has been transferred to the wetwell. A larger drywell volume contains more non-condensible gas, which is available for transfer to the wetwell airspace. Therefore, a larger drywell volume results in a higher wetwell airspace pressure at the time of peak drywell pressure.

Because a larger drywell volume produces a higher wetwell pressure, it also produces a greater peak drywell pressure. For this reason, the larger drywell volume was used for Case 3 to establish the limiting condition for peak drywell pressure.

NRC RAI ACVB.43/41

Describe how the make-up of nitrogen to the drywell and wetwell atmospheres could serve as a verification of containment integrity during normal operation.

TVA Response to RAI ACVB.43/41

A discussion of nitrogen makeup monitoring was previously provided by TVA Responses to RAI SPSB-A.11 in the March 23, 2006, letters (ADAMS ML060880460 and ML060880395 for Unit 1 and Units 2 and 3, respectively):

> During normal power operations, the containment is inerted with nitrogen. Per TS LCO 3.6.2.6, "The drywell pressure shall be maintained 1.1 psid above the pressure of the suppression chamber." Per TRM LCO 3.6.5, "When the primary containment is inerted the containment shall be continuously monitored for gross leakage by review of the inerting system makeup requirements. Nitrogen makeup to the primary containment, averaged over 24 hours (corrected for drywell temperature, pressure, and venting operations), shall not exceed 542 scfh." Per TRM Surveillance Requirement (TSR) 3.6.5.1, "When the primary containment is inerted, the containment shall be continuously monitored for gross leakage by review of the inerting system makeup requirements." The

frequency for this TSR is "24 hours." Satisfying these requirements would identify any pre-existing leak in the drywell portion of containment.

The following is provided as additional discussion.

During plant operation, the BFN containment is inerted with nitrogen. Drywell pressure is maintained positive with respect to the suppression pool per TS 3.6.2.6. Although normal operating pressures in the drywell and suppression pool atmosphere are less than that resulting from a Design Basis Accident, the fact that the containment is pressurized provides a reliable means of verifying that no large leak paths exist in the containment structure. Specifically, any substantial containment leak path will result in operational difficulties in maintaining positive pressure in the containment and the condition will manifest itself in an excessive nitrogen make-up rate. Monitoring for containment leakage is accomplished by monitoring the average daily nitrogen consumption used by the containment inerting system and is determined daily. Significant containment leakage would be identified through increased nitrogen usage needed to maintain the required TS pressure.

<u>NRC RAI ACVB.44/42</u>

Describe the measures taken to ensure that all containment penetrations are properly isolated prior to and during operation.

<u>TVA Response to RAI ACVB.44/42</u>

Primary containment integrity including control of primary containment penetrations is strictly detailed by the BFN Technical Specifications (Section 3.6) and implemented via plant procedures.

- The primary containment air lock (TS 3.6.1.2) is a double door with limit switches on both doors that provide control room indication of door position.

- Primary containment isolation valves (TS 3.6.1.3) are controlled under plant procedures that provide strict valve controls. Aspects include valve line-up checklists, locking of specific valves, second party verification or independent verification of valve manipulations, and periodic surveillance of positions for accessible valves.

Additionally, automatic containment isolation valves include position indications on the control room panels.

NRC RAI ACVB.45/43

Describe any other actions/programs which contribute to assurance that the containment is isolated.

TVA Response to RAI ACVB.45/43

Another sign of loss of integrity would be the presence of oxygen gas in containment. BFN Technical Specification (TS) 3.6.3.2 requires that the primary containment oxygen concentration be maintained less than 4.0 volume percent during reactor power operation. Oxygen monitors provide assurance that the oxygen concentration in containment is less than the TS limit. If a greater concentration of oxygen were detected, the operators would take the appropriate action in accordance with procedures.

NRC RAI ACVB.46/44

Address whether the RHR and core spray pumps can be throttled to increase available NPSH and decrease required NPSH. Discuss what, if any, guidance is provided in the emergency operating instructions (EOIs) or abnormal operating instructions regarding throttling these pumps to preserve NPSH margin during accident conditions.

TVA Response to RAI ACVB.46/44

The BFN RHR and core spray pumps can be throttled to increase available NPSH and decrease required NPSH. A discussion of EOI instructions was previously provided by the TVA Response to RAI ACVB.23 in the March 7, 2006 letter (ADAMS ML060720248 and ML060680583 for Unit 1 and Units 2 and 3, respectively). The following is provided as additional discussion.

RHR NPSH and CS NPSH limit curves are presented in the EOIs to provide the operators with guidance on NPSH margin. These curves are generated in accordance with the EPGs. Separate figures are provided for RHR and CS pumps. Each figure includes a set of curves for 0, 5, 10, and 15 psig containment pressures which correlate acceptable NPSH for varying suppression pool temperature and pump flow. Accordingly, based on containment

pressure and suppression pool temperature, the operator can determine acceptable pump flows to maintain acceptable NPSH.

NRC RAI ACVB.47/45

Discuss whether any of the units have features to automatically terminate drywell or wetwell spray. Describe the conditions under which the operator would terminate drywell and/or wetwell spray under accident conditions in accordance with the EOIs. Address those measures put in place to prevent an operator from reducing wetwell pressure below that needed for adequate available NPSH.

TVA Response to RAI ACVB.47/45

The Unit 1 EOIs are being prepared for restart.

The BFN units do not have features to automatically terminate drywell or wetwell sprays.

The BFN EOIs do not contain any NPSH specific conditions under which operator would terminate drywell or wetwell spray. The drywell and wetwell spray approach that will be defined by the EOIs has been used as input to the containment analyses to assure consistency regarding containment spray operation. The containment analyses results demonstrate that following a LOCA, continuous containment spray will not prevent adequate available NPSH.

In response to NRC Requests ACVB.40/38 and 56/54, TVA is performing additional analyses for the Appendix R, ATWS, and SBO events. The analyses will include the use of drywell sprays where appropriate in order to assess the effect on the containment pressure response.

NRC RAI ACVB.48/46

In a letter dated September 4, 1998 letter, Tennessee Valley Authority (TVA) requested the use of containment overpressure for Units 2 and 3. The letter stated that the short term NPSH analysis assumes a double-ended recirculation pump discharge line break while the long term analysis assumes a double-ended suction line break. Address whether this is the case for the EPU analyses. Any difference in assumptions should be explained.

TVA Response to RAI ACVB.48/46

The EPU containment calculation for NPSH evaluations, including assumptions, was previously provided by Enclosure 7 to the March 23, 2006, letters to the NRC (ADAMS ML060880460 and ML060880395 for Unit 1 and Units 2 and 3, respectively). As supplied in Table 7-2, "Assumptions for DBA LOCA Short-Term NPSH Evaluation," of that submittal, the EPU short-term NPSH analysis assumes a double-ended recirculation discharge line break. As supplied in Table 7-3, "Assumptions for DBA LOCA Long-Term NPSH Evaluation," of that submittal, the EPU long-term NPSH analysis assumes a double-ended suction line break. An explanation of the assumptions are included in Tables 7-2 and 7-3 in Enclosure 7 to the March 23, 2006, letters.

NRC RAI ACVB.50/48

Using Figure ACVB 7-1 of the March 7, 2006, letter, explain the physical occurrences which result in (1) the reduction in the steep slope at approximately 2 seconds; (2) the small sudden increase at approximately 8 seconds; and (3) the following steep decrease. Discuss at what time the torus-to-drywell vacuum breakers to actuate.

TVA Response to RAI ACVB.50/48

(1) Reduction in the steep drywell pressure slope at approximately 2 seconds

The change in the drywell pressure response near two seconds is driven by changes to the break flow into the drywell and vent flow out from the drywell during the first two seconds.

Break Flow

During the initial 2 seconds, the break flow is established by the critical break flow rate at the recirculation line break location which is controlled by the break area and by the pressure and enthalpy conditions at the break. The flows into the break region are established by the critical break flow at the minimum flow areas within the flow paths upstream of the break location, and the conditions (enthalpy and pressure) in the vessel downcomer and lower plenum regions which feed the break. The flow out of the break during this initial 2 second phase is greater than the flow feeding the break since total break area is larger than the sum of the minimum flow areas upstream of the

break. This flow imbalance produces a continuous drop in break flow until the flow from the lower plenum and downcomer regions feeding the break is approximately equal to the flow out of the break. This condition occurs at approximately 2 seconds.

After approximately 2 seconds, the break flow is effectively established by the flows feeding the break from the lower plenum and downcomer regions and is nearly constant until 8 seconds.

<u>Vent Flow</u>

During the first two seconds, the drywell pressure along with the drywell-to-wetwell pressure difference increase rapidly due to an initially high break flow rate and initially low vent flow rate. The increasing drywell-to-wetwell pressure difference produces an increasingly higher vent flow rate. By approximately 2 seconds, the vent flow increases to the point where it is sufficient to maintain a near constant difference between the drywell pressure and wetwell pressure.

<u>Combined Effect of Break Flow and Vent Flow</u>

The continuous reduction in break flow rate and increase in vent flow rate which occurs until approximately 2 seconds produces the change (reduction) in the drywell pressurization rate seen after 2 seconds.

(2) Occurrence of small sudden increase in drywell pressure at approximately 8 seconds; and (3) the following steep decrease

The sudden and temporary increase in drywell pressure at approximately 8 seconds occurs when the drop in vessel inventory produces an initial change in the break flow from all liquid break flow to a two-phase mixture of mostly liquid flow with some steam. The higher energy content associated with this flow mixture initially produces a temporary spike in the drywell pressure and temperature. However, the steam content of the break flow mixture rapidly increases thereafter. The increasingly higher steam content produces a rapid drop in the critical break flow rate and consequently the break mass flow rate to the drywell. The rapid reduction in the break mass flow rate offsets the effect of a higher enthalpy with a higher steam content on the drywell pressure response. This rapid reduction in the mass and energy release rate to the

drywell produces the steep drop in drywell pressure after approximately 8 seconds.

Time for torus-to-drywell vacuum breakers to actuate.

The time period used to generate Figure ACVB 7-1 covers the first 30 seconds of the DBA-LOCA. During this time, the drywell pressure is always greater than the wetwell airspace pressure. Therefore, for this analysis the torus-to-drywell vacuum breakers do not actuate. The long-term DBA-LOCA analysis shows that the torus-to-drywell vacuum breakers would open near 435 seconds. (See also Table ACVB. 53/51-1.)

NRC RAI ACVB.51/49

Page E1-3 of the letter dated September 4, 1998, indicates that containment pressure is only needed in the short term for the RHR pump at the maximum flow conditions and that "other pathways are available and functional without containment overpressure being relied upon." Discuss whether this is still true with the EPU NPSH analyses. If still true, elaborate on this statement.

TVA Response to RAI ACVB.51/49

In the EPU NPSH analysis, low pressure ECCS and containment heat removal pumps, RHR and core spray, require credit for containment pressure during some portion of the event scenario. No credit for other systems is taken in the NPSH analysis.

NRC RAI ACVB.52/50

In the safety evaluation dated September 3, 1999, on the credit for containment accident pressure in determining available NPSH, TVA discussed a 10-year frequency for suppression pool cleaning. Discuss whether suppression pool cleaning is still done on a 10-year frequency.

TVA Response to RAI ACVB.52/50

TVA designed the BFN suppression pool suction strainers assuming a frequency for cleaning the suppression pool of once every 10 years. The 10-year cleaning frequency is based on a conservatively-assumed sludge generation rate of 150 lbs. of dry sludge per year (Ref. NEDO-32686, "Utility Resolution Guidance for ECCS Suction Strainer Blockage").

A total of 1,500 lbs. of sludge was used in the design of the BFN ECCS strainers (see TVA letter to NRC dated July 25, 1997, "NRC Bulletin No. 96-03, Potential Plugging of Emergency Core Cooling Suction Strainers By Debris In Boiling-Water Reactors"). To ensure that the 1500 lb. limit is not exceeded, TVA has established a program for maintaining cleanliness and for determining the sludge generation rate for each suppression pool.

BFN suppression pool cleaning frequency and scope are based on either the conservative 150 lbs./year generation rate or a measured and calculated sludge generation rate. Using an assumed 150 lbs./year, cleaning would be required every 10 years. Because of the need to perform cleaning to support protective coating inspections, TVA anticipates cleaning to occur at least as often as a 10-year frequency. The important design consideration is the maintenance of the total debris loading below 1500 lbs.

NRC RAI ACVB.53/51

For Figures ACVB 7-3 and ACVB 7-4 from the March 7, 2006, letter, explain the physical occurrences that produce the significant changes in the shape of the curves as a function of time.

TVA Response to RAI ACVB.53/51

Table ACVB. 53/51-1 contains a chronology of the controlling phenomena and impact on the containment responses curves shown on Figure ACVB.7-3 (Drywell and Wetwell Pressure) and Figure ACVB.7-4 (Drywell and Suppression Pool Temperature).

Table ACVB.53/51-1
Chronology of Containment Response Curves

Time	Controlling Phenomena	Impact on Drywell Pressure and Drywell Temperature Figures ACVB 7-3 and 7-4	Impact on Wetwell Pressure Figure ACVB 7-3	Impact on Suppression Pool Temperature Figure ACVB 7-4
0- 27 seconds	Initial blowdown of vessel. Introduction of hot liquid break flow to the drywell from a pressurized vessel.	Increasing drywell pressure and temperature due to break flow mass and energy.	Increasing wetwell pressure mainly due to carryover of drywell air to the wetwell but also due to increase in wetwell airspace temperature and vapor pressure with increasing suppression pool temperature.	Increasing pool temperature due to break flow mass and energy transferred to the suppression pool through the vent system
27-60 seconds	Reactor vessel liquid elevation drops to the break elevation. Transition from liquid break flow to steam break flow results in a reduced break flow with intermittent liquid and steam flow to drywell.	Reduction in drywell pressure and temperature due to reduced break flow. The reduced break flow to the drywell creates a temporary imbalance between the steam formation rate in the drywell and the vent flow out the drywell at the beginning of this period. The drywell pressure and also the drywell-to-wetwell pressure difference fall which reduces the vent flow. This trend continues until a near constant drywell-to-wetwell pressure difference (and vent flow) is established which balances the reduced break flow (and drywell steam formation rate).	Carryover of drywell air to the wetwell is complete. Wetwell pressure continues to rise due to increasing wetwell airspace temperature and vapor pressure with increasing pool temperature.	Continued increasing suppression pool temperature as break flow mass and energy is transferred to the drywell and subsequently to the suppression pool via the vent system.

Table ACVB.53/51-1
Chronology of Containment Response Curves

Time	Controlling Phenomena	Impact on Drywell Pressure and Drywell Temperature Figures ACVB 7-3 and 7-4	Impact on Wetwell Pressure Figure ACVB 7-3	Impact on Suppression Pool Temperature Figure ACVB 7-4
60-116 seconds	Resumption of continuous liquid break flow due to vessel reflood following initiation of ECCS injection near 60 seconds. The vessel liquid temperature and therefore the break flow temperature remain higher than the drywell atmosphere temperature.	Increase in drywell pressure and temperature due to resumption of continuous flow of relatively hot break liquid.	Continued wetwell pressure increase due to increasing airspace temperature and vapor pressure with increasing suppression pool temperature.	Continued increasing pool temperature as mass and energy transfer from the drywell continues to the suppression pool.
116-411 seconds	The reactor vessel pressure drops below the drywell pressure due to cooling of the vessel liquid by ECCS injection. The vessel liquid elevation does not provide sufficient static head to maintain break flow to drywell. Break flow to the drywell stops. Vessel water level increases during this time due to ECCS injection.	Drywell pressure and temperature fall due to temporary stop in break flow.	During this time period, the suppression pool water removed by ECCS suction is greater than the return vent flow to the suppression pool. This reduces the suppression pool water volume and increases the wetwell airspace volume. The increase in the wetwell airspace volume produces a reduction in the wetwell airspace pressure	During this time, the pool temperature continues to rise but there is a reduction in the rise rate. This is attributed to the halt in the break flow to the drywell which reduces the vent flow to the pool.

Table ACVB.53/51-1
Chronology of Containment Response Curves

Time	Controlling Phenomena	Impact on Drywell Pressure and Drywell Temperature Figures ACVB 7-3 and 7-4	Impact on Wetwell Pressure Figure ACVB 7-3	Impact on Suppression Pool Temperature Figure ACVB 7-4
411-600 seconds	Near 411 seconds, the water level in the reactor vessel has increased to the point where there is sufficient static head in the vessel to allow resumption of near continuous liquid break flow to the drywell. Additionally, by 411 seconds, the vessel liquid temperature has dropped below the drywell atmosphere temperature due to the cooling effects of ECCS injection. This produces a liquid break flow with a temperature lower than the drywell atmosphere temperature. At 435 seconds, the wetwell (WW)- to - drywell (DW) vacuum breakers open. This allows wetwell air to flow back to the drywell.	The introduction of relatively colder break flow water into a hot drywell produces a rapid drop in both drywell temperature and pressure. The drywell pressure falls below the wetwell pressure near 435 seconds which induces the opening of the WW-to-DW vacuum breakers.	When the WW-to-DW vacuum breakers open near 435 seconds, wetwell air is transferred back to the drywell. This produces a rapid drop in the wetwell pressure which follows the drop in the drywell pressure.	The suppression pool temperature rise rate increases again during this time due to the resumption of break flow to the drywell and consequent increase in the vent flow to the pool.

Table ACVB.53/51-1
Chronology of Containment Response Curves

Time	Controlling Phenomena	Impact on Drywell Pressure and Drywell Temperature Figures ACVB 7-3 and 7-4	Impact on Wetwell Pressure Figure ACVB 7-3	Impact on Suppression Pool Temperature Figure ACVB 7-4
600 - 1200 seconds	At 600 seconds, the LPCI pumps are realigned from vessel injection mode to containment cooling mode. The RHR heat exchangers are aligned in containment spray mode including drywell and wetwell sprays. The re-alignment at 600 seconds results in the introduction of cold spray water to the drywell and wetwell airspace. This affects the drywell conditions directly. The effect on the wetwell conditions is indirect since thermodynamic equilibrium between the suppression pool water and wetwell airspace is assumed. This means that the WW airspace temperature is controlled by the pool temperature and not spray temperature. The realignment reduces the ECCS injection flow to the vessel. This reduction in ECCS flow produces a reduction in the break flow to the drywell.	The drywell spray causes the drywell temperature to fall below the temperature of the vessel liquid break flow. This results in a further increase in the drywell depressurization rate. The drywell pressure and temperature continue to drop rapidly until approximately 1200 seconds. By 1200 seconds, the difference between the drywell temperature and the colder drywell spray temperature is reduced to the point where the heat being transferred from the drywell atmosphere to the cold drywell spray water is approximately equal to the heat transferred back to the drywell atmosphere by the relatively hotter vessel break flow. This causes the halt in the drywell depressurization seen near 1200 seconds.	The rapid wetwell depressurization continues due to the flow of air from the wetwell to the drywell through the WW-to-DW vacuum breakers. Since the wetwell pressure follows the drywell pressure, the wetwell depressurization is halted when the drywell depressurization stops near 1200 seconds.	The suppression pool temperature continues to rise at a similar rate as during the previous period. During this time the effects of the RHR containment cooling on the suppression pool temperature are not yet pronounced.

Table ACVB.53/51-1
Chronology of Containment Response Curves

Time	Controlling Phenomena	Impact on Drywell Pressure and Drywell Temperature Figures ACVB 7-3 and 7-4	Impact on Wetwell Pressure Figure ACVB 7-3	Impact on Suppression Pool Temperature Figure ACVB 7-4
1200 - 18,700 seconds (time of peak suppression pool temperature).	During this time period there is near continuous liquid break flow to the drywell equal to the ECCS injection flow rate. Vessel sensible energy and decay heat energy are slowly transferred to the suppression pool in addition to pump heat. The vessel sensible energy and decay heat fall with time. The RHR heat exchangers, which were actuated at 600 seconds, continue to remove heat from the suppression pool. During this time, the heat removal rate by the RHR heat exchanger is less than the total heat addition rate to the suppression pool.	The drywell pressure slowly increases and peaks near the time of the peak suppression pool temperature (and peak wetwell pressure). The drywell pressure follows the wetwell pressure during this time period with the drywell pressure approximately equal to the wetwell pressure minus the WW-to-DW vacuum breaker setpoint pressure (0.5 psid). The drywell temperature is controlled by the combined effects of the vessel liquid break temperature and drywell spray temperature during this time. The vessel temperature (and therefore the break liquid flow temperature) decrease with time whereas the drywell spray temperature increases with time. These effects counteract each other resulting in a near constant drywell temperature response during this time.	The wetwell pressure slowly increases during this time period due to increasing airspace temperature and increasing vapor pressure with increasing suppression pool temperature.	The suppression pool temperature slowly rises during this time period due to the continued transfer of vessel sensible energy, decay heat and pump heat to the suppression pool. The temperature rise rate decreases with time as the decay heat is reduced. During this time, the rate of energy addition is greater than the rate of energy removal by the RHR heat exchanger. At the time of maximum suppression pool temperature (near 18,700 seconds), the rate of heat addition and heat removal from the pool are equal.

Table ACVB.53/51-1
Chronology of Containment Response Curves

Time	Controlling Phenomena	Impact on Drywell Pressure and Drywell Temperature Figures ACVB 7-3 and 7-4	Impact on Wetwell Pressure Figure ACVB 7-3	Impact on Suppression Pool Temperature Figure ACVB 7-4
18,700 seconds to end of analysis	During this time, there is a near continuous liquid break flow to the drywell which is equal to the ECCS injection flow rate. The vessel temperature and therefore the liquid break temperature slowly fall during this time due to the reduction in decay heat and the reduction in the ECCS injection water temperature. Containment spray temperature falls with falling pool temperature. Vessel sensible energy and decay heat energy are slowly transferred to the suppression pool in addition to pump heat. Decay heat continues to fall. The heat exchangers continue to remove energy from the suppression pool. During this time the heat removal rate by the RHR heat exchanger is greater than the total heat addition rate to the suppression pool.	The drywell pressure and temperature slowly fall during this time due to a decreasing break liquid temperature and decreasing drywell spray temperature.	The wetwell pressure falls during this time due to the decrease in the airspace temperature and decrease in the wetwell vapor pressure with falling suppression pool temperature.	The suppression pool temperature slowly decreases during this time due to the slow net decrease in suppression pool energy.

NRC RAI ACVB.54/52

Table ACVB 22-1 in response to ACVB 22 from the March 7, 2006, letter, states that the licensing basis calculation of NPSH assumes no heat sinks while the realistic calculation does. Address whether the reverse should be true to ensure conservatism. Also, see TVA reply to ACVB 27 and Table SPSB-A.11-2 which states that not crediting heat sinks is conservative.

TVA Response to RAI ACVB.54/52

Table ACVB.22-1, the response to ACVB.27, and Table SPSB-A.11-2 are based upon the efforts taken to provide re-analyses of the suppression pool temperature response to reflect realistic values. The containment analysis case that produces the peak suppression pool temperature (licensing basis case) assumes no credit for heat sinks. This is conservative as it maximizes suppression pool temperature. The realistic assumption would be to credit heat sinks. Table SPSB-A.11-2 includes some results of analyses with credit for heat sinks.

The containment analysis case that minimizes containment pressure includes credit for heat sinks. This is conservative as it will minimize containment pressure. No effort was taken to re-analyze this containment analysis case with realistic values.

NRC RAI ACVB.55/53

Table ACVB 22-1 in response to ACVB 22 from the March 7, 2006, letter, gives values of wetwell airspace and suppression pool volume that sum to different values for the realistic and the licensing basis values. Discuss whether the sums should be the same and equal to the total volume of the wetwell.

TVA Response to RAI ACVB.55/53

Table ACVB.22-1 was intended to provide an overview of realistic values that could be used in the NPSH calculations. The actual values that were modified in re-evaluating peak suppression pool temperatures utilizing realistic input values for selected parameters are listed in Table SPSB-A.11-2 of our March 23, 2006, letter.

Although wetwell airspace free volume and suppression pool volume are directly linked, their influence on NPSH calculations is different. A larger value for suppression pool volume would

provide a greater heat sink and result in a lower peak suppression pool temperature. Since this change would reduce the need for containment overpressure for pump NPSH, a larger realistic value based on a nominal value for this parameter was provided in Table ACVB.22-1. A corresponding smaller value for wetwell airspace free volume (to maintain the same total volume of the wetwell) would provide a smaller initial containment volume and could result in a higher available containment overpressure. Since this would not decrease the need for containment overpressure for pump NPSH, the realistic value for this parameter was not changed from the licensing basis value for this parameter in Table ACVB.22-1.

NRC RAI ACVB.57/55

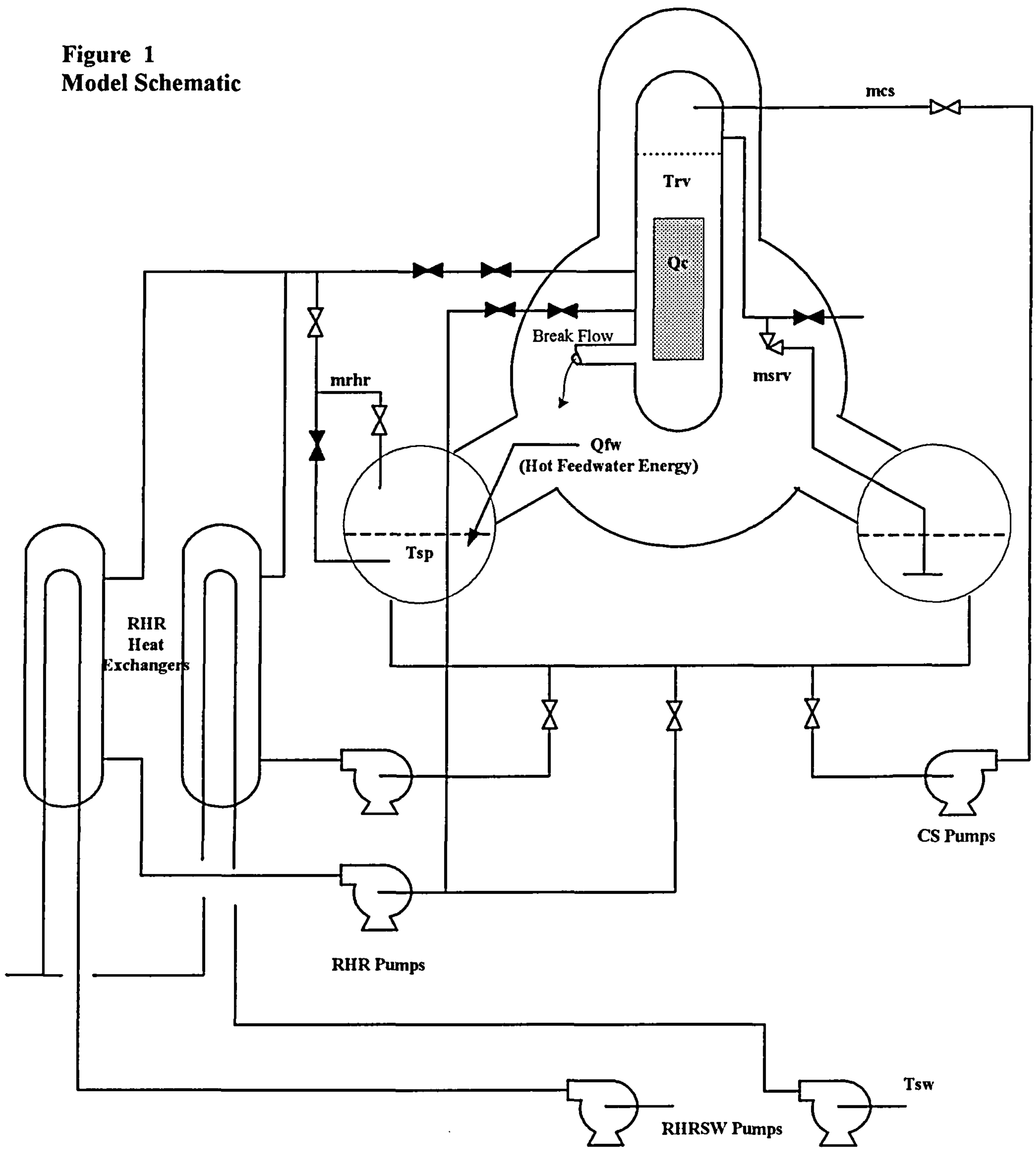
The response to RAI SPSB-A.11 provided Table SPSB-A.11-2, which contains calculations of suppression pool temperature with various assumptions. The cases are identified as either GE or TVA. Describe the analytical methods used for the TVA calculations and the steps taken to ensure a meaningful comparison with SHEX.

TVA Response to RAI ACVB.57/55

The TVA analytical method employed in the sensitivity study cases reported in Table SPSB-A.11-2 uses a simple, one-dimensional model of the suppression pool, the RCS and the RHR system, developed as shown in the attached schematic diagram (Figure ACVB.57/55-1). The mass and energy balance equations for this system were solved for suppression pool temperature. In order to ensure a meaningful comparison with design basis analysis methods, the model was benchmarked against existing GE results obtained with SHEX as shown in Case 1a of Table SBSB-A.11-2. The range of input parameters used to generate additional cases is limited to small changes and basic thermodynamic principles to ensure that the benchmarking remains valid. TVA and GE case results given in Table SPSB-A.11-2 are consistent over the range of parameters used in the sensitivity analysis.

Figure ACVB.57/55-1
Model Schematic

Figure 1
Model Schematic



ENCLOSURE 2

TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN)
UNITS 1, 2, AND 3

TECHNICAL SPECIFICATIONS (TS) CHANGES TS-431 AND TS-418 - EXTENDED POWER UPRATE (EPU) - RESPONSE TO ROUND 6 REQUESTS FOR ADDITIONAL INFORMATION (TAC NOS. MC3812, MC3743, AND MC3744)

BFN EPU CONTAINMENT OVERPRESSURE (COP) CREDIT RISK ASSESSMENT

(SEE ATTACHED)