Commonwealth Edison Company
1400 Opus Place
Downers Grove, IL 60515

ComEd

August 25, 1995

Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attn: Document Control Desk

Subject: Additional Information regarding Commonwealth Edison Company's Response to Questions Regarding the Increase in the Interim Plugging Criteria for Byron Unit 1 and Braidwood Unit 1
NRC Docket Numbers:50-454 and 50-456

Reference: D. Lynch letter to Commonwealth Edison Company dated August 3, 1995, transmitting Request for Additional Information

In reference letter the Nuclear Regulatory Commission transmitted to Commonwealth Edison Company (ComEd) request for additional information (RAI) regarding the technical bases supporting the pending license amendments, [illegible] involves an increase in the interim plugging criteria for steam generator tubes at [illegible]on Unit 1 and Braidwood Unit 1. Attached is ComEd's response to that RAI.

If you have any questions concerning this correspondence please contact this office.

Sincerely,

Denise M. Saccomando
Nuclear Licensing Administrator

Attachment

cc: D. Lynch, Senior Project Manager-NRR
R. Assa, Braidwood Project Manager-NRR
G. Dick, Byron Project Manager-NRR
S. Ray, Senior Resident Inspector-Braidwood
H. Peterson, Senior Resident Inspector-Byron
H. Miller, Regional Administrator-RIII
Office of Nuclear Safety-IDNS

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August 25, 1995

RESPONSE TO SUPPLEMENTAL QUESTIONS REGARDING TRANFLO

NRC Request Number 44

Provide experimental data which would support the validation of the TRANFLO code. This data should include pressure drops across internal structures comparable to the tube support plates (TSPS) and other internal steam generator (SG) structures. Additionally, the experimental data should include such parameters as void fractions as a function of space and time to demonstrate that the calculated hydrodynamic phenomena are predicted accurately for rapid depressurization events. Test data using simplified, properly scaled geometries of components similar to those in a SG would be appropriate. Some of the other experimental parameters which should be discussed are level swell and flashing phenomena. The rate of depressurization in the test data should be comparable to that expected for postulated accidents including a main steam line break (MSLB)

Response

The NRC staff concluded in 1982 that the TRANFLO code is an acceptable code for calculating mass and energy release data for use in containment analysis following a postulated MSLB. Therefore, it can be concluded that the TRANFLO model is appropriate for predicting macrosopic SG behavior (including tube bundle region) under the range of MSLB conditions. The distribution within the tube bundle is principally influenced by the TSP pressure loss. Westinghouse has conducted experimental tests of pressure loss through the prototypical TSP of the Westinghouse manufactured SGs. Based on this test data, the correlation of the TSP pressure loss coefficient was established (see Figure 5-2 in WCAP-14273).

The correlation of TSP pressure loss used in both TRANFLO and the GENF computer program has been verified using actual field data from Westinghouse manufactured steam generators and laboratory test data. GENF is a steam generator performance program used extensively by Westinghouse which has been shown to accurately predict operating steam generator conditions.

As discussed in WCAP-14273, flow which passes through the tube bundle is several times higher than the feedwater flow; the ratio of the tube bundle flow to the feedwater flow is called circulation ratio. An accurate prediction of the circulation ratio depends on an accurate pressure loss coefficient for flow conditions through the tube bundle including velocity and void fraction. Figure 5-3 of WCAP-14273 shows a typical comparison between predicted and actual measured circulation ratios versus power level. There is good agreement between the predicted and measured circulation ratio.

Correlations from the test or field data have been used in both steady state and dynamic flow conditions. Such an application provides realistic results, consistent with accepted industry practice, that are accurate within the uncertainty band associated with the Braidwood and Byron steam generator analyses (see Section 6 of WCAP-14273).

Enclosure 1 is Appendix D to an MPR report. Appendix D presents comparisons of circulation ratio and pressure drop of the field measurement and calculation by the drift flux version of the TRANFLO code for a Model D3 steam generator. On the basis of the comparisons, it is concluded that the drift flux version of the TRANFLO model adequately calculates the pressure drops through the baffle of the Model D3 preheater, and thus the circulation ratio.

Enclosure 2 is Appendix B of an MPR report. Appendix B describes the verification analyses for the particular application for a drift flux version of TRANFLO utilizing the same solution techniques as the drift flux version utilized by Westinghouse, Paragraph B.4 compares calculated results with measured results of void fraction and vessel pressure, for a test vessel that was partially filled with water at high pressure and then blows down through an orifice. Reference 3 in Enclosure 1 is, "Transient Two-Phase Blowdown Predictions of an Initially Stagnant Liquid Steam in a Vessel Using TRAC-PF1", Yassin A. Hassin, Nuclear Technology, Vol. 69, June 1985.

It is concluded that the TRANFLO model properly calculates the pressure drops and void fraction throughout the steam generator, including the tube bundle with TSPs.

NRC Request Number 45

Provide benchmarking and validation data for the drift flux version of the TRANFLO code to demonstrate the adequacy of the modeling.

Response

As discussed in Response to Request Number 1, Enclosure 2 provides benchmarking and validation information for the drift flux version of the TRANFLO code. The calculated results of void fraction and pressure compare well with measured results for a test vessel that was partially filled with water at high pressure and then blown down through an orifice.

Enclosure 3 is a paper presented at the ASME/IEEE Power Generation Conference in Dallas Texas, October 22-26, 1989. The paper describes the application of a version of TRANFLO using solution techniques that are essentially unchanged from those in the drift flux version of TRANFLO utilized by Westinghouse to calculate the steam pressure and flow rate from a steam generator following a turbine trip. The results indicate the measured water level and calculated mass flow respond at about the same frequency.

These comparisons support the adequacy of the drift flux modeling used in the TRANFLO code.

NRC Request Number 46

Since TRANFLO is a one-dimensional (1-D) computer code, provide your basis for accounting for multi-dimensional effects during rapid flashing events in the SGs. Specifically, address void drift, flow regime transitions (eg., bubbly to slug) and radial/axial variations of the steam and water flow. The fundamental concern to be resolved is the potential for uneven load distributions on the TSPs which cannot be properly evaluated by 1-D calculations.

Response

All the simulations have been done under the assumption that flow can be adequately described and quantified by a one-dimensional model. Some three dimensional effects can be postulated in the tube bundle. These effects have limited importance in determining TSP loading for the following reasons:

1) The peak load occurs in the very early part of the transient (within a few seconds), and is primarily driven by inertial flow considerations.

2) The tube bundle is submerged within liquid water for a water level well above the tube bundle (i.e., 487" elevation, right at the bottom of the swirlvane separators). The peak load happens within a few seconds, while the flow regime is essentially limited within bubbly flow; flow regime transition is not experienced this early in the transient.

3) The fluid conditions at the time of the peak TSP load are relatively uniform in the tube bundle, because of the uniform tube layout, and uniform temperature conditions at the beginning of the MSLB event from a hot standby, zero power conditions (A SLB from hot standby, zero power is the most conservative case). No temperature difference exists within the tube bundle; both primary and secondary fluids are at the same initial temperature of 557 °F.

4) For the Model D4 steam generators, there are differences in some TSPs and baffles between the hot leg and the cold leg. TRANFLO models these differences using separate nodes for hot and cold leg. Thus the model addresses the possible difference for the hot and cold legs of the TSPs.

5) Because of uniform geometry and uniform temperature discussed above, the two-phase flow resulting from water flashing due to depressurization is expected to be essentially uniform radially. Of course, there exists axial variation in fluid flow conditions, such as velocity, pressure and void fraction. However, the flow regime is essentially bubbly flow within the very early part of the transient, during the peak TSP load, as mentioned above.

6) In addition to the aforementioned geometrical and thermal uniformity, the existence of TSPs will also tend to suppress any radial variation of fluid flow variables (e.g., velocity, pressure, and void fraction), further inhibiting propagation of multidimensional effects.

On the basis of the above considerations, no significant variation of TSP load in the radial direction would be expected. However, axial variation of TSP load is accounted for and calculated results do show such axial variation (i.e., load varies from TSP to TSP).

NRC Request Number 47

Explain how TRANFLO accounts for the potentail for instability-induced counter-current flow limiting (CCFL) phenomenon across TSPs (especially at lower elevations). Effects of CCFL on pressure distributions and steam/water flows as a function of space and time need to be taken into account. Provide your basis for accounting for CCFL and discuss any available validation data.

Response

The initial conditions for the Commonwealth Edison analyses of Model D4 steam generators are at high pressure and saturated water. Following the break, the fluid in the tube bundle splits into two paths. The fluid at the top of the tube bundle is accelerated in an upward direction into the riser. The fluid at the lower bundle is accelerated downward and turned into the downcomer, Void fraction of the fluid in the tube bundle continues to increase as the event continues, but remains in the bubbly flow regime until after the peak TSP loads are experienced.

The peak loading on the TSPs occurs within a few seconds while the liquid inventory and absolute pressure in the steam generator remain high. The liquid and vapor velocities in the tube bundle tend to be mono-directional. Counter-current flow limiting phenomena would be expected to be important later in the transient, as blowdown progresses and fluid velocities drop to the point where buoyancy effects can dominate; it is not expected to experience the counter-current flow limiting phenomena in the initial fluid acceleration phase of the event.

To test these assumptions, the steam line break transient for Braidwood has been re-run using TRANFLO with the drift flux model turned off. This approach treats the flow as homogenous with no counter current flow. The TSP loads were not significantly affected during the first several seconds.

Enclosure 4 is an MPR report to assess the use of full-scale UPTF data to evaluate scaling of downcomer (ECC Bypass) and hot log two-phase flow phenomena, it is our understanding that problems of CCFL are encountered primarily at low pressure while introducing subcooled water.

On the basis of the above discussion, we do not consider CCFL to be a problem for the analyzed steam generator pressure and geometry for calculating TSP load (i.e., pressure drop).

NRC Request Number 48

Recognizing that there are inherent limitations in the 1-D TRANFLO model which you are using to depict rapid depressurization-induced flashing, describe how the hydrodynamic loads on the TSPs are evaluated using the simple static differential pressure formula for form loss alone. Provide all supporting information.

Response

The steam line break transient has been analyzed by Commonwealth Edison using RELAP5M2 employing a two fluid non-equilibrium flow model. In this analysis small volumes were created on either side of the TSP to more accurately predict the differential pressures. The RELAP5M2 calculated TSP pressure load was virtually identical to that calculated by the TRANFLO form loss method, for comparable mass flows through the TSP. This calculation will be provided in response to RAI 5.

A report of an independent assessment by two George Washington University professors of the approach used for calculation of TSP forces was distributed by Federal Express on July 27, 1995. It should be noted that the form loss correlation used does include the effects of two-phase flow. This report is provided as Enclosure 5.

Enclosure 1

Comparison of TRANFLO Calculations to Ringhals D-3 Steam Generator Data

COMPARISON OF TRANFLO CALCULATIONS TO RINGHALS D-3 STEAM GENERATOR DATA

This appendix presents the comparison of the TRANFLO computer code calculations to temperature, pressure drop and flow rate data obtained at the Ringhals D-3 steam generator.

The TRANFLO computer model is the same as that used to calculate the first five thermal transients in this report. This model is described in Appendix B; Figures 1 through 4 in Appendix B depict the nodalization, flow paths and heat connectors utilized.

On the basis of the comparisons described on the following pages it is concluded that the TRANFLO model used for these analyses adequately calculates the thermal hydraulic conditions of the D-3 steam generator.