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

February 28, 2005

TVA-BFN-TS-418

10 CFR 50.90

U.S. Nuclear Regulatory Commission
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Washington, D.C. 20555-0001

Gentlemen:

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

BROWNS FERRY NUCLEAR PLANT (BFN) - UNITS 2 AND 3 - TECHNICAL SPECIFICATIONS (TS) CHANGE TS-418 - RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION SPSB-A.11 REGARDING EXTENDED POWER UPRATE - CREDIT FOR NET POSITIVE SUCTION HEAD (TAC NOS. MC3743 AND MC3744)

This letter provides TVA's supplemental responses to the NRC request for additional information SPSB-A.11 regarding an assessment of the credit for containment overpressure against the five key principles of risk-informed decision making.

On June 25, 2004 (Reference 1), TVA requested a TS change to allow Units 2 and 3 to operate at extended power uprate conditions. As part of this TS change, TVA requested approval for extending the existing credit for containment overpressure in order to provide adequate net positive suction head (NPSH) to the Emergency Core Cooling System (ECCS) pumps. On October 3, 2005 (Reference 2), NRC requested TVA provide additional information regarding the ECCS pumps NPSH, including an assessment of the credit for containment overpressure against the five key principles of risk-informed decision making. The requested additional information is provided as Enclosure 1 to this letter. A detailed chronology of the correspondence related to the previous approval of NPSH for

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pre-uprate conditions is provided in Enclosure 2. A detailed description of plant systems related to the NPSH analysis is provided in Enclosure 3. The supporting risk assessment is provided as Enclosure 4.

The use of containment overpressure to ensure adequate NPSH for ECCS pumps during a limited time after a design basis accident is consistent with NRC staff positions, including Revision 3 of Regulatory Guide 1.82, and is part of the current licensing and design basis for Browns Ferry Units 2 and 3. Crediting containment overpressure results in a small increase in core damage frequency (CDF) and large early release frequency (LERF) of 1.53x10-9/yr. This small increase is well below the guidelines provided in Regulatory Guides 1.174 (10-6/yr for CDF and 10-7/yr for LERF).

TVA has determined that the additional information provided 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).

If you have any questions about this submittal, please contact me at (256) 729-2636. I declare under penalty of perjury that the foregoing is true and correct. Executed on February 28, 2006.

Sincerely,

William D. Crouch

William D. Crouch
Manager of Licensing
and Industry Affairs

References:

1. TVA letter, dated June 25, 2004, "Browns Ferry Nuclear Plant (BFN) - Units 2 and 3 - Proposed Technical Specifications (TS) Change TS-418 - Request for License Amendment Extended Power Uprate (EPU) Operation."

2. NRC letter, dated October 3, 2005, "Browns Ferry Nuclear Plant, Units 2 and 3 - Request for Additional Information for Extended Power Uprate (TS-431) (TAC Nos. MC3743 and MC3744)."

Enclosures:

1. Response to NRC Request for Additional Information Regarding Proposed Technical Specification (TS) TS-418 Extended Power Uprate - Credit for Net Positive Suction Head.

2. Detailed Chronology of Correspondence Related to the Previous Approval of NPSH for Pre-uprate Conditions

3. Detailed Description of Plant Systems Related to the NPSH Analysis

4. BFN Extended Power Uprate Containment Overpressure Credit Risk Assessment

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ENCLOSURE 1

TENNESSEE VALLEY AUTHORITY (TVA)

BROWNS FERRY NUCLEAR PLANT (BFN) UNITS 2 AND 3

RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION

REGARDING PROPOSED TECHNICAL SPECIFICATION (TS) TS-418

EXTENDED POWER UPRATE - CREDIT FOR NET POSITIVE SUCTION HEAD

NRC REQUEST SPSB-A.11

As part of its EPU submittal, the licensee has proposed taking credit (Unit 1) or extending the existing credit (Units 2 and 3) for containment accident pressure to provide adequate net positive suction head (NPSH) to the ECCS pumps. Section 3.1 in Attachment 2 to Matrix 13 of Section 2.1 of RS-001, Revision 0 states that the licensee needs to address the risk impacts of the extended power uprate on functional and system-level success criteria. The staff observes that crediting containment accident pressure affects the Probabilistic Risk Assessment (PRA) success criteria; therefore, the PRA should contain accident sequences involving ECCS pump cavitation due to inadequate containment pressure. Section 1.1 of Regulatory Guide (RG) 1.174 states that licensee-initiated licensing basis change requests that go beyond current staff positions may be evaluated by the staff using traditional engineering analyses as well as a risk-informed approach, and that a licensee may be requested to submit supplemental risk information if such information is not submitted by the licensee. It is necessary to consider risk insights, in addition to the results of traditional engineering analyses, while determining the regulatory acceptability of crediting containment accident pressure.

Considering the above discussion, please provide an assessment of the credit for containment accident pressure against the five key principles of risk-informed decision making stated in RG 1.174 and SRP Chapter 19. Specifically, demonstrate that the proposed containment accident pressure credit meets current regulations, is consistent with the defense-in-depth philosophy, maintains sufficient safety margins, results in an increase in core-damage frequency and risk that is small and consistent with the intent of the Commission's Safety Goal Policy Statement, and will be monitored using performance measurement strategies. With respect to the fourth key principle (small increase in risk), provide a quantitative risk assessment that demonstrates that the proposed containment accident pressure credit meets the numerical risk acceptance guidelines in Section 2.2.4 of

RG 1.174. This quantitative risk assessment must include specific containment failure mechanisms (e.g., liner failures, penetration failures, primary containment isolation system failures) that cause a loss of containment pressure and subsequent loss of NPSH to the ECCS pumps.

TVA RESPONSE

INTRODUCTION

The proposed change for BFN Units 2 and 3 Extended Power Uprate (EPU) includes increasing the pressure which is credited for containment overpressure (COP) in ensuring adequate NPSH to Emergency Core Cooling System (ECCS) pumps following limiting events which cause suppression pool temperature increase. These events are Loss of Coolant Accident (LOCA), Anticipated Transients Without Scram (ATWS), Appendix R and Station Blackout (SBO). COP is defined for BFN as containment pressure in excess of 14.4 PSIA. For the Design Basis Accident (DBA) LOCA, the need to credit COP is due only to consideration of a number of worst case assumptions. More realistic analyses show that elimination of worst case assumptions that have reasonable probability distributions would eliminate the need for COP credit. Results of realistic analyses are presented along with associated probability distributions.

Parameters affecting NPSH were included in a modified PRA model along with probability distributions to show the risk impact associated with reliance on containment integrity and overpressure for ECCS pump NPSH.

RG 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis" was utilized as a guide for providing risk insights and more realistic analyses to supplement the deterministic analyses and worst case assumptions used in the licensing basis LOCA analysis. These risk insights are used to characterize the degree to which COP is relied upon in the safety design basis.

BACKGROUND

The following provides an abbreviated background for ECCS strainer issues and the use of COP. An in-depth discussion of the regulatory background is provided in Enclosure 2.

Previously, BFN Units 2 and 3 installed new large capacity ECCS strainers to meet the requested actions of NRC Bulletin 96-03, "Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling-Water Reactors." As part of the resolution of Bulletin 96-03, credit for available COP to maintain adequate NPSH following a LOCA was required. BFN requested a change to the licensing basis for Units 2 and 3 in Reference 1 (as supplemented by Reference 2) and received NRC approval for the requested change in Reference 3.

For EPU, BFN is proposing a change in the licensing basis to extend the existing approved credit for COP to provide adequate NPSH following a LOCA for Units 2 and 3.

Currently for BFN Units 2 and 3, Reference 3 approves the crediting of 3 psi COP for the Residual Heat Removal (RHR) pumps for the first 10 minutes following a LOCA (short-term requirement) and 1 psi COP for the core spray pumps from approximately 5500 to 35000 seconds (about 8.2 hours) following a LOCA (long-term requirement). For EPU, BFN is requesting for all three units approval of 3 psi COP for the RHR pumps for the first 10 minutes following a LOCA (short-term requirement) and 3 psi COP for the core spray pumps from approximately 4,100 to 52,300 seconds (about 13.4 hours) following a LOCA (long-term requirement).

As part of the EPU effort, BFN has also given more consideration for NPSH requirements during Appendix R, ATWS, and SBO events. These events (designated as Special Events at BFN) were not addressed in response to Generic Letters 96-03 and 97-04 and are not addressed in Regulatory Guide (RG) 1.82. Conservative evaluation of these events determined that BFN will credit available containment pressure for the RHR pumps following an SBO, ATWS, and Appendix R events.

SYSTEM DESCRIPTION

The following provides an abbreviated system description. An in-depth description of the BFN containment and ECCS systems is provided in Enclosure 3. The BFN units are BWR-4s with Mark I containments, which incorporate a large torus shaped suppression pool. Four RHR pumps and four Core Spray pumps take suction from the suppression pool through a common ring header which connects to the torus at four locations through a stacked disc strainer mounted on each nozzle. The ECCS ring header is also the alternate suction for the High Pressure Core Injection

(HPCI) and Reactor Core Isolation Cooling (RCIC) system pumps. The normal suction path for the HPCI and RCIC system pumps is the condensate storage tank (CST).

The four strainers are not associated with individual pump suctions but direct suppression pool water to the common ECCS ring header. Therefore, interaction between operating pumps is considered when determining pump suction pressures.

LOCA EVENT DESCRIPTION

SHORT TERM (T<10 minutes)

The bounding design basis event for determining NPSH margin is a double ended recirculation discharge line break. This event results in maximum suppression pool temperature and maximum total pump flow. The discharge line break is chosen because the low system resistance on the broken line produces the most limiting flow and NPSH for two RHR pumps which are assumed to be pumping into the broken line inside containment. At the beginning of the event, four RHR pumps and four Core Spray pumps start automatically and align to inject to the Reactor Pressure Vessel (RPV). Two RHR pumps inject to the RPV at 10,000 gpm each, two RHR pumps inject through the broken line into the containment at 11,000 gpm each (greater than design flow), and four Core Spray pumps inject to the RPV at 3,125 gpm each. This mode of operation is assumed for 10 minutes consistent with not crediting operator action for 10 minutes. ECCS strainers are assumed to accumulate the maximum equilibrium debris load. During this time suppression pool temperature reaches 155.4°F and only the RHR pumps require credit for COP in order to have sufficient NPSH margin as shown in Figure 1.

LONG TERM (T>10 minutes)

At 10 minutes, operator action is assumed which places the minimum complement of ECCS pumps into modes required for long term cooling. Two Core Spray pumps (one loop) at design flow of 3,125 gpm each are assumed for core cooling, and two RHR pumps in one loop in containment cooling mode at 6,500 gpm each are assumed for pool cooling. Containment spray mode of containment cooling is chosen to minimize available containment pressure. Only two of four RHR pumps are assumed for pool cooling due to single failure considerations. ECCS strainers are assumed to accumulate the maximum equilibrium debris load. During this time suppression pool temperature reaches 187.4°F and only the two Core Spray pumps require credit for COP in order to have sufficient NPSH margin as shown in Figure 2.

REGULATORY GUIDE 1.174 ASSESSMENT

RG 1.174, Section 2, provides the set of five key principles that licensing basis changes are expected to meet:

1. The proposed change meets the current regulations unless it is explicitly related to a requested exemption or rule change, i.e., a "specific exemption" under 10 CFR 50.12 or a "petition for rulemaking" under 10 CFR 2.802.

2. The proposed change is consistent with the defense-in-depth philosophy.

3. The proposed change maintains sufficient safety margins.

4. When proposed changes result in an increase in core damage frequency or risk, the increases should be small and consistent with the intent of the Commission's Safety Goal Policy Statement (Ref. RG 1.175).

5. The impact of the proposed change should be monitored using performance measurement strategies.

1. CURRENT REGULATIONS

On June 25, 2004, TVA requested a TS change to allow Units 2 and 3 to operate at extended power uprate conditions. As part of this TS change, TVA requested approval for extending the existing credit for post-accident COP in order to provide adequate NPSH to the ECCS pumps.

TVA has reviewed the requested credit for COP against those aspects of the BFN licensing basis that may be affected by the proposed change, including rules and regulations, the Updated Final Safety Analysis Report (UFSAR), TSs, License Conditions, and licensing commitments. As previously discussed, NRC previously approved the use of COP to maintain adequate ECCS pump NPSH on BFN Units 2 and 3. The use of COP does not invalidate TVA's compliance with 10 CFR 50.54(o), Appendix J to 10 CFR 50, 10 CFR 50.46 and Appendix K to 10 CFR 50. The use of COP is discussed in UFSAR Section 6.5.5.

The approval of credit for post-accident COP is consistent with the NRC's Final Policy Statement on the Use of Probabilistic Risk Assessment Methods in Nuclear Regulatory Activities, is consistent with NRC staff positions, including Revision 3 of Regulatory Guide 1.82, and is part of the current licensing and design basis for Browns Ferry Units 2 and 3. The credit is supported by the BFN PRAs and the results satisfy the numerical targets contained in NRC Regulatory Guide 1.174. Alternatives which would preclude the need for the use of COP, such as the replacement of pumps or heat exchangers are not practical.

2. DEFENSE-IN-DEPTH

Defense in depth philosophy is maintained by avoiding over reliance on specific features, human actions and assumptions to ensure plant safety. By preserving the function of the ECCS, multiple barriers of fuel cladding and primary containment are maintained. The ECCS functions are being preserved by the proposed plant design and operation. For a LOCA, reliance on COP is only necessary assuming low probability combinations of worst case assumptions governing heatup of the suppression pool. RG 1.174 provides guidance for acceptable methods to assess defense in depth principles. The following addressed the aspects of defense in depth that are potentially impacted by the requested change.

- Capability of Containment to Provide Containment Overpressure

  The containment is designed to withstand conditions well in excess of those associated with a DBA. Pre-existing containment leakage is well below that which could defeat maintenance of required COP. At the end of 24 hours, 2 percent leakage results in an approximate 0.3 psi decrease in the 3.4 psig available containment pressure compared with no leakage. The containment is equipped with automatic containment isolation which is designed to single failure criteria. The COP available is the thermodynamic result of the event itself and does not depend on operator actions or systems other than the containment.

- Excess Containment Cooling Capability

  Long-term suppression pool temperature in design basis events is determined crediting only two of the four RHR pumps and heat exchangers. Emergency Operating Instructions (EOIs) dictate using all available RHR pumps for suppression pool cooling. Single failures such as loss of a power supply or failure of containment cooling valves, failure of a service water pump or RHR heat exchanger valves can disable one or two RHR pumps for containment cooling. If no such single failure is assumed in the long term analysis (>10 minutes) then suppression pool temperature remains below 166.4°F with four RHR pumps or 175°F with any three pumps and positive NPSH margin would be maintained long term without COP. These analyses were performed using the same conservative assumptions for input parameters as the licensing basis analysis. Core Spray pumps require credit for COP above 175.8°F. The RHR pumps do not require COP at the peak pool temperature of 187.4°F. The likelihood of failing any two RHR pumps is 8.2E-3.

It can be concluded that defense in depth philosophy is preserved following the proposed change since multiple failures of safety related features would have to be postulated in order to impact ECCS functions. Credit for COP does not rely upon new operator actions or changes to the accident analysis methodologies.

3. SAFETY MARGINS

Analyses for design basis events are performed with established margins added to important parameters to account for uncertainty. Significant parameter margins included in the NPSH analysis were examined and analysis results were obtained using more realistic values. This demonstrates that there is ample margin to ECCS pump functional failure in design basis LOCA events without credit for COP. The following table provides the parameters of interest, the values used in the safety analysis and the associated realistic values.

PARAMETER	LICENSING BASIS VALUE	REALISTIC VALUE	COMMENT
Initial Power	102% Licensed Thermal Power	100% Licensed Thermal Power	Probability of 102% power is 5.0E-3
Decay Heat Model	ANSI 5.1 (plus 2σ)	ANSI 5.1 (w/o 2σ)	
Service Water Temperature	95°F	92°F	Exceedance probability for 92°F is less than 6.0E-2

PARAMETER	LICENSING BASIS VALUE	REALISTIC VALUE	COMMENT
Initial Suppression Pool Temperature	95°F (TS maximum)	92°F	Exceedance probability for 92°F is 8.25E-2
Heat Exchanger K Value	223 BTU/Hr-°F	241 BTU/Hr-°F 225 BTU/Hr-°F	Based on realistic fouling factor of 0.0020 vs 0.0025 and maximum number of tubes plugged (1.5%) 1.5% tube plugging only
Initial Suppression Pool Volume	121,500 ft^3 (TS minimum)	125,640 ft^3	Nominal value
Containment Heat Sinks	Assumes no heat sinks	Includes realistic heat sinks	Heat sinks are always present but not normally credited

Sensitivity analyses were performed (with selected analyses verified), which are summarized in Table 1. The purpose of these analyses was to identify input parameter combinations where COP was not required (e.g., suppression pool temperature below 175.8°F).

- Sensitivity to RHR Service Water (RHRSW) Temperature

  Suppression pool temperature response was examined as a function of RHRSW temperature which is a seasonal variable. Figure 3 shows Suppression Pool temperature as a function of RHRSW temperature using both licensing basis input values and realistic values. These analyses show that COP is not required for RHRSW temperatures 70°F or below assuming all design basis inputs and 86°F using realistic inputs. The probability of exceeding 70°F is 3.97E-1 and for 86°F is 1.40E-1.

- Realistic Values

  Suppression pool temperature for the DBA-LOCA was evaluated by altering the input parameters to reflect the realistic values given above. Defense in depth assumptions such as RHR pump availability were not changed. This evaluation shows that suppression pool temperature remains below that which COP is required (175.8°F). This is indicated as Case 4a in Table 1 and shows that credit for COP is not required when realistic input values are assumed.

- Margin in Manufacturers Curves for NPSH - Required ($NPSH_R$)

  The licensing basis need for COP is based on the conservative assumption in NPSH calculations that the RHR and Core spray pumps will not perform their function at NPSH Available ($NPSH_a$) values less than the manufacturers $NPSH_R$. The values used were derived from manufacturers testing for each pump. Suction pressures were reduced with 3 percent reduction in total dynamic head (TDH) to establish minimum NPSH. At this value, the pumps will operate without degradation.

  BFN RHR pumps are Sulzer-Bingham model 18x24x28 CVIC. Assuming no credit for COP in the limiting short-term LOCA scenario, RHR pumps would be required to be operated for less than 10 minutes at 24.3 feet $NPSH_a$ (broken loop) versus 30 feet $NPSH_R$ or 25.2 feet $NPSH_a$ (intact loop) versus 26 feet $NPSH_R$. Negative NPSH margin of this magnitude for short periods of time will not prevent the RHR pumps from performing long-term in the event. Additional NPSH testing was performed on a BFN RHR pump in 1976 and reported to NRC in Reference 4. In this test, the RHR pump was operated 10,000 GPM (design flow) at approximately 24 feet of NPSH without cavitation and as low as 16 feet without damage. This is compared to 26 feet assumed to be the NPSH limit for the short-term COP requirements for the intact loop at design flow. This demonstrated that the RHR pumps can be operated below the manufacturers curve for at least 10 minutes without damage. This data demonstrated that the RHR pumps have NPSH margin assuming COP is not available. Therefore, in the unlikely event that COP was lost in the short-term LOCA, the function of the RHR pumps would not be affected for the short- and long-term.

  By comparison to the RHR pumps, the Core Spray pumps would be challenged in the long-term scenario in the event that

COP was lost. Core Spray pumps do not require COP in the short-term (Refer to Figure 1). BFN Core Spray pumps are Sulzer-Bingham model 12x16x14.5 CVDS. Assuming no credit for COP, the Core Spray pumps used for long-term core cooling (>10 minutes) would be expected to operate between 27 feet and 22.6 feet of NPSH verses 27 feet used in NPSH calculations for approximately 13.4 hours as Suppression Pool temperature peaks above 175.8°F during the LOCA. In the unlikely event they become degraded, there is a reasonable likelihood that the affected pumps would still be able to function. In addition, only one of the two Core Spray loops is required to be operated for adequate core cooling and the non-operating Core Spray loop would be available to operators if the operating loop failed after some time period. RHR pumps would also be available in the LPCI mode for core cooling in conjunction with their suppression pool cooling function should all Core Spray pumps become unavailable. COP is not required for RHR pumps in the long-term scenario. Therefore in the unlikely event that COP was lost in the long-term LOCA, the decay heat removal and core cooling functions would be maintained.

It can be concluded that safety margins are preserved following the proposed change. Sensitivity analyses show that COP is not required if realistic inputs are utilized without any changes to the accident analysis methodologies.

4. RISK ASSESSMENT

TVA has evaluated the risk impact of utilizing COP to satisfy the NPSH requirements for RHR and Core Spray pumps to mitigate the consequences of a DBA LOCA. The risk assessment evaluation used the current BFN Unit 1 PRA internal events (including internal floods) model. The evaluation is provided as Enclosure 4 to this letter. The steps taken to perform this risk assessment evaluation were:

1. Evaluate sensitivities to the DBA LOCA accident calculations to determine under what conditions credit for COP is necessary to satisfy low pressure ECCS pump NPSH requirements;

2. Revise all large LOCA accident sequence event trees to make low pressure ECCS pumps dependent upon containment isolation when other plant pre-conditions exist (i.e., Service Water initial high temperature, Suppression Pool initial high temperature);

3. Modify the existing Containment Isolation System fault tree to include the probability of pre-existing containment leakage;

4. Quantify the modified PRA models and determine the change in Core Damage Frequency (CDF) and Large Early Release Frequency (LERF); and

5. Perform modeling sensitivity studies and a parametric uncertainty analysis to assess the variability of the results.

Crediting COP resulted in a small increase in CDF and LERF of 1.53 E-9/yr. This small increase was well below the guidelines provided in RG 1.174.

ATWS, SBO, and Appendix R are highly unlikely event scenarios which are defined by failure of multiple features. Failure assumptions in these events are beyond design basis. Additional failures such as loss of containment integrity need not be assumed. Deterministic analyses have shown that COP will be available as thermodynamic result of the event itself provided that containment integrity is maintained. This is acceptable given the low probability of the events.

5. MONITORING

Performance monitoring is performed for parameters important to ECCS NPSH analyses to ensure that assumptions remain valid and that corrective actions are initiated for deficiencies.

- Containment Integrity Monitoring

  During normal power operations, the containment is inerted with nitrogen and maintained at greater than or equal to 1.1 psi positive pressure relative to the suppression chamber in accordance with TS 3.6.2.6. Technical Requirements Manual 3.6.5 limits nitrogen makeup to 542 scfh and is determined every 24 hours. This would identify any pre-existing leak in the drywell portion of containment.

10 CFR 50.54(o) and 10 CFR Part 50 Appendix J require leak rate testing of the containment structure, penetrations and isolation valves at the maximum predicted LOCA pressure. Containment leak rate testing tests containment penetrations and limits total leakage to < 0.6La. La is two weight percent per day at 50.6 PSIG. Available containment pressure is calculated assuming two weight percent per day throughout the event which is conservative.

10 CFR 50.55a(ii)B requires periodic in-service examination of the containment structure in accordance with the American Society of Mechanical Engineers Code.

- NPSH Monitoring

  The EOIs include precautionary statements warning the operator that continuous operation of the low pressure injection system pumps with inadequate NPSH may result in pump damage or pump inoperability and that reducing containment pressure may affect pump NPSH. The operator is instructed to monitor NPSH using an NPSH limit curve, showing pump flow versus suppression pool temperature for various suppression pool pressures. The EOIs also list additional indications of inadequate NPSH. Operators are trained on these procedures as part of their periodic re-qualification program.

RG 1.174 CONCLUSION

The use of COP to ensure an adequate NPSH for ECCS pumps during a limited time after a design basis accident is consistent with NRC staff positions, including Revision 3 of RG 1.82, and is part of the current licensing and design basis for BFN Units 2 and 3. Alternatives which would preclude the need for the use of COP, such as the replacement of pumps or heat exchangers are not practical. Deterministic evaluations and analyses, which were performed in accordance with regulatory requirements, have demonstrated that an adequate level of protection is maintained.

Even though the use of COP was requested on a deterministic basis, a risk-informed assessment was performed in accordance with the guidelines contained in RG 1.174, Revision 1. In summary, a defense-in-depth philosophy is maintained by avoiding an over reliance on specific features, human actions, or assumptions to ensure safety. Safety margins are maintained since realistic analyses demonstrate that adequate NPSH exists for the ECCS pumps without crediting COP. Crediting COP results in a small increase in CDF and LERF of 1.53×10^{-9}/yr. This small increase is well below the guidelines provided in RG 1.174 (10^{-6}/yr for CDF and 10^{-7}/yr for LERF). The integrity of the primary containment and the associated primary containment isolation valves are monitored using diverse performance measurement strategies that ensure the detection and correction of adverse conditions.

REFERENCES

1. TVA letter, T.E. Abney to NRC, "Browns Ferry Nuclear Plant (BFN) - Units 2 and 3 - License Amendment Regarding Use of Containment Overpressure for Emergency Core Cooling System (ECCS) Pump Net Positive Suction Head (NPSH) Analyses," September 4, 1998.

2. TVA letter, T.E. Abney to NRC, "Browns Ferry Nuclear Plant (BFN) - Response to Request for Additional Information (RAI) Relating to Units 2 and 3 License Amendment Regarding Use of Containment Overpressure for Emergency Core Cooling System (ECCS) Pump Net Positive Suction Head (NPSH) Analyses," November 25, 1998.

3. NRC letter, W.O. Long to TVA, "Browns Ferry Nuclear Plants, Units 2 and 3 - Issuance of Amendments Regarding Crediting of Containment Overpressure for Net Positive Suction Head Calculations for Emergency Core Cooling Pumps (TAC Nos. MA3492 and MA3493)," September 3, 1999.

4. TVA letter, J.E. Gilleland to NRC, "Browns Ferry Nuclear Plant Unit 3 - Reportable Deficiency - Potential for RHR Pump Operation in Excess of Design Runout - IE Control No. H01172F2," May 21, 1976.

TABLE 1
SENSITIVITY ANALYSES OF VARIOUS REALISTIC INPUT PARAMETERS
DURING THE DESIGN BASIS ACCIDENT LOSS OF COOLANT ACCIDENT LONG-TERM PHASE

Case	Case Description	Initial Power	Decay Heat	Service Water (SW) Initial Temp (°F)	Suppression Pool (SP) Initial Temp (°F)	Number of RHR pumps in Operation	RHR and CS Pump Flow Rate Per Pump	Number of RHR Heat Exchangers in Operation	Number of RHRSW pumps in Operation	RHRSW Pump Flow Rate Per Pump (gpm)	RHR Heat Exchanger K Value	Core Spray Pumps in Operation	Initial SP Water Volume	ECCS Strainer Debris Loading	Credit for Containment Heat Sinks	Peak SP Temp (°F)	Containment Overpressure Credit Required
Base Case*	EPU Licensing Calculation – DBA LOCA	102% EPU	ANSI 5.1 w/2σ	95	95	2	Full design	2	2	4000	223	2	Minimum	Yes	No	187.3	Yes
Case 1*	No Single Failure	102% EPU	ANSI 5.1 w/2σ	95	95	4	Full design	4	4	4000	223	4	Minimum	Yes	No	166.4	No
Case 1a*	3 Pumps in SPC	102% EPU	ANSI 5.1 w/2σ	95	95	3	Full design	3	3	4000	223	4	Minimum	Yes	No	175.0	No
Case 2	DBA Calculation but Initial SW Temperature = 85°F	102% EPU	ANSI 5.1 w/2σ	85	95	2	Full design	2	2	4000	223	2	Minimum	Yes	No	182.0	Yes
Case 2a	DBA Calculation but Initial SW Temperature = 75°F	102% EPU	ANSI 5.1 w/2σ	75	95	2	Full design	2	2	4000	223	2	Minimum	Yes	No	177.6	Yes
Case 2b*	DBA Calculation but Initial SW Temperature = 70°F	102% EPU	ANSI 5.1 w/2σ	70	95	2	Full design	2	2	4000	223	2	Minimum	Yes	No	175.9**	No
Case 2c	DBA Calculation but Initial SW Temperature = 65°F	102% EPU	ANSI 5.1 w/2σ	65	95	2	Full design	2	2	4000	223	2	Minimum	Yes	No	174.3	No
Case 3	DBA Calculation but Initial SP Temperature = 85°F	102% EPU	ANSI 5.1 w/2σ	95	85	2	Full design	2	2	4000	223	2	Minimum	Yes	No	183.8	Yes
Case 4	100% Initial Power, Minimum SP Level, and No Heat Sink Credit	100% EPU	ANSI 5.1 w/o 2σ	92	92	2	Full design	2	2	4000	241	2	Minimum	Yes	No	177.0	Yes
Case 4a	100% Initial Power, Nominal SP Level, and Heat Sink Credit	100% EPU	ANSI 5.1 w/o 2σ	92	92	2	Full design	2	2	4000	241	2	Nominal	Yes	Yes	174.7	No
Case 4b*	100% Initial Power, Minimum SP Level, and Heat Sink Credit	100% EPU	ANSI 5.1 w/o 2σ	92	92	2	Full design	2	2	4000	225	2	Minimum	Yes	Yes	178.9	Yes
Case 4c*	100% Initial Power, Minimum SP Level, Heat Sink Credit, and SW Temp. that results in Peak SP Temp. equal to/less than 176°F	100% EPU	ANSI 5.1 w/o 2σ	88	92	2	Full design	2	2	4000	225	2	Minimum	Yes	Yes	175.8	No

*- Case verified by formal analyses.   ** - This value is acceptable for demonstrating sensitivity analysis results.

FIGURE 1
NET POSITIVE SUCTION HEAD REQUIREMENTS FOR DESIGN BASIS LOSS OF COOLANT ACCIDENT – SHORT TERM

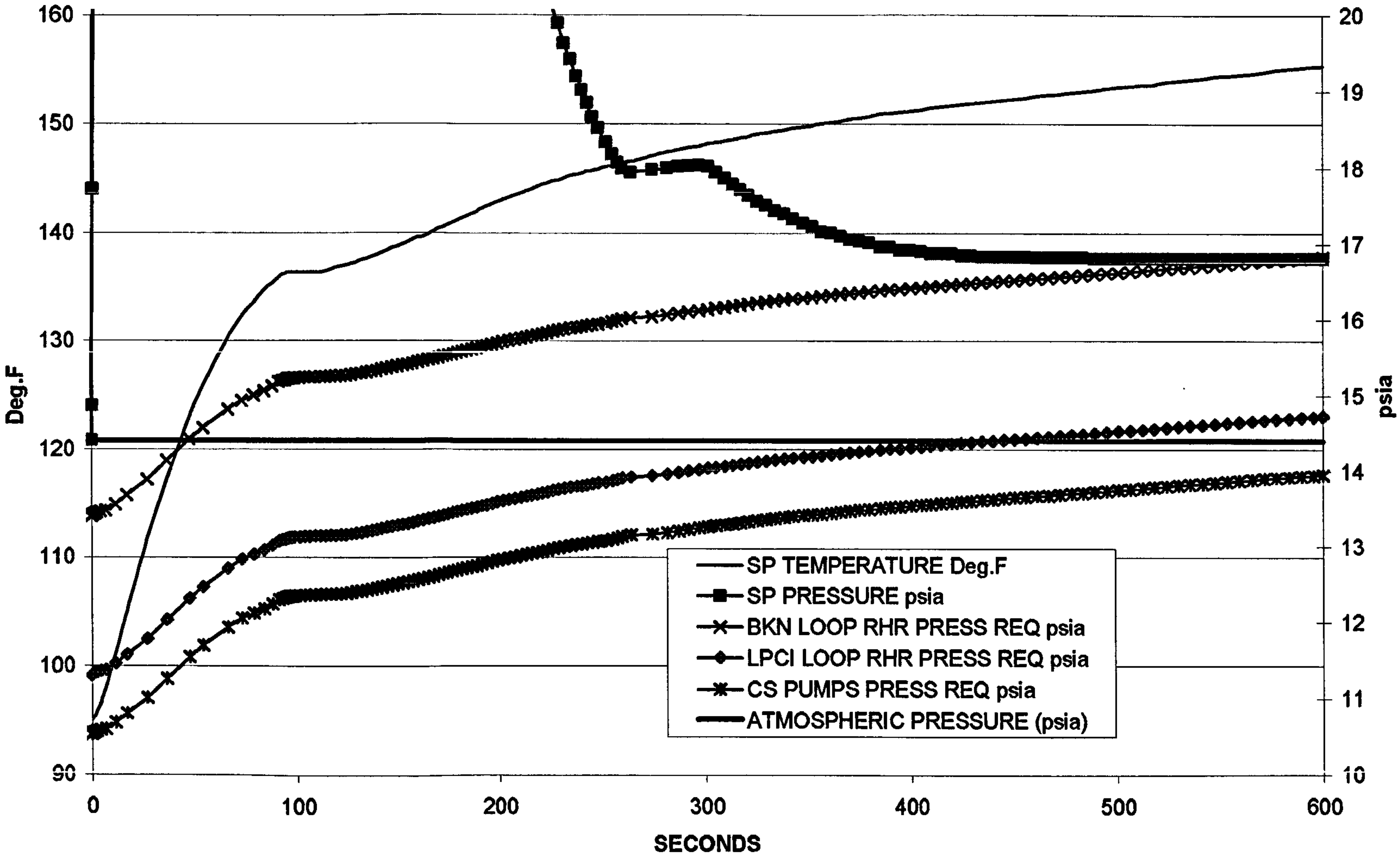


FIGURE 2
NET POSITIVE SUCTION HEAD REQUIREMENTS FOR DESIGN BASIS LOSS OF COOLANT ACCIDENT – LONG TERM

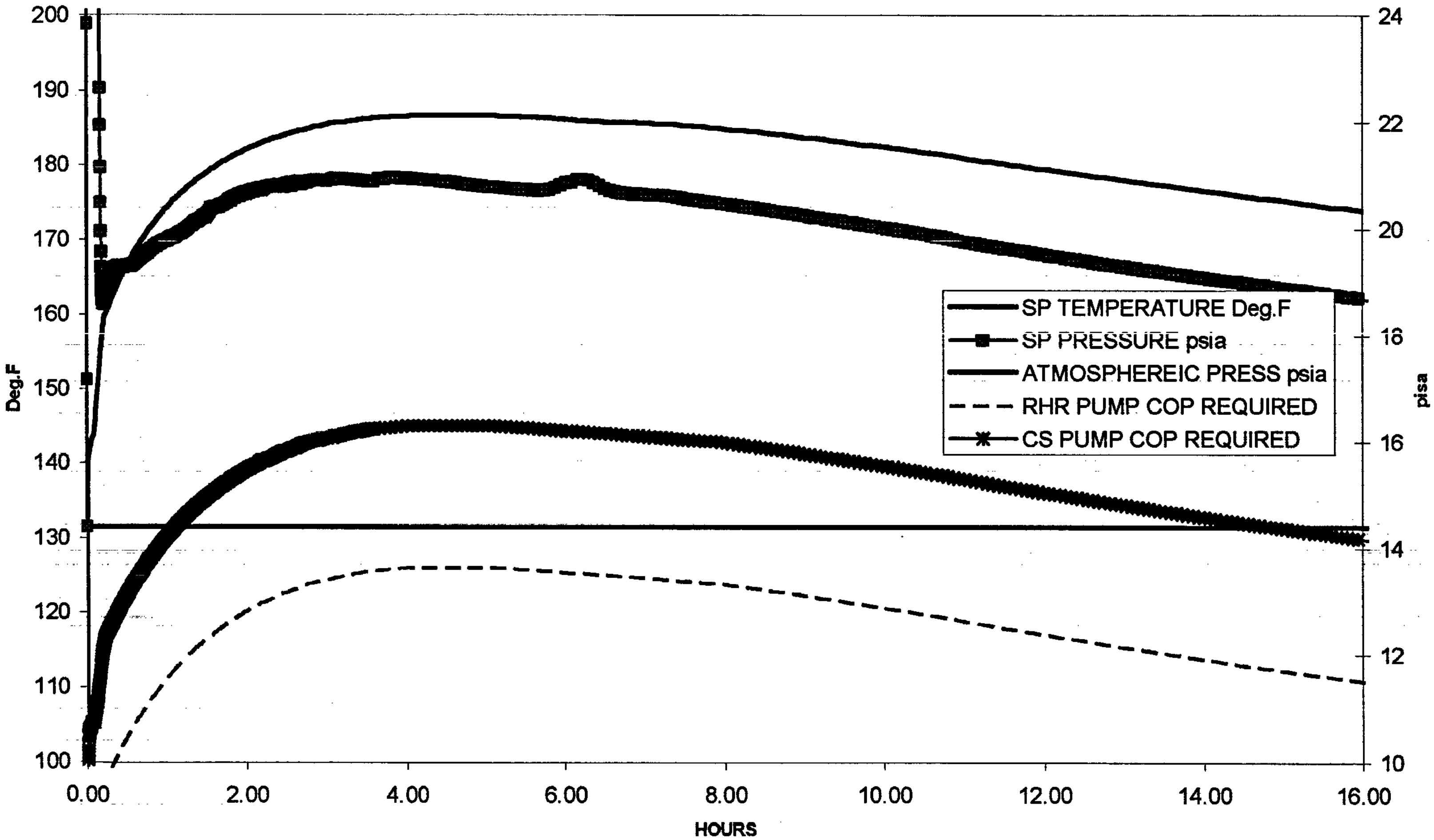
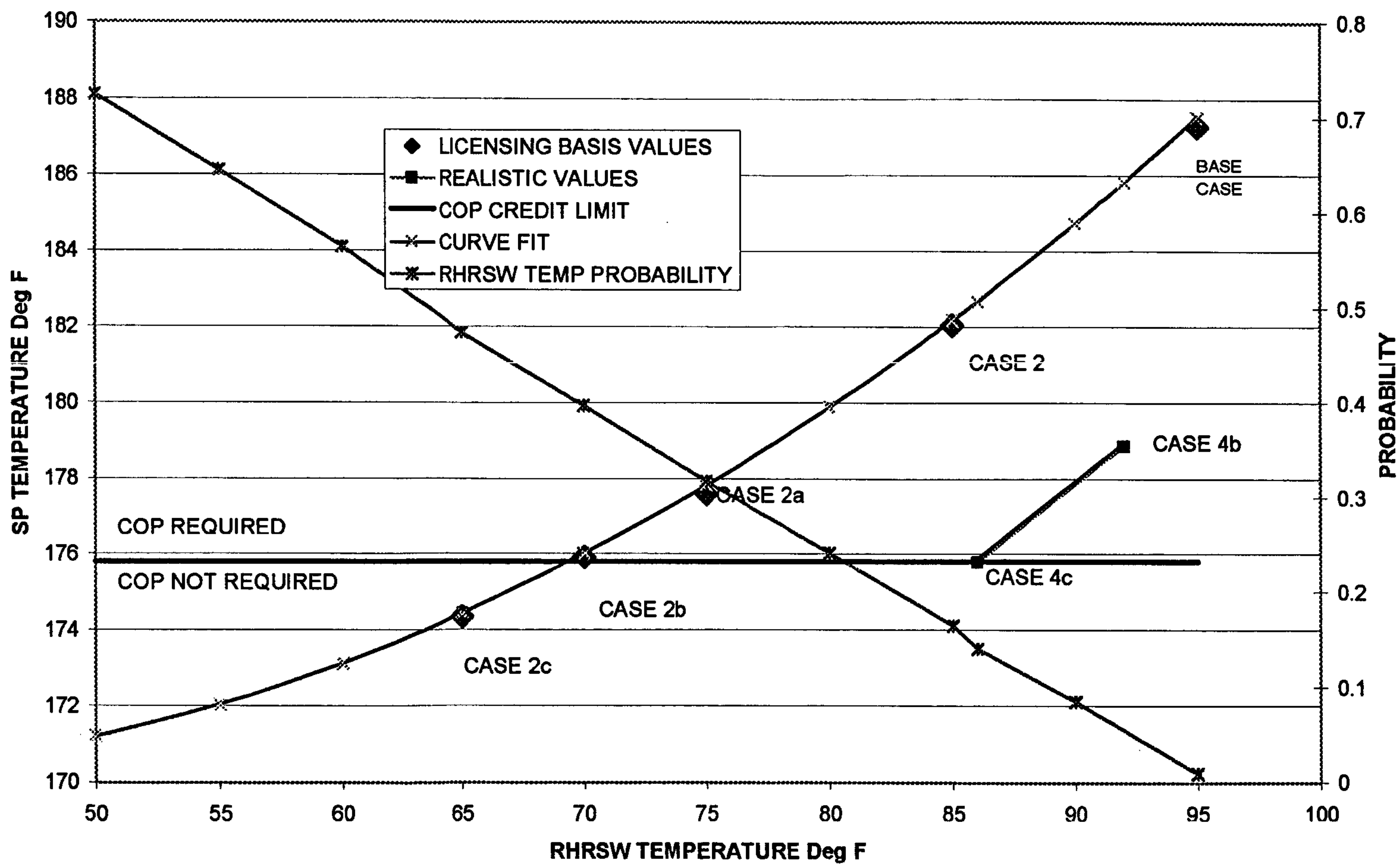


FIGURE 3
CONTAINMENT OVERPRESSURE SENSITIVITY TO RESIDUAL HEAT REMOVAL SERVICE WATER (RHRSW) TEMPERATURE AND NET POSITIVE SUCTION HEAD SENSITIVITY TO RHRSW TEMPERATURE



ENCLOSURE 2
TENNESSEE VALLEY AUTHORITY (TVA)
BROWNS FERRY NUCLEAR PLANT UNITS 2 AND 3
DETAILED CHRONOLOGY OF CORRESPONDENCE RELATED TO THE PREVIOUS APPROVAL OF NPSH FOR PRE-UPRATE CONDITIONS

Following a postulated Loss of Coolant Accident (LOCA), the Residual Heat Removal (RHR) and Low Pressure Core Spray (LPCS) pumps operate to provide the required core and containment cooling. The use of containment overpressure to maintain adequate pump net positive suction head (NPSH) is required to ensure essential pump operation. The limiting NPSH conditions occur during either short-term or long-term post-LOCA pump operation depending on the total pump flow rates, debris loading on the suction strainers, and suppression pool temperature. As chronicled below, credit for containment overpressure (up to 3 psi short-term for the RHR pumps and 1 psi long-term for the LPCS pumps) was extensively reviewed and subsequently approved by NRC.

On May 6, 1996, the NRC issued NRC Bulletin 96-03, "Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling-Water Reactors," (Reference 1). That bulletin was issued following events at several operating reactors where clogging of containment cooling pump suction strainers adversely impacted pump operation. As a result the NRC requested licensees to take actions to protect Emergency Core Cooling System (ECCS) pump strainers from clogging, and ensure pumps have adequate NPSH to fulfill their function.

By letter dated July 25, 1997, TVA responded to NRC Bulletin 96-03 (Reference 2). That letter outlined its proposed actions for resolution of NRC'S concerns for loss of ECCS following a Design Basis LOCA. To ensure adequate ECCS NPSH during and following accidents, TVA stated it planned to install larger capacity passive strainers and credit for a containment pressure in excess of atmosphere for a short period of time.

By letter dated August 25, 1997, TVA supplemented its July 25, 1997 response to NRC Bulletin 96-03 (Reference 3). TVA indicated that pursuant to discussions with the NRC staff, it was preparing a license amendment request to allow crediting containment overpressure to ensure adequate ECCS pump NPSH during and following accidents. TVA also indicated that the NRC had previously approved crediting containment overpressure for ensuring ECCS NPSH as part of the BFN original licensing basis.

By letter dated October 7, 1997, the NRC issued Generic Letter (GL) 97-04, "Assurance of Sufficient Net Positive Suction Head (NPSH) for Emergency Core Cooling and Containment Heat Removal Pumps," (Reference 4). GL 97-04 requested that licensees review their design basis analyses used to determine the available NPSH for the ECCS and containment heat removal pumps that take suction from the containment following a design basis LOCA, and to provide specific information used therein. GL 97-04 requested, in part, that licensees specify whether credit is taken in their ECCS NPSH analyses for containment overpressure, and if so, identify the amount of overpressure needed and the minimum overpressure available.

TVA provided its 90-day response to GL 97-04 with a letter dated January 5, 1998 (Reference 5). TVA summarized actions taken and planned in response to NRC Bulletin 96-03, provided a description of containment debris analyses performed for BFN Units 2 and 3, and reiterated its intent to submit a license amendment request to support credit for containment overpressure. That submittal also provided required and available BFN Units 2 and 3 ECCS pump NPSH, and assumed a containment overpressure of 2 psig for the limiting case. By letter dated June 11, 1998, the NRC closed GL 97-04 for BFN Units 2 and 3 (Reference 6).

On September 4, 1998, TVA submitted a request to change the BFN Units 2 and 3 license basis to permit the use of available containment overpressure for ECCS pump NPSH (Reference 7). On November 25, 1998, in response to a verbal NRC request for additional information, TVA provided (Reference 8):

- The short- and long-term NPSH calculations for the RHR and LPCS pumps;
- Supporting information for these calculations;
- An explanation as to how the analysis at pre-power uprate conditions bounds the uprated conditions;

- A rationale for why the analysis assumed a design flow rate for the LPCS pumps when one RHR pump is in a runout condition;

- A discussion of the requested overpressure value; and

- Graphs showing the NPSH required for the RHR and LPCS pumps versus time and available containment pressure.

On September 3, 1999, NRC approved the use of containment overpressure to maintain adequate ECCS pump NPSH on BFN Units 2 and 3 (Reference 9). The NRC approved 3 psi for the short-term and 1 psi for the long-term period from 5,500 to 35,000 seconds (approximately 92 minutes to 9.7 hours).

By letter dated November 15, 1999, the NRC closed Bulletin 96-03 for BFN Units 2 and 3 (Reference 10). That closure acknowledged actions taken by TVA to address the potential for ECCS suction strainer clogging, and acknowledged closure of the containment overpressure issue for BFN Units 2 and 3 with issuance of corresponding amendments on September 3, 1999.

On June 25, 2004 (Reference 11), TVA requested a TS change to allow Units 2 and 3 to operate at extended power uprate conditions. As part of this TS change, TVA requested approval for extending the existing credit for containment overpressure in order to provide adequate NPSH to the ECCS pumps. Specifically, TVA requested approval to credit 3 psi containment overpressure for the RHR pumps for the first 10 minutes following a LOCA (short-term requirement) and 3 psi containment overpressure for the LPCS pumps from approximately 4,100 to 52,300 seconds (about 13.4 hours) following a LOCA (long-term requirement).

REFERENCES

1. NRC letter, NRC Bulletin 96-03, "Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling-Water Reactors," May 6, 1996.

2. TVA letter, T.E. Abney to NRC, "Browns Ferry Nuclear Plant (BFN) - NRC Bulletin 96-03, Potential Plugging of Emergency Core Cooling Suction (ECCS) Strainers by Debris in Boiling Water Reactors (TAC Nos. M96135, M96136, M96137)," July 25, 1997.

3. TVA letter, T.E. Abney to NRC, "Browns Ferry Nuclear Plant (BFN) Unit 2 - NRC Bulletin 96-03, Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling Water Reactors (TAC No. M96136)," August 25, 1997.

4. NRC Letter, J. W. Roe to All Licensees, NRC Generic Letter 97-04, "Assurance of Sufficient Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps," October 7, 1997.

5. TVA letter, T. E. Abney to NRC, "Browns Ferry Nuclear Plant (BFN) - Response To NRC Generic Letter (GL) 97-04, Assurance of Sufficient Net Positive Suction Head (NPSH) for Emergency Core Cooling and Containment Heat Removal Pumps," January 5, 1998.

6. NRC letter, A. W. De Agazio to O. J. Zeringue, "Browns Ferry Nuclear Plant, Units 2 And 3-Completion of Licensing Action For Generic Letter 97-04 (TAC NOS. M99964 AND M99965)," June 11, 1998.

7. TVA letter, T.E. Abney to NRC, "Browns Ferry Nuclear Plant (BFN) - Units 2 and 3 - License Amendment Regarding Use of Containment Overpressure for Emergency Core Cooling System (ECCS) Pump Net Positive Suction Head (NPSH) Analyses," September 4, 1998.

8. TVA letter, T.E. Abney to NRC, "Browns Ferry Nuclear Plant (BFN) - Response to Request for Additional Information (RAI) Relating to Units 2 and 3 License Amendment Regarding Use of Containment Overpressure for Emergency Core Cooling System (ECCS) Pump Net Positive Suction Head (NPSH) Analyses," November 25, 1998.

9. NRC letter, W.O. Long to TVA, "Browns Ferry Nuclear Plants, Units 2 and 3 - Issuance of Amendments Regarding Crediting of Containment Overpressure for Net Positive Suction Head Calculations for Emergency Core Cooling Pumps (TAC Nos. MA3492 and MA3493)," September 3, 1999.

10. NRC letter, W. O. Long to J. A. Scalice, "Browns Ferry Nuclear Plant Units 2 and 3, Completion of Licensing Actions for Bulletin 96-06, 'Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling-Water Reactors,' Dated May 6, 1996 (TAC NOS. M96135, M96136 and M96137)," November 15, 1999.

11. TVA letter, "Browns Ferry Nuclear Plant (BFN) - Units 2 and 3 - Proposed Technical Specifications (TS) Change TS-418 - Request for License Amendment Extended Power Uprate (EPU) Operation," dated June 25, 2004.

ENCLOSURE 3
TENNESSEE VALLEY AUTHORITY (TVA)
BROWNS FERRY NUCLEAR PLANT UNITS 2 AND 3
DETAILED DESCRIPTION OF PLANT SYSTEMS
RELATED TO THE NPSH ANALYSIS

Each BFN unit employs a pressure suppression containment system which houses the reactor vessel, the reactor coolant recirculation loops, and other branch connections of the Reactor Primary System. The pressure suppression system consists of a drywell, a pressure suppression chamber (alternatively referred to as the torus or wetwell) which stores a large volume of water, a connecting vent system between the drywell and the suppression chamber, isolation valves, containment cooling systems, equipment for establishing and maintaining a pressure differential between the drywell and pressure suppression chamber, and other service equipment.

The drywell is a steel pressure vessel with a spherical lower portion 67 feet in diameter, and a cylindrical upper portion 38 feet 6 inches in diameter. The overall height is approximately 115 feet. In the event of a process system piping failure within the drywell, reactor water and steam would be released into the drywell air space. The resulting increased drywell pressure would then force a mixture of air, steam, and water through the vents into the pool of water which is stored in the suppression chamber. The steam would condense rapidly and completely in the suppression chamber, resulting in rapid pressure reduction in the drywell. Air that is transferred to the suppression chamber pressurizes the chamber and is subsequently vented to the drywell to equalize the pressure between the two vessels.

The pressure suppression chamber is a steal pressure vessel in the shape of a torus below and encircling the drywell, with a centerline diameter of approximately 111 feet and a cross-sectional diameter of 31 feet. Large vent pipes form a connection between the drywell and the pressure suppression chamber. A total of eight circular vent pipes are provided, each having a diameter of 6.75 feet.

A 30-inch diameter Emergency Core Cooling System (ECCS) suction header circumscribes the suppression chamber. Four 30-inch diameter tees are used to connect the suction header to the suppression chamber. Four strainers on connecting lines between the suction header and the suppression chamber have been provided. The suction lines from the Residual Heat Removal (RHR), High Pressure Coolant Injection (HPCI), Low Pressure Core Spray (LPCS), and Reactor Core Isolation Cooling (RCIC) systems are supplied from this header. The four strainers are not individually associated with separate pump suctions but direct suppression pool water to the common ECCS ring header. Therefore interaction between operating pumps are considered when determining suction losses. The normal suction path for the HPCI and RCIC system pumps is the Condensate Storage Tank. Figure 1 provides a general overview of the primary containment.

As shown in Figure 2, the BFN ECCS consists of the following:

- HPCI;
- Automatic Depressurization System (ADS);
- LPCS; and
- Low Pressure Coolant Injection (LPCI), which is an operating mode of RHR.

The ECCS subsystems are designed to limit clad temperature over the complete spectrum of possible break sizes in the nuclear system process barrier, including the design basis break. The design basis break is defined as the complete and sudden circumferential rupture of the largest pipe connected to the reactor vessel (i.e., one of the recirculation loop pipes) with displacement of the ends so that blowdown occurs from both ends.

The low-pressure ECCS consists of LPCS and LPCI. The LPCS consists of two independent loops. Each loop consists of two pumps, a spray sparger inside the core shroud and above the core, piping and valves to convey water from the pressure suppression pool to the sparger, and the associated controls and instrumentation. When the system is actuated, water is taken from the pressure suppression pool. Flow then passes through a normally open motor-operated valve in the suction line to each 50 percent capacity pump.

The RHR System is designed for five modes of operation (i.e., shutdown cooling; containment spray and suppression pool cooling; LPCI; standby cooling; and supplemental fuel pool cooling). During LPCI operation, the four RHR pumps take suction from the pressure suppression pool and discharge to the reactor vessel into the core region through both of the recirculation loops. Two pumps discharge to each recirculation loop.

An important consideration in the operation of the LPCS and RHR pumps is the available net positive suction head (NPSH). Adequate available NPSH is important in ensuring that the pump will deliver the flow assumed in the safety analyses at the expected discharge pressure. In order to ensure acceptable flow and discharge pressure, the available NPSH must be equal to or greater than the required NPSH. The required NPSH is a function of the pump design and is determined by the pump vendor.

The available NPSH is calculated from the equation:

$$\text{Available NPSH} = h_{atm} + h_{static} - h_{loss} - h_{vapor}$$

where:

h_{atm} = head on the surface of the suppression pool

h_{static} = the head due to the difference in elevation between the suppression pool surface and the centerline of the pump suction

h_{loss} = the head loss due to fluid friction, fittings in the flow path from the suppression pool to the pump, and the suction strainers which prevent ingestion of debris into the pumps

h_{vapor} = head due to the vapor pressure of the suppression pool water at the suppression pool water temperature

The increase in power from extended power uprate results in increased decay heat, and a subsequent increase in the suppression pool temperature following the design basis Loss of Coolant Accident. The increased water temperature reduces the available NPSH of the RHR pumps and the LPCS pumps since the vapor pressure of the suppression pool water (or h_{vapor}) increases. The reduction in available NPSH is mitigated, where necessary, by crediting the containment accident pressure, that is, by increasing h_{atm}.

FIGURE 1
GENERAL CONTAINMENT LAYOUT

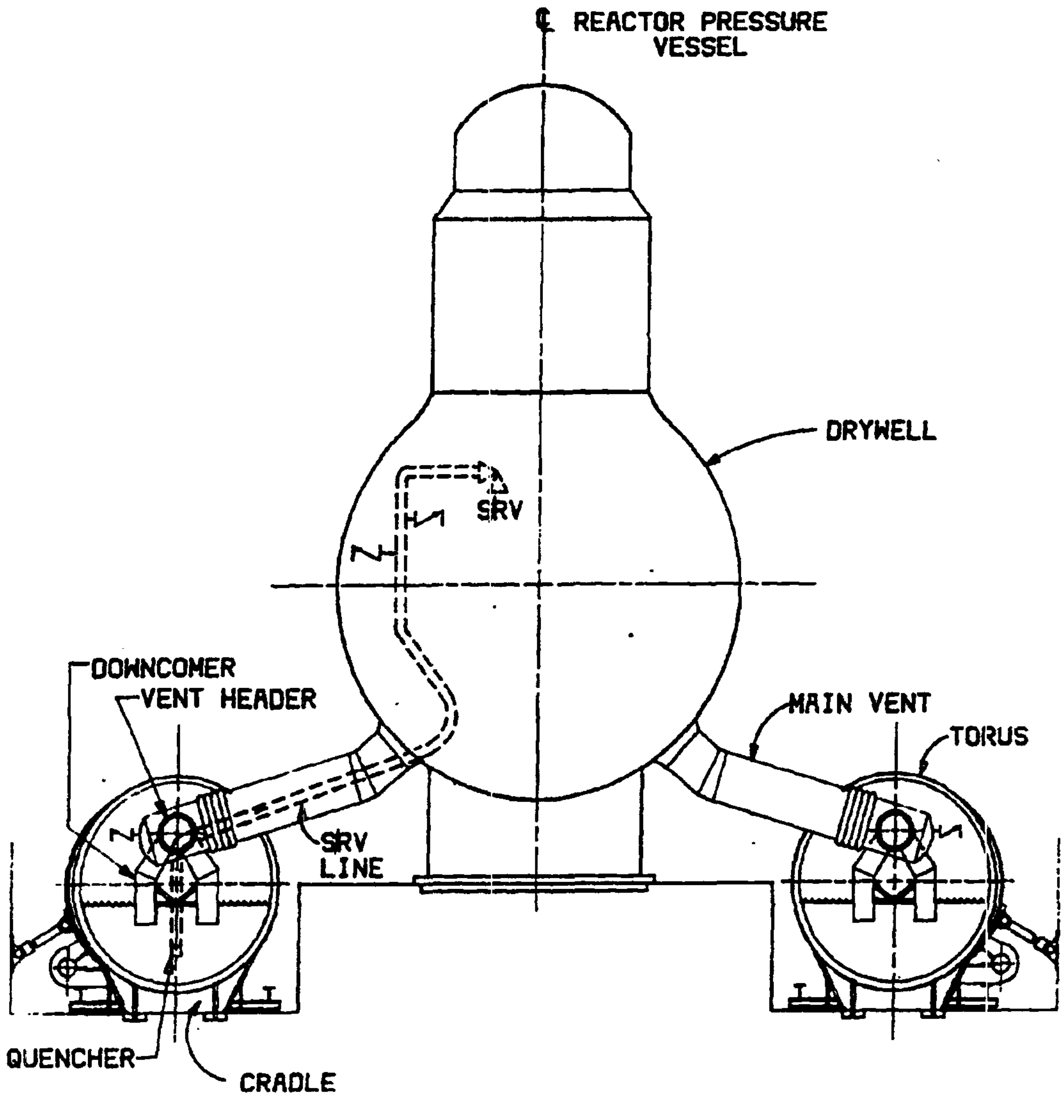


FIGURE 2

LAYOUT OF THE EMERGENCY CORE COOLING SYSTEM