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

March 12, 2009

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

10 CFR 50.90

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

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) – RESULTS OF REVISED ANALYSES FOR SHORT-TERM LOSS-OF-COOLANT ACCIDENT (LOCA) AND APPENDIX R REGARDING CONTAINMENT OVERPRESSURE (COP) CREDIT (TAC NOS. MD5262, MD5263, AND MD5264)

By letters dated June 28, 2004 and June 25, 2004 (ADAMS Accession Nos. ML041840109 and ML041840301), TVA submitted license amendment requests to the NRC for the EPU operation of BFN Unit 1 and BFN Units 2 and 3, respectively. The proposed amendments would change the operating licenses to increase the maximum authorized core thermal power level of each reactor by approximately 14 percent to 3952 megawatts. In the EPU license applications, additional COP credit was requested for the LOCA design basis accident analysis and for three special event analyses including Appendix R. TVA subsequently submitted the results of the EPU net positive suction head (NPSH)/COP calculations for the LOCA and special events in a letter dated August 31, 2006 (ML062510371).

During a February 3, 2009, conference call with NRC staff, TVA discussed a revision to the NPSH/COP calculations for the short-term LOCA analysis and the Appendix R licensing basis analysis to remove excess conservatism. This submittal provides the results of the revised calculations. The short-term LOCA results show a reduction in amount of COP credit needed and that the available NPSH always exceeds required NPSH. For Appendix R, the duration and magnitude of COP credit is reduced, and the margin to the available containment pressure is increased. A description and justification for the analyses revisions is provided in the enclosure along with the specific results.

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NRR

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 are made in this submittal. If you have any questions regarding this letter, please contact J. E. Emens at (256)729-7658.

I declare under penalty of perjury that the foregoing is true and correct. Executed on this 12th day of March, 2009.

Sincerely,

R. G. West
Site Vice President

Enclosure:

Results of Revised Analyses for Short-Term Loss-of-Coolant Accident (LOCA) and Appendix R Regarding Containment Overpressure (COP) Credit

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ENCLOSURE

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)

RESULTS OF REVISED ANALYSES FOR SHORT-TERM LOSS-OF-COOLANT ACCIDENT (LOCA) AND APPENDIX R REGARDING CONTAINMENT OVERPRESSURE (COP) CREDIT

Introduction

Historically, credit for COP has been required for many Boiling Water Reactors including BFN Units 1, 2, and 3 for a limited period of time in the large pipe break LOCA design basis accident analysis and during other low probability special event analyses. For the BFN EPU license applications, LOCA and special event analyses were performed to demonstrate that the available NPSH (NPSHa) will be greater than the Emergency Core Cooling System (ECCS) pump vendor's required NPSH (NPSHr) assuming worst case thermohydraulic conditions and equipment failures specified in licensing basis analyses. If COP is required, additional analyses are performed to demonstrate the minimum expected containment pressure exceeds the NPSHr for ECCS pump operation.

The EPU NPSH/COP calculation results for LOCA and the special events were submitted to NRC on August 31, 2006 (ADAMS Accession No. ML062510371) as summarized in Table 6.2-1, Summary of NPSH and Containment Pressure Margins, in Enclosure 2 of that submittal. The calculated containment pressure was always greater than NPSHr except for a brief time period in the short-term LOCA calculations for the Residual Heat Removal (RHR) pumps. For Appendix R, the largest amount of COP credit was required

During a February 3, 2009, conference call with NRC staff, TVA discussed revisions to the NPSH/COP calculations for the short-term LOCA analysis and for the Appendix R licensing basis analysis to remove excess conservatism. This submittal provides the results of the revised analyses. In summary, the short-term LOCA results show a reduction in amount of COP credit needed and NPSHa always exceeds NPSHr. For Appendix R, the duration and magnitude of COP credit is reduced, and the margin to the available containment pressure is increased. A description and justification for the calculation changes along with the specific analysis results is provided below.

Previous Short-Term LOCA NPSH/COP Analysis Results

The LOCA design basis event is analyzed in a short-term (<10 minutes) and a long-term (>10 minutes) time segment based on the point in time (10 minutes) when operator action is credited in the licensing basis analysis. The limiting short-term LOCA event for NPSH determination is a double-ended recirculation pump loop break on the RHR discharge line side. In this scenario, all four RHR pumps and all four Core Spray pumps start automatically and align to inject to the Reactor Pressure Vessel (RPV) at full system flow. Two of the RHR pumps inject to the RPV via the intact recirculation loop piping and the other two RHR pumps inject into containment via the broken recirculation loop piping.

A COP credit of 2 pounds per square inch (psi) is required for Core Spray pump operation for 9 minutes as shown in Table 6.2-1 from Enclosure 2 of the August 31, 2006, submittal. For the two RHR pumps pumping to the intact recirculation loop, a maximum of 0.8 psi of COP credit is needed with a duration of 5 minutes. For the two RHR pumps on the broken recirculation loop, a maximum COP credit of 3.3 psi is needed and results in a condition where NPSHa ≤ NPSHr for approximately 4 minutes. As discussed in TVA's October 5, 2006, response (ML062860267) to request for information (RAI) ACVB-68/66, in the RHR pump broken loop analysis, the RHR pumps are not performing any function during the time period when NPSHa ≤ NPSHr. The success criteria for this analysis is that no pump damage occurs that results in failure of the RHR pumps in order that they can be credited later in the event (>10 minutes) while operating in the containment cooling mode in the event of a single failure which could disable the heat removal function on the other loop of RHR.

Revised Short-Term LOCA NPSH/COP Calculation

The following changes to the short-term LOCA NPSH/COP analysis calculations have been made to remove excess conservatism.

Reduction in RHR Flow Rate to Broken Recirculation Loop

The previous short-term LOCA NPSH/COP calculations for the two RHR pumps, broken recirculation loop case, used a conservative RHR flow value of 11,500 gallons per minute (gpm) in the NPSHa calculation and in the NPSHr calculation, whereas the actual RHR flow is calculated to be 11,000 gpm. In the revised short-term LOCA calculation for the determination of NPSHr, the RHR flow has been reduced to 11,000 gpm to match the actual calculated RHR maximum flow. At the 10 minute mark, which for the short-term LOCA analysis is the point of maximum COP need, this change reduces NPSHr from 28.4 feet to 25.6 feet. The NPSHa calculation was not changed and continues to use 11,500 gpm, which is conservative since the higher RHR flow rate reduces NPSHa due to higher line loss in the pump suction line.

Use of Time-Dependent NPSHr For RHR

The previous short-term LOCA NPSH/COP calculations used a fixed value for NPSHr derived from the pump vendor's (Sulzer) 8000 hour operational life curves for the RHR pumps and Core Spray pumps. The Sulzer 8000 hour NPSHr curves were submitted to NRC on October 13, 2006 (ML062920154) as Curves 3 and 6 in Enclosure 1 for the RHR and Core Spray pumps, respectively. The fixed NPSHr value that was used in the calculation is the value at 10 minutes, which is 25.5 feet for the RHR pumps injecting into the intact recirculation loop (10,500 gpm curve) and 28.4 feet for the RHR pumps injecting into the broken recirculation loop (11,500 gpm curve). For Core Spray, NPSHr was 25.5 feet at 4125 gpm.

In the revised short-term LOCA calculation, NPSHr was changed to a time-dependent value from Curve 3 from the Sulzer report. For the RHR pumps injecting into the intact recirculation loop, this has the effect of NPSHr varying from 25.7 feet to 24.3 feet (10,500 gpm curve) and from 27 feet to 25.6 feet at 11,000 gpm based on the revised flow rate from the first change above for the RHR pumps injecting into the broken recirculation loop over the first 10 minutes. The Core Spray continues to use the same fixed NPSHr value of 25.5 feet in the short-term calculation since the curve does not change during the first 10 minutes.

Decrease in Initial Drywell Humidity Analysis Condition

The calculation results presented in the August 31, 2006, submittal utilized a drywell relative humidity (RH) value of 100% as an initial condition. TVA performed a parametric analysis, which concluded that the maximum RH that could exist in the drywell without producing condensation in excess of allowable TS unidentified leakage (5 gpm) is 40%. Therefore, in the revised short-term LOCA calculation, a value of 50% RH was used, which removes excess conservatism. This change has the net effect of increasing the initial amount of noncondensible gases in containment, which improves NPSHa for both RHR and Core Spray pumps.

Results from Revised Short-Term LOCA NPSH/COP Calculation

The impact of these three changes is shown in Table 1, which also lists the results of the previous calculations for comparison. Figures 1 and 2 provide graphs for the revised and previous short-term LOCA analysis results.

In summary, the amount and duration of COP required for the RHR pumps for the intact and broken recirculation loops injection paths is reduced. For the two RHR pumps pumping to the intact recirculation loop, a maximum of 0.2 psi of COP credit is required with duration of 3.2 minutes. For the two RHR pumps on the broken recirculation loop, a maximum COP credit of 2.1 psi is needed with duration of 9.3 minutes and NPSHa ≥ NPSHr throughout the event. A maximum COP credit of 2 psi is required for Core Spray pump operation with 8.9 minutes duration and the minimum margin increases to 1.3 psi.

Table 1
Short-Term LOCA NPSH/COP Calculation Results

Pump	Maximum Required COP (psi)	Minimum Containment Margin (psi)	Duration COP Needed (minutes)
Revised Results			
Core Spray	2	1.3	8.9
RHR – Intact Loop	0.2	2.6	3.2
RHR – Broken Loop	2.1	0.7	9.3
Previous Results			
Core Spray	2	0.4	9
RHR – Intact Loop	0.8	1.6	5
RHR – Broken Loop	3.3	-0.9	10

Figure 1: Short-Term LOCA NPSH/COP Calculation Results (Revised)

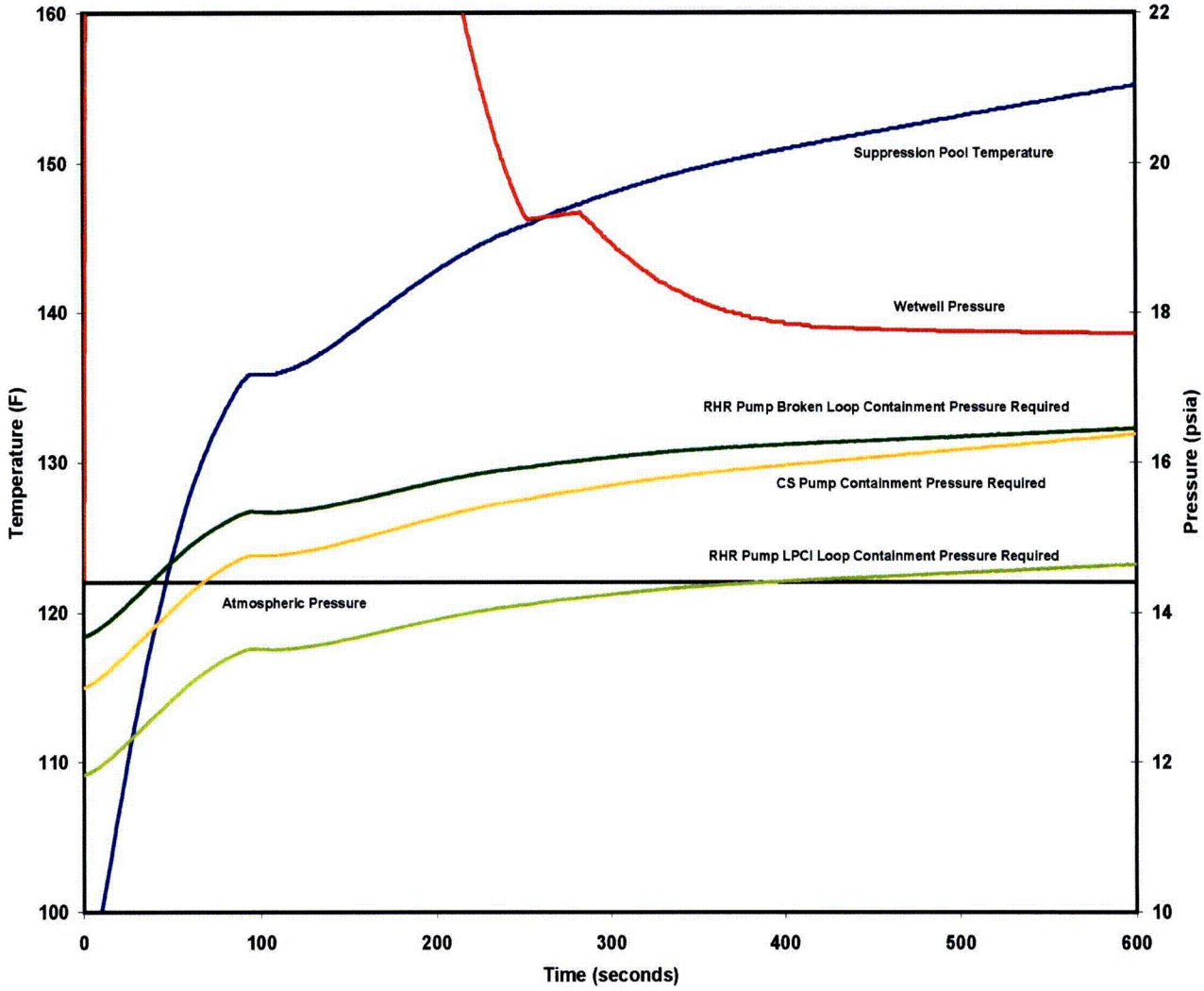
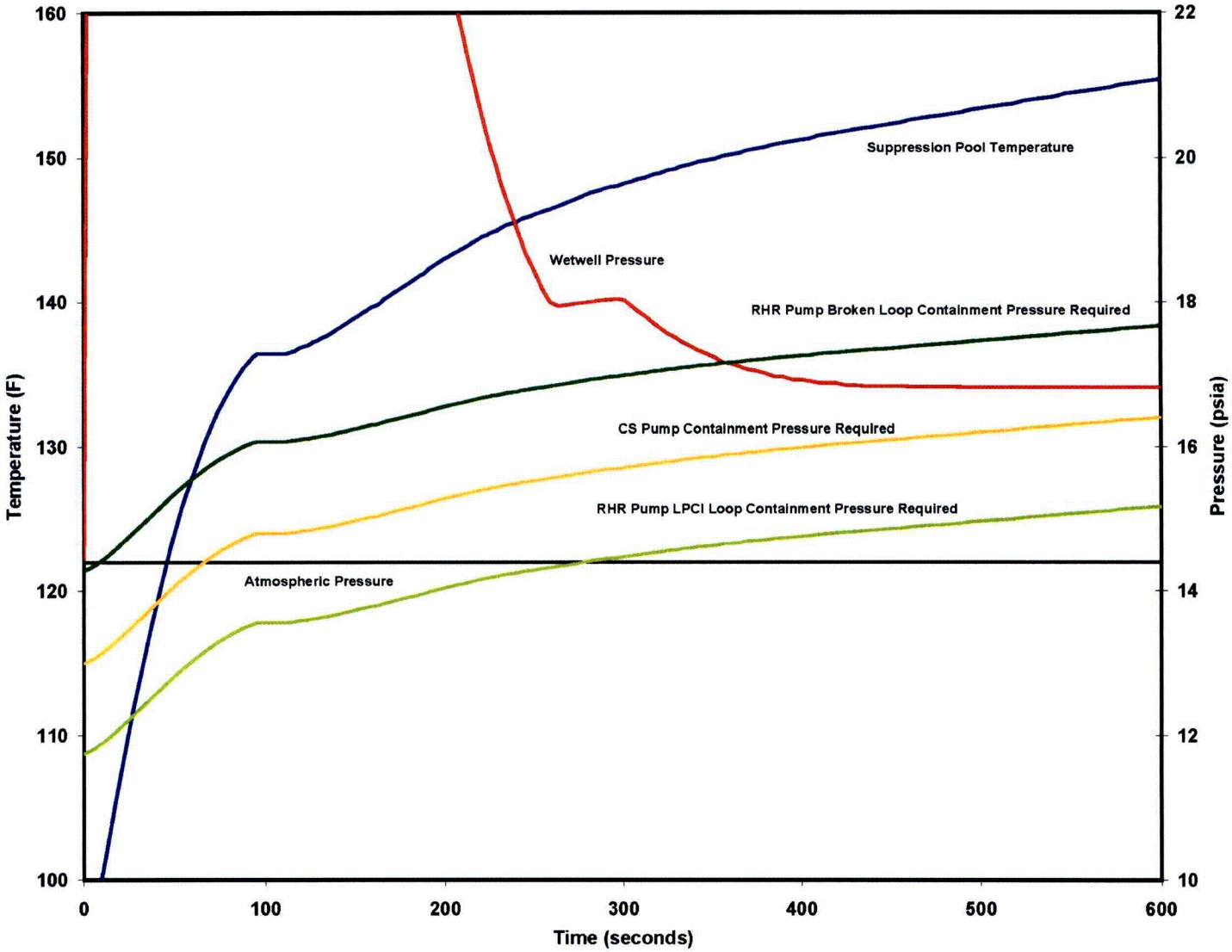


Figure 2: Short-Term LOCA NPSH/COP Calculation Results (Previous)



Previous Licensing Basis Appendix R Event Calculation Results

In the licensing basis Appendix R event analysis, a fire is assumed to damage all of the equipment located in a given fire area not meeting the physical separation and protection requirements of the Appendix R rule. The operators manually depressurize the reactor within 20 minutes using three safety relief valves (SRVs) and use one RHR pump for vessel injection taking suction from the suppression pool to establish a closed loop through the SRVs back to the suppression pool. At two hours, the RHR heat exchanger for the operating RHR pump is placed in service by starting an RHR service water (RHRSW) pump and aligning the heat exchanger RHRSW discharge flow path, which establishes containment cooling commonly referred to as the Appendix R Alternate Shutdown Cooling mode. The operators also terminate drywell cooling by isolating the cooling water within two hours to increase containment pressure. For the purposes of demonstrating Appendix R rule compliance, the analysis assumes the Alternate Shutdown Cooling alignment is maintained for the remainder of 72 hour event duration.

The RHR pumps are designed for 40,000 hours of operation in normal operating modes, shutdown cooling and suppression pool cooling, where NPSHa is in excess of 42 feet. For the LOCA and special event analyses, time-dependant NPSHr values were used that are based on integrated wear on the pump impeller during a shortened 8000 hour operating life. This is a conservative approach for low probability, one-time events.

As shown in Table 6.2-1 of the August 31, 2006, submittal, for the Appendix R licensing basis analysis, COP credit is required for the RHR pump with a maximum of 9.6 psi and an overall duration of 69 hours.

Revised Appendix R NPSH/COP Calculation Results

For special events such as Appendix R, less conservatism is used for analysis inputs and assumptions while still applying bounding values. For limited duration pump operation such as that assumed in the Appendix R analysis, use of 8000 hour time-dependent Sulzer NPSHr curves is overly conservative since the duration of the Appendix R event is 72 hours. There are three other RHR pumps/heat exchanger combinations that would be available for service during the recovery phase of the event after 72 hours when NPSHa is much larger. Therefore, the basis for NPSHr used in the Appendix R licensing basis analysis was changed to a fixed value based upon the industry standard definition of NPSHr.

ANSI/HI 9.6.1-1998, "Centrifugal and Vertical Pumps for NPSH Margin," defines NPSHr as the NPSH that will cause total head to be reduced by 3% due to cavitation. This will be referred to as the 3% NPSHr below. The 3% NPSHr curve for the model of RHR pump used on all 3 BFN units is shown in Figure 2 of the Sulzer report. NPSH affects both the operating life and function of a pump. Decreasing NPSH increases impeller wear rate and NPSH below particular values called the "knee" may result in surging and loss of flow. Operation at 3% NPSHr values is above the knee and is a concern only for pump operating life and not pump function. In the case of the Appendix R event, discharge head and flow rate are not critical to mitigation of the event and, thus, use of the 3% head loss NPSHr would not be a concern for hydraulic performance. In the Appendix R analysis, a low RHR flow rate flow rate of 6000 gpm is assumed for heat removal. For NPSHr purposes, a high flow rate is assumed (9000 gpm).

The 3% NPSHr curve yields 17 feet of NPSHr at the 9000 gpm flow rate and has been determined by the vendor to be adequate for the limited duration of the Appendix R event. Use

of the 3% NPSHr is also consistent with the deterministic approach recommended in NEDC-33347P Revision 0, "Containment Overpressure Credit for Net Positive Suction Head (NPSH), January 2008" (ML080520261). The model of RHR pumps used at BFN has been tested by the pump vendor at 3% NPSHr and below with satisfactory pump operation. Additionally, as referenced in the TVA response to RAI ACVB-64 in the September 15, 2006, submittal (ML060620328), TVA performed in situ NPSH tests on a Unit 3 RHR pump in 1976. This included testing at NPSHa values of 14.2 feet and 16.4 feet at 8000 gpm and 10000 gpm, respectively with acceptable pump performance and some cavitation noise. TVA provided copies of the original Unit 3 test reports to NRC by letter dated May 21, 1976.

Accordingly, in the revised Appendix R calculation, a fixed NPSHr value of 17 feet was used. The impact of this change is shown in Table 2, which also lists the results of the previous Appendix R calculation for comparison. Figures 3 and 4 provide graphs for the revised and previous Appendix R analysis. The revised analysis shows the duration of COP need is substantially reduced to 27.8 hours with a smaller maximum value of 6.1 psi. The minimum NPSH margin increases from 1.6 to 4.1 psi. This is shown graphically in Figure 5, which shows that after the early minimum, NPSH margin steadily increases during the remainder of the event.

Table 2
Appendix R Calculation Results

Pump	Maximum Required COP (psi)	Minimum Containment Margin (psi)	Duration COP Needed (hours)
Revised Results			
RHR	6.1	4.1	27.8
Previous Results			
RHR	9.6	1.6	69

Figure 3: Licensing Basis Appendix R NPSH/COP Calculation Results (Revised)

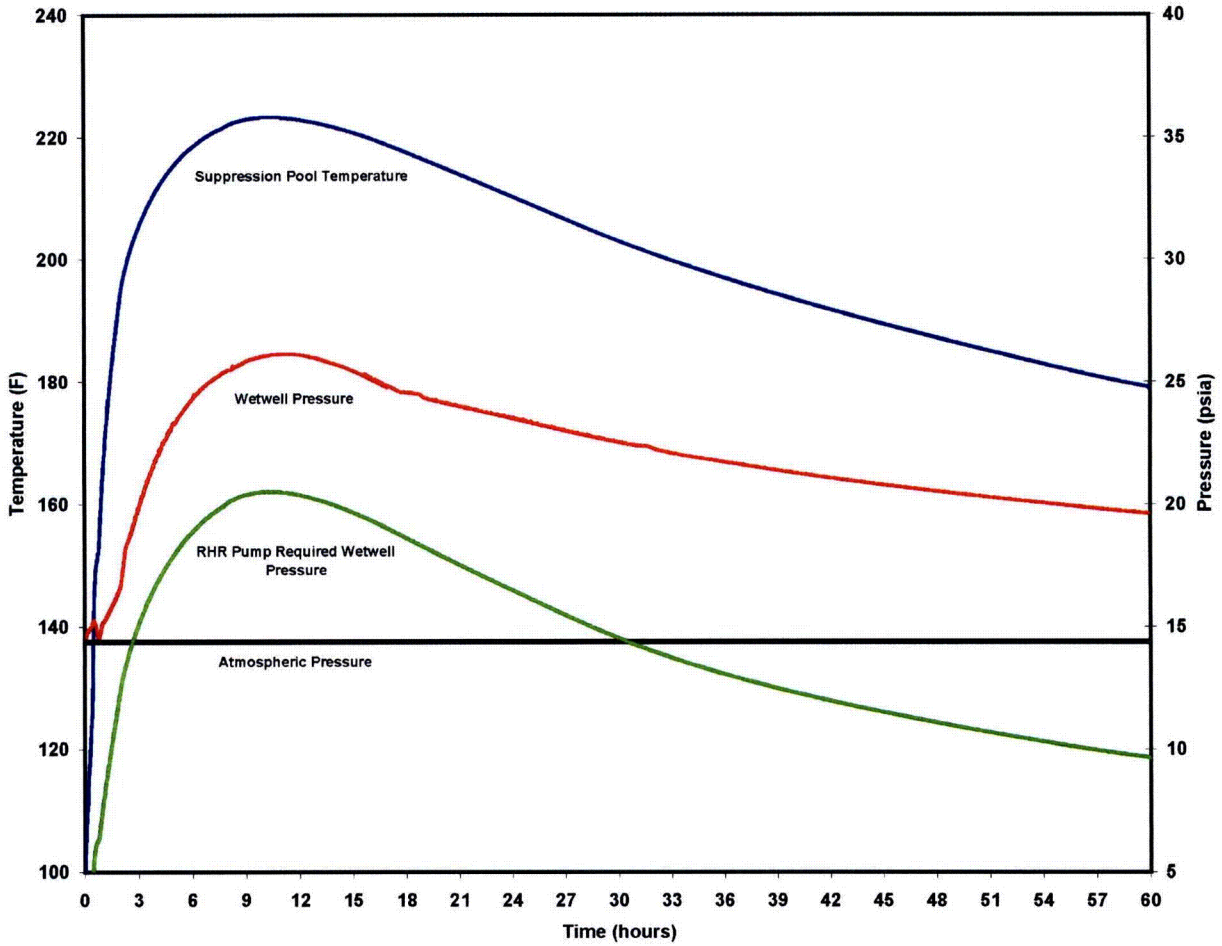


Figure 4: Licensing Basis Appendix R NPSH/COP Calculation Results (Previous)

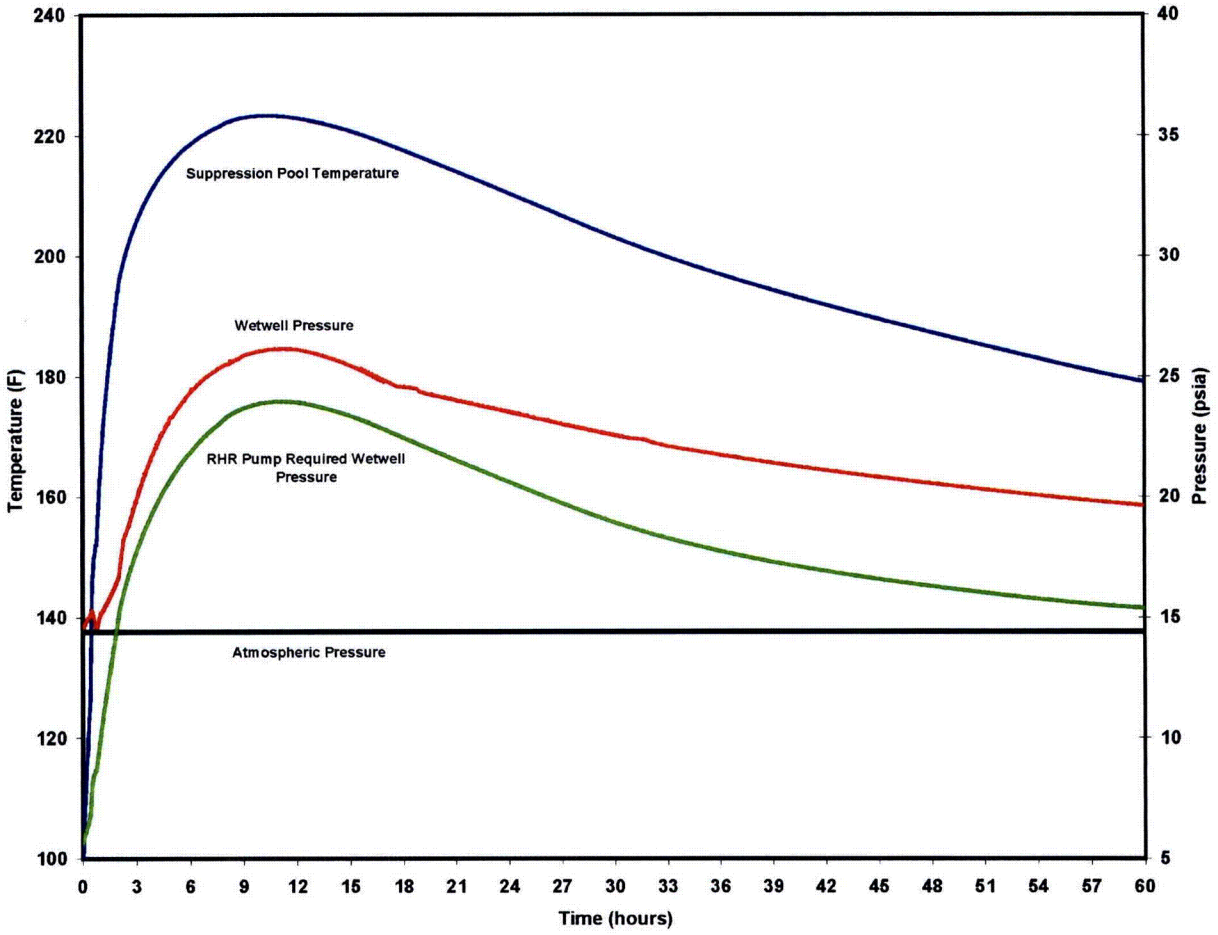


Figure 5: Appendix R (NPSH margin)