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SUBJECT: Discusses rept of error in large break loca eccs analysis & forwards rept to determine new LHR limits.

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DUKE POWER

February 1, 1995

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

Subject: Oconee Nuclear Site
Docket Nos. 50-269, -270, -287
Report of Error in Large Break LOCA ECCS Analysis

On January 26, 1995 at 1700 hours, Oconee Nuclear Station (ONS) received notification from B&W Nuclear Technologies (BWNT) that an error exists in the ECCS Evaluation Model. A copy of this notification is supplied as Attachment 1.

The BWNT notification provides information concerning the effects of initial Core Flood Tank (CFT) conditions used for large break LOCA analyses for ECCS evaluations and reports non-conservative data was used. When corrected data is used, a peak clad temperature (PCT) change of 50°F results. This could lead to PCT in excess of the 2200°F acceptance criteria as specified by 10 CFR50.46(b)(1). This only effects the core at the 2 ft. elevations and can be corrected by limiting the allowable linear heat rate at those locations during normal operating conditions.

The generic LOCA analysis for the lowered loop B&W plants has shown a required linear heat rate (LHR) reduction of approximately 0.3 to 1.3 kw/ft, depending on the plant and fuel designs, to ensure that calculated PCT's are within the acceptance criteria of 10 CFR50.46. Duke Power has requested that BWNT perform a plant specific analysis for Oconee. Preliminary estimates indicate that the LOCA linear heat rate (LHR) reduction from this plant specific analysis should be in the range of 0.3 kw/ft from the current allowable normal operating limits.

Duke power's Nuclear Engineering staff has used the bounding reduction in LHR of 1.3 kw/ft to conservatively establish new operating limits on axial imbalance for all three Oconee units. These new limits were administratively imposed on January 26, 1995.The Core Operating Limits Report (COLR) was changed to incorporate the reduction in LHR for current cycle Oconee units on January 30, 1995. This action will ensure the acceptance criteria of 10 CFR50.46(b)(1) will remain satisfied in the

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event that, when the BWNT analyses are completed, a reduction in the LHR limit at the 2 foot elevation is actually required.

As specified in the BWNT report (Attachment 1), the large break LOCA analyses required to determine the new LHR limits and their impact on operating limits are scheduled to be complete by August 1, 1995.

Pursuant to 10 CFR50.46(a)(3)(ii), I am submitting this as a report of a significant error discovered in the ECCS Evaluation Model.

Very truly yours,

J. W. Hampton

cc: Mr. S. D. Ebneter, Regional Administrator
U. S. Nuclear Regulatory Commission, Region II

Mr. L. A. Wiens, Project Manager
Office of Nuclear Reactor Regulation

Mr. P. E. Harmon
Senior Resident Inspector
Oconee Nuclear Site

(Attachment 1)

BW

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January 27, 1995
JHT-95-12

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Subject: Report of Preliminary Safety Concern Related to Large Break LOCA ECCS Analyses

Gentlemen:

The purpose of this letter is to advise you of a potential safety concern regarding the effects of initial conditions used for large break LOCA analyses for ECCS evaluations of the B&W operating plants and to report a condition of nonconservative data handling in the Evaluation Model that, when corrected, results in a change in peak clad temperature of greater than 50 F.

This concern relates to the initial core flood tank (CFT) conditions of pressure and inventory and their potential effects on peak clad temperature (PCT) predictions. Historically, the CFT conditions assumed for calculations at the 2-ft core elevations have been based on the minimum CFT pressure and liquid inventory. These inputs, which represent the range of Technical Specification limits plus instrument uncertainty, were considered to be the most-limiting initial conditions for the 2-ft LBLOCA PCT analysis. Recently, a sensitivity study performed with a new unapproved Evaluation Model (BAW-10192), concluded that the most-limiting 2-ft PCT is calculated when the maximum CFT liquid inventory and minimum pressure were input as the initial conditions. When the initial conditions of maximum CFT liquid inventory and minimum pressure were applied in the currently approved Evaluation Model (BAW-10104), the peak clad temperature change was found to be greater than 50 F.

The 2-ft LOCA linear heat rate analysis limits for all operating plants require preliminary reductions ranging from approximately 0.3 to 1.3 kW/ft, depending on the plant and fuel designs, to ensure that calculated PCT's are within the acceptance criteria contained in 10 CFR 50.46. A preliminary review of all core operating limits for plants for which BWNT performs the power distribution (all operating B&W designed plants, except the Oconee Units), with administrative reductions in the LOCA limits appropriate for the fuel and plant in question, suggests that the current operating limits will be unchanged by these reductions. This information has been transmitted to all operating plant utilities. Duke Power Company has performed an evaluation based on preliminary plant specific LOCA kW/ft limits and has determined that a small reduction in core operating limits would be necessary.

In accordance with 10 CFR 50.46, this letter documents NRC notification of a PCT change in excess of 50 F. A change in peak clad temperature in excess of 50 F will result from the change in CFT initial conditions or from correcting the nonconservatism in data handling. The peak clad temperature limit of 2200 F specified in 10 CFR 50.46.b.1 would be exceeded.

95-0203-0105

Attached is a more detailed description of the concern, including a technical justification for the position that no safety concern exists. Further analytical work will more formally document this conclusion. A plan for resolution of this concern is currently being discussed with the B&W operating plant owners for their approval. BWNT believes it is prudent to inform the NRC at this time on the nature of the concern. All analyses are expected to be completed by August 1, 1995. A final report will be submitted to the NRC at that time. At the present time, it has not been determined that this matter is a reportable item under 10 CFR 21.

If you have any questions concerning this matter, please contact the undersigned at 804-832-2817, or you may contact Mr. Robert Schomaker at 804-832-2917.

Very Truly Yours,

J. H. Taylor, Manager
Licensing Services

cc: R. C. Jones
Linda Gundrum

Preliminary Safety Concern of Initial CFT Conditions for LBLOCA ECCS Analysis

Introduction:

B&W Nuclear Technologies is in the process of evaluating a Preliminary Safety Concern (PSC 5-94) related to the core flood tank (CFT) initial conditions assumed in the large break loss-of-coolant accident (LBLOCA) evaluation model (EM) calculations. The LBLOCA calculations in question are those performed according to the methods described in BAW-10104 Revision 5 for the 2-ft core power peak. Since 1991, the initial CFT conditions for all 2-ft LOCA limit calculations have used the minimum CFT pressure and liquid inventory. These inputs, which represent the lower range of Technical Specification limits plus instrument uncertainties, were considered to be the most limiting initial conditions for the 2-ft LBLOCA PCT analysis. A sensitivity study performed with a new (unapproved) RELAP5/MOD2-based EM (BAW-10192), concluded that the most limiting PCT is calculated when the maximum CFT liquid inventory and minimum pressure are input as the initial conditions. When these input changes were analyzed with the current (approved) CRAFT2-based EM, the PCT change was found to be greater than 50 F. In fact, the LOCA linear heat rate limits (LHRs) had to be reduced by 0.3 to 1.3 kW/ft, depending upon the plant and fuel designs, to calculate PCTs that do not violate the 2200 F acceptance criteria contained in 10 CFR 50.46.

Analyses were begun to redefine LOCA LHRs, given the effect of the more limiting CFT inputs on results for the 2-ft elevation. In the course of these studies, it was further determined that the process by which fluid enthalpies have been passed from the CRAFT2 blowdown calculation to the THETA1B heatup analysis may have led to nonconservative conditions being used during a short period of the THETA1B calculation. Investigation has shown this data transfer process to affect the fluid enthalpies used at all core elevations, but the effect upon peak cladding temperature is significant only at the 2-ft elevation. Moreover, the sensitivity of the PCT results at the 2-ft elevation that had been attributed solely to the CFT inputs was found to include both

the effects of the CFT inputs and the fluid enthalpy transfer. At this point, the CRAFT2-to-THETA1B data transfer has been revised to assure that conservative fluid enthalpies are used in calculating clad surface heat transfer, and a fresh set of analyses are underway to reestablish the limiting core linear heat rates.

Background:

In 1991, the B&W Owners Group Analysis Committee directed BWNT to use the most conservative set of CFT liquid level, pressure, and line resistance inputs to envelope possible plant conditions (Technical Specification limits plus instrument uncertainty) for all subsequent LBLOCA analyses. BWNT performed a sensitivity study for the 6-ft elevation and determined that the maximum pressure, minimum liquid level, and minimum line resistance produced the highest PCT. A CFT line resistance study performed for the 2-ft elevation showed that the minimum pressure and maximum resistance produced the highest PCT for the 2-ft cases. The minimum inventory was used because the downcomer was not completely filled before the CFT emptied, and this condition limits the core inlet flooding rate. These input changes were incorporated into the LOCA limit analyses performed after 1991, for Mark-B9, Mark-B10(OL), and Mark-B9A.

In November 1994, a sensitivity study performed using the RELAP5/MOD2-based evaluation model (EM) for the Mark-B11 fuel design revealed that the maximum CFT liquid inventory would produce the highest PCT. It was found that the combination of minimum gas volume and minimum pressure would result in the lowest CFT flow during the adiabatic heatup period. This low flow decreased the liquid remaining in the reactor vessel lower plenum and extended the time period to refill the lower plenum. The net result was an increase in the adiabatic heatup period by approximately 20 percent. For a PCT defined by the ruptured segment near the onset of core recovery, the PCT was found to be significantly higher than would be produced with the minimum liquid volume. On this basis, Preliminary Safety Concern (PSC) 5-94 was written, related to the anticipated PCT variation associated with the input of the minimum versus

the maximum CFT liquid inventory in the LBLOCA emergency core cooling system (ECCS) analyses of record.

Discussion:

The CRAFT2-based EM LOCA LHR limit at the 2-ft elevation is ruptured-node limited. A 2-ft analysis was performed with CRAFT2 for the Mark-B10(OL) fuel design. This analysis confirmed the RELAP5/MOD2 results that prompted PSC 5-94. During the initial investigation of this PSC, the generic 177-FA lowered-loop (LL) LOCA LHR limit for the Mark-B9 fuel had to be reduced by 1.3 kW/ft to accommodate the PCT increase in the 2-ft analysis. This reduction consisted of two components. The adverse effects from the CFT parameter changes were compounded by an observed variation in the CRAFT2 core path inlet enthalpy supplied to THETA1-B for the fuel pin thermal analysis. The enthalpy was supplied to THETA1-B on a coarse data frequency (one point every 0.5 seconds), and was subject to high frequency oscillations that corresponded to the changes in instantaneous flow direction. The calculated PCT was found to be sensitive to the enthalpy sampling because a large enthalpy difference existed between the two nodes surrounding the 2-ft elevation. For the previous Mark-B9 LOCA analysis, the coarse data frequency had resulted in the use of a nonconservative enthalpy, which led to improved heat removal and a higher 2-ft LOCA LHR limit. The previous Mark-B9A and Mark-B10(OL) limits were reviewed with respect to this nonconservative enthalpy used for the hot pin calculations. The review concluded that the nonconservatism had probably been contained in those results. All cases that could require reanalysis were identified, and a schedule for resolution was prepared.

Several Mark-B8 and Mark-B8A 2-ft LOCA limits were included as candidates for reanalysis used nominal CFT conditions as the licensing basis. Therefore, the 2-ft LOCA limits are not subject to the CFT input change, however, the analysis is subject to the enthalpy data transfer nonconservatism. The adjustment related strictly to the Mark-B8 enthalpy contribution is expected to be sufficiently small, such that no change is needed to core operating limits.

At the start of the reanalyses, other aspects were identified relative to the core path inlet enthalpy calculated by CRAFT2. In addition to the high frequency oscillations, it was observed that the enthalpy could also be skewed in the nonconservative direction by a nonhomogeneous treatment of the core nodes following total dryout with subsequent return to two-phase conditions. The LBLOCA blowdown model is constrained to homogeneous flows calculated by homogeneous node conditions. So long as the nodes remain continuously two-phase, the homogeneous conditions are correctly calculated. After dryout and return to two-phase conditions, however, the homogeneous condition is not met. Under these conditions, CRAFT2 allows the node to separate the steam and liquid phases. Figure 1 shows the code model with the separate interpretations of the nodal conditions. Because of the flow path connections, this configuration can artificially cause the inlet flow path enthalpy to be lower than the nodal homogeneous enthalpy. Since this enthalpy is transferred to THETA1-B, it can cause nonconservative conditions to be used for the hot pin analysis.

This nonhomogeneous behavior was found to occur in all LBLOCA analyses, regardless of the peak power elevation. The timing and duration of the condition varied as a function of core height. This discovery forced an investigation into the cause and led to an expanded scope of review to validate all LOCA LHR limits. Approximately two weeks were needed to evaluate the cause and effects of these conditions. CRAFT2 input model changes were made to preclude the possibility of the nonhomogeneous condition. A temporary CRAFT2 code version was created to force the flow path conditions to be consistent with the homogeneous nodal conditions. This work concluded that no change was required in the 4-ft through 10-ft elevation LOCA limits. The PCTs calculated for these elevations may increase, but the increase is less than 20 F. All 2-ft elevation cases, however, can have additional nonconservative heat removal due to this lower enthalpy supplied to THETA1-B.

The work performed to date supports the validity of a simple change in the enthalpy data transfer to the THETA1-B analysis, without input model changes or a new CRAFT2 code version. The current analyses will continue to calculate the CRAFT2 blowdown transient without any changes. The inlet enthalpy from

the CRAFT2 analysis will be adjusted before the input is supplied to THETA1-B. The inlet enthalpy will be conservatively set to envelope the upstream homogeneous nodal enthalpy based on the filtered flow direction. THETA1-B will be run with this conservative enthalpy to determine a PCT.

After the initial 2-ft LHR limit reduction estimates were available, BWNT performed preliminary evaluations of the current fuel cycles (except the Oconee Units) to determine if the operating limits remained valid given a 1.3 kW/ft decrease in the 2-ft Mark-B9 and Mark-B9A LOCA LHR limits. The preliminary results indicated that no changes to the operating limits were needed for the present fuel cycles. Duke Power Company performs the power distribution analyses for the Oconee units, and preliminary review by Duke concluded that the Oconee operating limits will be more restrictive. To minimize the effect on the Oconee units, additional analyses using less restrictive, plant-specific CFT inputs have been included as a part of the evaluation scope. The expected reduction in the 2-ft LOCA limit is expected to be approximately 0.3 kW/ft, which will result in a very small change in the core operating limits.

Evaluation Schedule and Plant Operation:

The LBLOCA analyses required to determine the new LHR limits and their impact on operating limits are scheduled to be complete by August 1. A final report will be sent to the NRC upon completion of all of this work. In the interim, plant operation is justified based on the preliminary assessment that the 2-ft LOCA LHR limit, with a 1.3 kW/ft reduction for Mark-B9 and Mark-B9A fuel types, will not lead to changes in the current core operating limits for any plants that BWNT performs the power distribution analyses. The operating limits will prevent the core maximum LHR from reaching a power level that could violate the 10 CFR 50.46 criteria. Duke Power Company performs the power distribution analyses for the Oconee Units, and plant specific analyses have determined that operation of the Oconee Units is justified with implementation of more restrictive operating limits. At this time in the evaluation, these bases support the expectation that the subject PSC and

adjustment of enthalpies applied in the heatup analyses will not represent a substantial safety concern.

Summary and Conclusions:

The adjustment of the traditional CFT liquid inventory input assumption and nonconservative enthalpy specified to the hot pin thermal analysis will produce changes in the LBLOCA peak cladding temperature in excess of 50 F. Reductions in the LOCA LHR limits of 0.3 (Oconee specific) to 1.3 kW/ft (Generic 177-FA RL and LL) are required to continue to meet the 10 CFR 50.46 acceptance criteria of 2200 F. The majority of the reduction is related to the CFT inventory input and its effect upon the adiabatic heatup time. The nonconservative enthalpy used in the hot pin analysis can cause PCT changes that are difficult to quantify without separate analyses isolating the coarse data frequency from the nonhomogeneous effects. The most conservative CFT liquid inventory input will be used in analyses that conservatively adjust the enthalpy transferred from the CRAFT2 results to THETA1-B for the hot pin analysis. The new 2-ft LOCA LHR limits will be used in power distribution analyses to determine if any changes are needed to the core operating limits. The required analyses are in progress. The results of the LOCA analyses, including any potential changes to core operating limits, are scheduled to be complete by August of this year.

Figure 1. CRAFT2 Core Noding Representation.