Westinghouse
Electric Corporation

Energy Systems

Nuclear and Advanced
Technology Division

Box 355
Pittsburgh Pennsylvania 15230-0355

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U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Subject: Results of Technical Evaluation of Containment Initial Temperature Assumptions for Large Break Loss of Coolant Accident Analysis

Reference: ET-NRC-92-3695 dated 4/30/92

Westinghouse provided an interim report (ET-NRC-92-3695 dated 4/30/92) pursuant to 10CFR Part 21.21(a)(2) requirements regarding the containment initial temperature assumption used in the analysis of the postulated Large Break Loss of Coolant Accident. Please find attached the results of the evaluation of this issue.

Very truly yours,

Nicholas J. Liparulo, Manager
Nuclear Safety and Regulatory Activities

Attachment

NRC/WPF-PR/6-92

IE19

Introduction:

Westinghouse has completed its evaluation of a Potential Safety Issue concerning the accumulator initial temperature, the containment initial temperature, and the containment initial pressure assumptions used in the Large Break Loss-Of-Coolant Accident (LBLOCA) Evaluation Models (EMs). A utility initially raised this issue by questioning the 90°F containment initial temperature assumption in its LBLOCA analysis, when the Technical Specifications allow a range of temperatures at 100% power. Upon further investigation of this issue the scope was broadened to include concerns with respect to the containment initial pressure and the accumulator initial temperature assumptions used in the LBLOCA EM.

Under the requirements of 10 CFR 21.21(a)(2), interim reports were issued to the NRC in references 1 and 2. Since the issuance of the interim reports, the evaluation has been completed and it has been concluded that the traditional Westinghouse assumptions for containment and accumulator initial conditions in the LBLOCA Emergency Core Cooling System (ECCS) EMs are appropriate. The basis for this conclusion is outlined below.

Containment Initial Conditions:

Evaluation Models used to calculate the Peak Cladding Temperature (PCT) during a LBLOCA require the calculation of the containment pressure during the transient. This pressure, to which fluid from the broken pipe exhausts, is important when the RCS pressure is nearly equal to the containment pressure. The effect of lower containment pressure is the decrease in the reflooding rate, which ultimately is a PCT penalty. This is addressed by the regulations of 10CFR50 Appendix K (I.D.2):

> "The containment pressure used for evaluating cooling effectiveness during reflood and spray cooling shall not exceed a pressure calculated conservatively for this purpose."

In the Branch Technical Position CSB 6-1, the NRC recognizes the effect of other parameters on the containment pressure. The Branch Technical Position specifically identifies a conservative trend for containment initial temperature:

> "Therefore, the following branch technical position has been developed to provide guidance in the performance of minimum containment pressure analysis."
>
> "The minimum containment gas temperature, minimum containment pressure, and maximum h[illegible] that may be encountered under limiting normal operating conditions should be [illegible]."

For the LBLOCA EMs, Westinghouse has defined normal operating conditions to be those associated with full power operation, which is consistent with the 102% power assumption required by 10CFR50 Appendix K (I.A). The containment parameters assumed in the LBLOCA EM need not be the same as the Limiting Conditions for Operation (LCO) as defined in the

Containment Technical Specifications. The LCOs in the Technical Specifications often represent extreme conditions that are not typically encountered during normal operation. In addition, the LCOs associated with the Containment Technical Specifications are based upon containment integrity and equipment operability considerations, not ECCS performance considerations. Consequently, some LBLOCA EM values were chosen as being representative of limiting conditions during normal full power operation and others were set at the Technical Specification LCO value. In all cases the combination of containment parameter values were chosen to assure that the overall calculation of containment pressure during a LBLOCA would be conservative.

Typical Westinghouse assumptions for dry-atmospheric containments are 90°F initial temperature and 14.7 psia initial pressure. For subatmospheric plants Westinghouse uses the Technical Specification minimum containment pressure along with a representatively low temperature of 90°F. Also, ice-condenser containments typically use 14.7 psia and the maximum Technical Specification containment temperature. The use of the maximum containment temperature for an ice-condenser containment provides a lower containment backpressure during the reflood transient and is therefore conservative with respect to 10CFR50 Appendix K requirements.

Westinghouse has always used these assumptions. The containment initial temperature and pressure assumptions in a plant's LBLOCA analysis have been consistently reported to the NRC in the Final Safety Analysis Report. The NRC has reviewed and approved this aspect of the LBLOCA transient via plant specific Safety Evaluation Reports.

The effect of variations in initial containment parameters has been determined for the LBLOCA EMs through sensitivity studies. As expected, ECCS EMs show PCT increases for lower containment pressures. The 1978 LBLOCA EM [3] can experience as high as a 51°F Peak Cladding Temperature (PCT) increase for a 1 psi decrease in containment pressure. However, the sensitivity to containment pressure has decreased as the LBLOCA EMs have evolved. The BASH Evaluation Model [4] has shown a 10°F PCT increase for a 1 psi decrease in containment pressure, and the BART Evaluation Model [5] has an increase of 4°F in PCT for a 1 psi decrease in containment pressure. The <u>W</u>COBRA/TRAC Two-Loop UPI LBLOCA Best-Estimate Evaluation Model [9] has a 7°F PCT increase for a 1 psi decrease in containment pressure.

In addition, two analyses with the BASH EM for a dry containment plant were performed to assess the effect of the containment initial temperature on the peak cladding temperature. Decreasing the containment initial temperature by 15°F and 30°F resulted in a PCT penalty of 3°F and a PCT benefit of 4°F respectively. Thus, the containment initial pressure and temperature sensitivities for the current BART, BASH, and <u>W</u>COBRA/TRAC Two-Loop UPI Evaluation Models have a small effect upon the calculated PCT.

It is concluded that the LBLOCA ECCS analyses do not need to assume the containment temperature and pressure Technical Specification limits in order to produce a conservative prediction of ECCS performance. The utilization of representative values in the ECCS analysis does not invalidate the basis for the containment pressure and temperature Technical Specification limits. The traditional Westinghouse assumptions for containment initial conditions in the LBLOCA ECCS EMs are judged by Westinghouse to be appropriate.

Accumulator Water Initial Temperature:

During the containment initial temperature investigation, a related issue arose concerning the accumulator initial temperature assumption. For the LBLOCA analysis, Westinghouse has typically assumed a value of 90°F for the accumulators. As a result of the decreasing influence of containment pressure on the calculated PCT results, a concern was raised with respect to the appropriateness of the 90°F accumulator water assumption.

Westinghouse is not aware of any utilities that measure accumulator water temperature as part of normal operations. Therefore, any estimation of typical accumulator water temperature during normal full power operation can only be inferred from containment temperature conditions. Containment temperatures during full power operation will vary considerably with location inside of containment, with the warmest locations being inside the biological shield near the RCS piping as well as at the higher elevations. The coolest locations are typically in the lower elevations outside of the biological shield. A review of the containment layouts for various plants have shown that the accumulators are typically located in the lower elevations of the containment, and outside of the biological shield. Discussions with several utilities have indicated that 90°F is representative of the containment temperature in the lower elevations of the containment outside of the biological shield, and therefore is representative of actual accumulator temperature during normal operation.

Sensitivity studies were performed with the BASH EM to determine the effect on PCT for variations in accumulator initial temperature. A typical three-loop plant, an ice-condenser containment plant, and two four-loop dry containment plants were analyzed. The results of these studies indicate that the effect on the PCT can vary between 49°F and 150°F for a 30°F increase in the accumulator water temperature.

Sufficient inherent conservatism already exists in the Westinghouse LBLOCA EMs to bound the uncertainty associated with the accumulator water temperature assumption. Reference 4 provides information concerning the inherent conservative nature of the BASH Evaluation Model. Specifically, the Technical Evaluation Report for the BASH EM provides the following information in the conclusions and recommendations section:

> "Some of the basis for determining the actual amount of margin existing in current EMs results from our experience reviewing the results of LOCA analyses from other thermal-hydraulic codes. One of the most applicable set of analyses for this discussion was completed by Rohatgi and Yuelys-Miksis at Brookhaven National Laboratory while the BASH review was underway. [7] (That study is briefly referred to in Section 11 of the (BASH) WCAP.) The Brookhaven study concluded that there is approximately 1200°F of conservatism in the peak clad temperature predictions contained in representative EM calculations. Based on their analyses, they attributed almost 650°F of that conservatism to the licensing type operating and boundary conditions and scenarios used by the EM, and the other 550°F, or so, to the physical models required by Appendix K. We and others have previously seen that this estimate of the amount of margin available is realistic."

Some of the conservatism outside of 10CFR50 Appendix K is detailed in reference 4, page 9 of the Safety Evaluation Report, which states:

> "The sources of the conservative margin are attributed to a tendency by the BASH model to underpredict the flooding rate and the hot channel heat transfer."

Furthermore, as detailed in Appendix I of reference 4, the BART Evaluation Model contains approximately 50°F of conservatism over the BASH Evaluation Model. Thus, there is considerable conservatism in the Westinghouse LBLOCA Evaluation Models in addition to those resulting from the 10CFR50 Appendix K requirements.

Reference 9 also indicates that the WCOBRA/TRAC Two-Loop UPI LBLOCA Best-Estimate Evaluation Model has sufficient conservatism to bound any variation in accumulator water temperature. Page 55 of the Technical Evaluation Report in reference 9 states:

> "The four - channel, super - bounded PCT with uncertainties is a conservative estimate of the 95% probability level PCT. The realistic 95% probability level PCT is less than this value and there is a large margin."

During this evaluation available experimental data from the FLECHT-SEASET tests [6] and from the Cylindrical Core Test Facility (CCTF) [8] were reviewed. Figure 1, which is from the FLECHT-SEASET tests, shows that the effect of coolant subcooling on temperature rise is inconclusive. For FLECHT-SEASET and FLECHT Cosine tests, more coolant subcooling (colder ECCS water temperature) was found to give lower peak temperatures. In the FLECHT skewed power tests, the opposite effect was found, greater subcooling resulted in higher cladding temperature. The CCTF tests indicate that the temperature rises during the reflood transient are small over a wide range of initial conditions, including different core inlet subcoolings. However, the CCTF tests do not include a single effect which can be used to establish a clear trend with respect to subcooling.

In conclusion, sufficient inherent conservatism exists in the Westinghouse LBLOCA EMs to bound any uncertainty associated with the traditional 90°F accumulator water temperature assumption. Use of an extremely high accumulator water temperature assumption would unnecessarily add further conservatism to the already conservative LBLOCA EMs.

Summary and Conclusions:

The traditional Westinghouse assumptions for containment and accumulator initial conditions in the LBLOCA ECCS EM's are judged by Westinghouse to be appropriate. There is sufficient inherent conservatism in the Westinghouse LBLOCA ECCS EMs to bound any uncertainty associated with the current containment and accumulator temperature assumptions, and to assure with high probability that the criteria of 10CFR50.46 would not be exceeded in the highly unlikely event of a Large Break LOCA. As new LBLOCA analyses are performed with either the BART, BASH, or WCOBRA/TRAC Two-Loop UPI EMs, these assumptions will be evaluated and justified on a case by case basis.

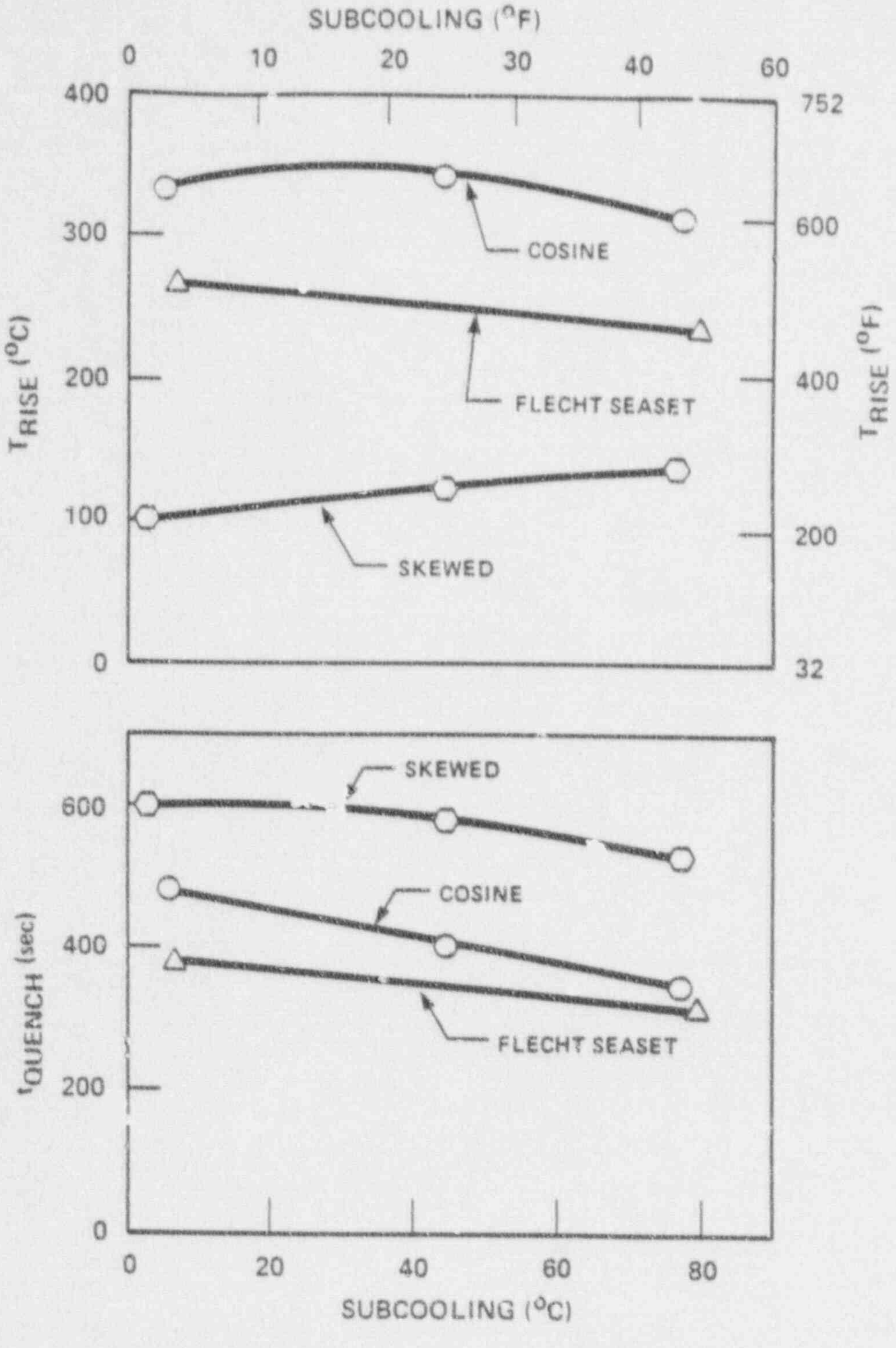

Figure 1. Subcooling Effect on Temperature Rise and Quench Time. From Lee, N. et al., "PWR FLECHT SEASET Unblocked Bundle Forced and Gravity Reflood Task," EPRI NP-2013, WCAP-9891, February 1982.

References

1. ET-NRC-91-3647, Interim Report of Evaluation of a Deviation or Failure to Comply Pursuant to 10CFR21.21(a)(2), December 20, 1991.

2. ET-NRC-92-3695, Interim Report of Evaluation of a Deviation or Failure to Comply Pursuant to 10CFR21.21(a)(2), April 30, 1992.

3. "Westinghouse ECCS Evaluation Model: 1978 Version", WCAP-9220-P-A, February 1978.

4. "The 1981 Version of the Westinghouse ECCS Evaluation Model Using the BASH Code", J. J. Besspiata, J. N. Kabadi, H. C. Yeh, and M. Y. Young, WCAP-10266-P-A Rev. 2, March 1987.

5. "BART-A1: A Computer Code for the Best Estimate Analysis of Reflood Transients", M. Y. Young, J. S. Chiou, J. Kabadi, T. A. Porsching, S. R. Rod, A. C. Spencer, WCAP-9561-P-A, March 1984.

6. Lee, N. et al., "PWR FLECHT SEASET Unblocked Bundle Forced and Gravity Reflood Task," EPRI NP-2013, WCAP-9891, February 1982.

7. "Safety Research Programs Sponsored by Office of Nuclear regulatory Research, Quarterly progress report, October 1 - December 31, 1984." Brookhaven National Laboratory, NUREG/CR-2331, Vol. 4, No. 4, May 1985, pp. 66, 67, and 74.

8. "Research Information Report for the Core Cylindrical Test Facility, Core II Test Series.", MPR-934, Volume I of II, April 1988.

9. Hochreiter, L. E., Schwarz, W. R., Takeuchi, K., Tsai, C. K., and Young, M. Y., "Westinghouse Large-Break LOCA Best-Estimate Methodology, Volume 2: Application to Two-Loop PWRs Equipped with Upper Plenum Injection", WCAP-10924-P-A, Rev.2, and Addenda. December 1988.