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2000 – Annual Reporting of Changes and Errors in ECCS Evaluation Models

Attached is a summary report of the changes and error corrections implemented in the ECCS evaluation models for the period of January 1, 2000 to December 31, 2000.

Framatome ANP Richland, Inc. (FRA-ANP) used the EXEM BWR Evaluation Model for boiling water reactor large and small break LOCA evaluations, the SEM/PWR-98 PWR Evaluation Model for pressurized water reactor large break LOCA evaluations, and the EXEM PWR Small Break Model for pressurized water reactor small break LOCA evaluations.

FRA-ANP considers the BWR and PWR ECCS evaluation models to include both the codes and the methodology for using the codes. Changes to inputs that result from fuel or plant changes and that are treated according to the methodology are not considered model changes and therefore are not reported in the attachment. Changes in peak cladding temperatures (PCTs) due to changes to LOCA evaluation models and input changes are reported on a plant specific basis by FRA-ANP to affected licensees. The licensees have the obligation under 10 CFR Part 50.46 to report the nature of changes and errors affecting PCT. This report is provided for information only.

Very truly yours,

James F. Mallay, Director
Regulatory Affairs

/arn

Attachment

cc: N. Kalyanam (w/Attachment)
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Annual Reporting of EXEM BWR Model Changes and Error Corrections (2000)

The EXEM BWR Evaluation Model is used to assess both large break and small break loss of coolant accidents in BWRs. The Evaluation Model consists of four computer codes: (1) RELAX to compute the system and hot channel response during blowdown, (2) FLEX to calculate the time for refill of the lower plenum and reflood of the core, (3) HUXY to calculate the heatup of the peak power plane, and (4) RODEX2 to determine the rod conditions at the start of the transient.

The code or methodology changes to this Evaluation Model implemented during this reporting period are described below.

Wilson Bubble Rise Model in FLEX

The FLEX code is used to calculate the time to reflood in the BWR LOCA calculation. It picks up the RELAX output at the time of rated core spray and calculates the additional time to reach the defined reflood criteria. This time difference constitutes the time period over which the Appendix K spray heat transfer coefficients are required to be used.

The Wilson Bubble Rise model is used in the lower plenum and guide tubes and is part of the original version of FLEX. This correlation has two regions that use different empirical equations. FLEX was found to use an incorrect value for the transition logic between the regions, which created a discontinuity between the two regions. The intended application of the correlation is to have a continuous function, which can be ensured by using a MAX function on the two empirical equations. The error results in FLEX calculating a bubble rise velocity different by about a factor of two at about 10% void fraction as compared to RELAX. Beyond about 20% void fraction they are the same. Thus, FLEX would produce less level swell in the void region from ~5% to 20%. The code was changed to implement the model correctly.

The impact of this change on the PCTs for plants for which FRA-ANP performs LOCA analyses was estimated to range from 0 to +1 °F.

Momentum Equation in FLEX

The momentum equation in FLEX for pipe geometries adjacent to the break was missing an area divider in the ECC flow term. This error is only relevant if the ECC flow is injected into a piping node next to the break. Only one plant was modeled in this way.

The impact of this change on the PCTs for the affected plant was estimated to be 0 °F.

FLEX Verification and Validation

In response to the 1997 NRC inspection, FRA-ANP committed to perform additional verification and validation of its key codes. A number of minor errors were identified and corrected in the code FLEX as part of this effort.

The impact of this collective change on the PCTs for plants for which FRA-ANP performs LOCA analyses was estimated to range from 0 to +8 °F.

HUXY Strain Correlations

The BALLON and BULGEX subroutines in HUXY use the term [exp(strain)] in the radial displacement calculation for the cladding. The term should be (1+strain). The subroutines were corrected to contain the correct expression.

The impact of this change on the PCTs for plants for which FRA-ANP performs LOCA analyses was estimated to range from -5 to +1 °F.

NOTE: This correction was implemented in February 1999. The PCT impacts of the correction were inadvertently not reported to licensees in 1999 nor to the NRC in SPC's (now FRA-ANP's) 1999 – Annual Reporting of Changes and Errors in ECCS Evaluation Models.* All affected licensees were notified for their 10 CFR 50.46 reports.

* Letter, James F. Mallay (SPC) to Document Control Desk (NRC), "1999 – Annual Reporting of Changes and Errors in ECCS Evaluation Models," NRC:00:010, February 23, 2000.

Annual Reporting of PWR Small Break LOCA Model
Changes and Error Corrections (2000)

The FRA-ANP PWR SBLOCA Evaluation Model consists of three computer codes: (1) ANF-RELAP to compute the system response, (2) TOODEE2 to calculate the hot rod heatup, and (3) RODEX2 to determine the rod conditions at the start of the transient.

The code or methodology changes to this Evaluation Model implemented during this reporting period are described below.

Loop Seal Clearing

FRA-ANP identified an unacceptable level of variability in its SBLOCA analyses, which resulted in unpredictable and unexpected differences in loop seal clearing response and, consequently, in the PCT due to small changes in code input. The model changes made to gain more consistency are summarized below. FRA-ANP informed the NRC of this issue in the letter NRC:00:034 dated September 7, 2000.

The following changes to the currently approved ANF-RELAP based SBLOCA methodology have been made:

1. The loop seals on the broken loop and one intact loop are biased to be one foot below the actual geometry. As in the model that uses S-RELAP5, this promotes conservative loop seal clearing behavior. Such biasing is similar to that prescribed in the current methodology for the crossflow resistance sensitivity calculations. (The biasing applies to all calculations including the break spectrum.) This model will be applied for both the CE 2x4 and Westinghouse three loop PWR plant configurations.

2. In the event that one loop seal is calculated to clear for a CE 2x4 plant SBLOCA for a break size of 0.03 ft^2 or larger (0.03 was chosen to bound the observed behavior), this case will be recalculated with a minor adjustment to allow the conservative behavior of clearing two loop seals. The minor adjustments will be either: (a) reducing time step sizes during the time period when loop seal clearing is calculated to occur, or (b) initiating the transient calculation at a different time. To date, such small changes have always resulted in the clearing of two loop seals.

3. For the larger break sizes in the SBLOCA break spectrum, the number of loop seals that clear will eventually increase even with the conservative biasing described in item 1. If this behavior is predicted as a transition occurring as a function of break size, the results will be accepted. However, if the behavior is anomalous within the spectrum, the calculation will be repeated with the minor adjustments set forth in item 2.

An estimate of the impact on the PCT has been made for each PWR plant for which FRA-ANP performs SBLOCA analyses, and these estimates have been provided to the respective licensees for their consideration relative to the reporting requirements of 10 CFR 50.46. The estimated impact of this change in PCT was +25 °F for one plant and 0 °F for all other plants.

Annual Reporting of PWR Large Break LOCA Model
Changes and Error Corrections (2000)

The FRA-ANP PWR LBLOCA Evaluation Model consists of four primary computer codes: (1) RELAP4 to compute the system and hot channel response, (2) RFPAC to compute the containment pressures, reflood rates, and axial shape factors, (3) TOODEE2 to calculate the hot rod heatup, and (4) RODEX2 to determine the rod conditions at the start of the transient.

The error corrections and model changes to the FRA-ANP PWR LBLOCA Evaluation Model implemented during this reporting period are described below.

PWR LBLOCA Split Break Modeling

The modeling of the split break configuration for PWR LBLOCA analyses was determined to be incorrect. The node adjacent to the downcomer was the node from which the break flow was assumed to occur for a split break. An artificially large flow area was assigned to this node to overcome RELAP4 limitations with respect to momentum in a node with more than two high flow junctions. The modeling in RELAP4 resulted in a non-physical, high pressure in the broken cold leg volume connected to the vessel downcomer. This lead to early flow reversal between the broken cold leg and the downcomer which potentially causes an early end of bypass time to be predicted for split breaks. The modeling in RFPAC was also determined to be incorrect (it double accounted for the expansion to containment) and resulted in a pressure at the break node that was higher than should be calculated.

The modeling in RELAP4 was changed so that the break flow occurs from the node adjacent to the node next to the downcomer. The break flow occurs from the same junction, but is attached to the adjacent node. A large flow area is assigned to this node rather than the node adjacent to the downcomer. This eliminates the potential for the prediction of an early end of bypass time. The modeling in RFPAC was changed to correctly account for the expansion to containment.

The impact of this change on the PCTs for those plants for which FRA-ANP performs LBLOCA analyses was estimated to range from 0 to +10°F. The impact on an individual split break size is greater than 0°F; but, unless the split break becomes limiting, the impact on the limiting cases is 0°F.

End of Bypass Calculation

The end of bypass calculation chooses the last time there is sustained flow reversal from the broken cold leg to the downcomer or from the upper downcomer to the lower downcomer to determine the end of bypass time. The end of bypass time should be defined as the earliest time that sustained flow reversal is achieved instead of the last time (EMF-2087(P)(A) Revision 0, Section 3.3). The end of bypass calculation was corrected to choose the correct end of bypass time.

The impact of this change on the PCTs for those plants for which FRA-ANP performs LBLOCA analyses was estimated to range from 0 to +1°F.