

Browns Ferry – Use of Containment Overpressure (COP) Credit for EPU

In support of the extended power uprate (EPU) at Tennessee Valley Authority's (TVA) Browns Ferry Nuclear Plant (BFN), COP is required for the design basis pipe break and special event analyses.

On March 18, 2009, the Advisory Committee on Reactor Safeguards (ACRS) issued a letter report entitled "Crediting Containment Overpressure in Meeting the Net Positive Suction Head Required to Demonstrate that the Safety Systems Can Mitigate the Accidents as Designed." The purpose of the letter report was to facilitate the resolution of the containment overpressure (COP) credit issue. TVA has performed a comparison of the BFN approach to crediting COP with the guidance provided in the ACRS letter report. The results of the comparison are provided in response to each of the "Conclusions and Recommendations" listed in the ACRS letter report.

- 1. To preserve safety margin in all reactors, credit for COP should be limited in amount and duration. Licensees requesting such credit should continue to be required to demonstrate that it is not practical to reduce or eliminate the need for overpressure credit by hardware changes or requalification of equipment.*

BFN requires COP credit for the Loss of Coolant Accident (LOCA), and the Anticipated Transient Without Scram (ATWS), Appendix R Fire and Station Blackout (SBO). With the exception of Appendix R, the magnitude of COP credited for BFN is comparable with or less than that approved for EPU for plants of a similar vintage including Vermont Yankee, Brunswick, Duane Arnold, Quad Cities and Dresden.

BFN has evaluated a number of potential modifications to attempt to eliminate or reduce the need for COP. A discussion of each modification that could positively affect COP is provided below. These modifications were determined to be impractical because of the dose involved in implementation, the inability to install the proposed change, or the cost prohibitive nature of the change with limited results.

- Upgrade the Residual Heat Removal (RHR) heat exchangers**

Scope

This would require replacement of the RHR heat exchanger tube bundles with a different design having better heat transfer characteristics. Cost for this effort including design, materials, installation of new heat exchangers, and disposal of the existing heat exchangers is estimated to exceed \$10 million per BFN unit. Personnel exposure is estimated to be 40 Man-rem per heat exchanger removal/installation (160 Man-rem per unit).

Impact on COP

This modification would likely eliminate the need for COP for long-term LOCA and reduce the magnitude of required COP credit for Appendix R and ATWS. It would have no effect on short-term LOCA or SBO COP.

- **Protect Additional RHR pump/heat exchanger/ RHR Service Water (RHRSW) Pump (for Appendix R)**

Scope

This modification involves protection of an additional RHR subsystem per the licensing basis requirements of Appendix R. Each credited RHR pump would require protection of power and control cabling, additional switchgear, a diesel generator AC power source with battery control power and control cabling as well as an additional RHR Service Water Pump with associated power and control cabling.

The physical locations of key electrical distribution boards in some of the electrical board rooms also make it impractical to ensure that two RHR pumps/heat exchangers are available in the limiting fire areas. For instance, switchgear controlling an RHR pump from one RHR loop is located in the same room as switchgear controlling the valves from the opposite loop and thus 3 RHR pumps could be disabled for the fire affected unit.

For these board rooms and other less limiting fire areas, a significant reanalysis and licensing approval would be required to accomplish the availability of the RHR Pumps, RHRSW pumps, and associated equipment needed to operate (i.e. valves, room coolers, etc.) to make a second RHR pump available. Based on these analyses, new or different plant procedures for manual operator actions would be required.

In the licensing basis Appendix R event, fire is assumed to damage all equipment located in a given fire area not meeting the physical separation and protection requirements of the rule. This rule-based approach results in limiting the equipment that is credited in mitigating fire events. BFN has recently committed to adopt the risk-informed, performance-based approach per National Fire Protection Association (NFPA) Standard 805. The design scoping, the detailed design completion, physical modifications, plant procedures revision, and licensing actions necessary to protect a second RHR pump per the requirements of Appendix R would constitute a major effort and would not be consistent with the NFPA 805 approach.

Impact on COP

This option would eliminate COP for Appendix R. It would not affect COP for other events.

- **Lower the RHR and Core Spray Pumps**

Scope

Lowering the elevation of the RHR and Core Spray pumps would increase the static water head available to the pumps. The pumps, however, are already located at the lowest elevation of the reactor building. So this would require excavation of the basemat for the reactor building and design/procurement of new pumps of vertical deep well design. This type of modification is not

considered practical because it would involve excavating inside the reactor building structure below the elevation of the base mat.

Impact on COP

This would eliminate COP from all events by increasing the necessary elevation head to the pump suctions.

2. *Licensees should continue to be requested to use the current guidance in Regulatory Guide 1.82 Revision 3 and the licensing basis analysis assumptions and methods to demonstrate that the available net positive suction head (NPSH) exceeds that required for operation of the emergency core cooling system (ECCS) and containment heat removal pumps.*

Historically, credit for COP has been required for many BWRs including BFN Units 1, 2, and 3 for a limited period of time in the LOCA analysis and during other low probability special event analyses. Following the guidance provided in Regulatory Guide 1.82 Revision 3, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident," the BFN EPU license application for the 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 thermo-hydraulic 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). The calculated containment pressure was always greater than NPSHr except for a brief time period in the short-term LOCA calculations for the (RHR pumps. For Appendix R, the largest amount of COP credit was required. On March 12, 2009, TVA submitted revisions to the NPSH/COP calculations for the short-term LOCA analysis and for the Appendix R licensing basis analysis to remove excess conservatism. 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 summary of current NPSH/COP calculations is presented below.

EVENT	RHR Pumps		Core Spray	
	PEAK COP	MARGIN	PEAK COP	MARGIN
LOCA Short-Term (< 10 minutes) Licensing Basis	<u>intact loop</u> 0.2 psi	2.6 psi	2 psi	1.3 psi
	<u>broken loop</u> 2.1 psi	0.7 psi		
LOCA Long-Term - (> 10 Minutes) Licensing Basis	none	7.1psi	3 psi	3.1 psi
Appendix R - Licensing Basis DW cooling off @2 Hrs	6.1 psi	4.1 psi	NA	NA
SBO - Licensing Basis	1.4 psi	4.5 psi	NA	NA
ATWS-Licensing Basis	1.9 psi	1.2 psi	NA	NA

3. *Regulatory Guide 1.82 Revision 3 should be revised to request that licensees submit additional analyses and information if the amount of accident pressure that must be credited based on the licensing-basis analyses is not a small fraction of the total containment accident pressure and limited in duration. The additional information should include thermal-hydraulic analyses, which address the conservatism associated with the licensing-basis analyses and explicitly account for uncertainties and probabilistic risk assessment (PRA) results consistent in scope and quality with that specified by Regulatory Guide 1.174.*

For BFN the amount of accident pressure that must be credited based on the licensing basis events analysis is not a small fraction of the total containment accident pressure. The duration, however, is limited. Therefore, additional analyses were performed to provide risk insights to COP credit.

LOCA, ATWS, and SBO

Additional thermal-hydraulic analyses were performed for the LOCA (March 23, 2006 submittal), which were used to determine parameters important to NPSH requirements and the need for COP. For ATWS and SBO, it was assumed that COP is always needed. The resulting success criteria were then used for analyses to

address RG 1.174 for LOCA, ATWS and SBO events. This was submitted July 21, 2006, and showed the risk of relying on COP was very small (Delta CDF = $2.4E-8/\text{Yr}$).

Additionally, ATWS was reanalyzed using best estimate model (August 4, 2006 submittal), which showed that COP is not needed when reactor power is modeled using TRACG as opposed to ODYN used for the current licensing basis analysis.

Appendix R Fire

Fire events were analyzed using alternate, more realistic fire scenarios and additional thermal-hydraulic analyses. Using basic principles of fire protection engineering which consider combustible loading, volume of the room and ignition sources, fire areas were screened for realistic impact of a fire on equipment. Then using equipment that would not be damaged by fire, thermal-hydraulic analyses were performed for the bounding fire area. These analyses, which were submitted November 15, 2007 and June 12, 2008, showed that only a small amount of COP (0.5 psi/6 hours) is realistically required and only in a small number of fire areas. The analysis also showed that ECCS pumps taking suction from the suppression pool are not relied upon for core cooling, thus addressing the defense in depth impact of COP.

4. *For cases in which operator actions are required to maintain containment overpressure, licensees should show how these actions can be implemented in their procedures, that they can be performed reliably, and that any increase in risk associated with these actions is acceptably small.*

The Appendix R licensing basis analysis previously took credit for operator action to terminate drywell cooling within two hours of the event initiation. Terminating drywell air space cooling increases drywell and wet well pressure, which provides additional COP margin.

The Appendix R NPSH calculations have been revised with updated analyses that show that NPSHa remains greater than NPSHr assuming full drywell cooler were in operation for the duration of the event. The minimum COP margin is 1.5 psi with all drywell coolers in service and, therefore, operator actions are not required to maintain containment overpressure. TVA submitted this analysis to NRC in a submittal dated May 7 2009.

5. *The staff review guidance in the current Standard Review Plan (SRP) should be revised to state that, if COP credit is granted to a plant based on risk information, all subsequent licensing applications involving COP credit at that plant should also include risk information.*

This recommendation is applicable to future licensing actions after EPU and was not evaluated as part of TVA's review of the ACRS letter report.