SIEMENS

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Document Control Desk
ATTN: Chief, Planning, Program and Management Support Branch
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Siemens Power Corporation Small Break LOCA Methodology

Ref.: 1. XN-NF-82-49(P)(A) Revision 1, Supplement 1, *Exxon Nuclear Company Evaluation Model Revised EXEM PWR Small Break Model*, Siemens Power Corporation, December 1994.

Ref.: 2. EMF-2328(P) Revision 0, *PWR Small Break LOCA Evaluation Model, S-RELAP5 Based*, Siemens Power Corporation, January 2000.

Siemens Power Corporation (SPC) has identified a deviation in its small break loss of coolant accident (SBLOCA) methodology (see Reference 1). This letter describes the actions SPC has taken to correct this deviation. SPC 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 peak cladding temperature (PCT) due to small changes in code input. SPC evaluated this deviation in accordance with the requirements of 10 CFR 21 and determined that it was not reportable.

An estimate of the impact on the PCT has been made for each PWR plant for which SPC 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.

SPC submitted a revision to its current SBLOCA model in January 2000 (Reference 2). This revision replaces the code ANF-RELAP with S-RELAP5. S-RELAP5 was developed for use in the SPC realistic large break loss of coolant accident methodology. The methodology which uses S-RELAP5 does not exhibit unacceptable variability.

A description of the changes made to correct the deviation in the SBLOCA model is presented in the attachment to this letter.

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In accordance with 10 CFR 50.46, SPC has initiated the application of the revised model in support of our PWR licensees.

Very truly yours,

James F. Mallay, Director
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/arn

Attachment

cc: N. Kalyanam
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SBLOCA Model Changes Made to Reduce Variability

An unacceptable variability was identified while performing SBLOCA calculations to evaluate the effects of minor errors in the RODEX2 input. (The errors in RODEX2 were also evaluated for reporting per 10 CFR 50.46.) A small change in gap dimensions was made to increase average fuel temperature in ANF-RELAP to agree with RODEX2 results. The matching of average fuel temperatures between ANF-RELAP and RODEX2 is part of the SBLOCA methodology. This change should have little or no effect on the calculated SBLOCA system behavior. However, for one calculation of one break size the number of loop seals calculated to clear changed and consequently the calculated PCT for this particular SBLOCA changed dramatically due to this trivial change in input.

The potential for excessive variability in SBLOCA analyses has long been recognized. The NRC approval of the current SBLOCA model (Reference 1) required that a cross-flow loss coefficient study be performed on the limiting break identified from the break spectrum study. In addition, a time step study was required if the PCT for SBLOCA was close to that of the PCT from the LBLOCA. When these sensitivity studies produce anomalous results due to the variability problem, our practice is to conservatively accept the highest PCT. SPC modified its SBLOCA model in 1996 (reported in Reference 2) to produce more conservative and consistent results. The 1996 modification consisted of biasing the broken loop to plug. The code was allowed to determine if any other loops would plug.

A condition report was written addressing the variability in the SBLOCA model in 1998. The conclusion at that time was that since the results were always conservative that no deviation existed. A result of that condition report was that increased emphasis was placed on the development of a SBLOCA model using S-RELAP5. A revised SBLOCA model using S-RELAP5 was submitted to the NRC for review in January 2000 (Reference 3).

Loop seal clearing occurs during the SBLOCA when the steam generators can no longer remove the decay heat generated in the core. Steam is formed which fills the vessel upper plenum and steam generators. Pressure builds up forcing the fluid levels downward in the core and loop seals. This action continues until the fluid level in some of the loop seals reaches the top of the crossover piping, and steam can begin to flow across the top of the crossover pipe, up through the pump, and out the break either directly or through the vessel downcomer. This venting of steam clears all or most of the liquid from some of the loop seals, relieves the pressure in the upper plenum allowing water levels in the core and downcomer to equilibrate, and permits the liquid in the cold legs to drain into the downcomer.

The Combustion Engineering (CE) 2x4 plant design has four loop seals, all of which are geometrically identical. Minor differences in loop seal clearing behavior are possible due to the location of individual loop seals relative to the break and the pressurizer. However, the calculated results show that these differences have no significant effect on the loop seal clearing. The upper plenum pressure is pushing the fluid down so that each of the loop seals has effectively the same liquid level vs. time behavior. However, as observed in SBLOCA experiments and as calculated by the codes, loop seal clearing is not the same in all loop seals. This means that loop seal clearing is not controlled by the dominant LOCA phenomena, but appears to be triggered by small perturbations among the loops. These perturbations may be real or an artifact of the calculation.

There are small differences which perturb calculated behavior among the loop seals, and some of these differences are oscillatory. Examples of such perturbations include: pressure variations caused by cycling of pressure relief valves on each of the steam generators, oscillations of the fluid levels in each loop in response to attempts to equalize the pressure, and oscillations in core heat transfer rates as the fluid levels change. These effects are real. Numerical oscillations and void propagation are also possible contributors. All these factors interact with each other and with the basic system calculation so that finding a specific perturbation or perturbation combination causing one loop seal to clear in preference to another is very difficult. However, because of the oscillatory nature of these perturbations, it is not surprising that any small change which could alter the event timing relative to these perturbations could affect which and how many loop seals are calculated to clear.

Results for the cases showing the variable PCTs are essentially identical up to the point of loop seal clearing. With a different number of loops seals calculated to clear, the calculated results after loop seal clearing diverge and the PCT varies as a result of this divergence. However, there is a consistent trend to the divergent results. Smaller flow resistances in the vent path of steam from the upper plenum to the break causes decreased depth and duration of the SBLOCA core uncovery, which reduces the calculated PCT. Therefore, if more loop seals are calculated to clear, the calculated PCT will decrease. Likewise, venting through the broken loop seal directly to the break offers less resistance than venting through a cleared intact loop seal. Thus, for cases where the same number of loop seals clear, the PCT will be lower if the broken loop seal clears than for the same situation where only the intact loop seals clear. The PCT is essentially independent of which intact loop seals clear so long as the number of cleared loop seals is the same. This effect is calculated consistently by both the ANF-RELAP and S-RELAP5 codes.

Justification for Model Changes

The calculations and some experimental evidence indicates that loop seal clearing may in fact be a somewhat random event initiated and affected by small perturbations. For this situation, a bounding approach is preferable to ensure that ECCS criteria are not exceeded rather than attempting to accurately calculate the small perturbations. Based on the information described above, if a minimum number of intact loops can be shown to clear for a given plant design, this case will yield a bounding PCT for other cases where additional intact loop seals or the broken loop seal might clear.

This approach is part of the new S-RELAP5 methodology, which artificially biases the geometry of loop seal input to promote the bounding loop seal clearing case for both the CE 2x4 plant design and the 3-loop Westinghouse plant design. For both designs, the bottom of the broken loop seal and one intact loop seal are artificially input to be one foot lower than their actual geometry. The intent is that these loop seals remain plugged while the unbiased intact loop seals will preferentially clear.

For the CE 2x4 plant design with SBLOCA break sizes of 0.05 ft^2 or larger, based on preliminary results, S-RELAP5 consistently calculates that two or more loop seals will clear. This code has been validated against experimental data and been shown to conservatively predict SBLOCA loop seal clearing as documented in the SBLOCA methodology submittal. Many preliminary calculations have also been made with the ANF-RELAP code for this break size range in a CE 2x4 PWR. Of these calculations, 90 percent or more also show that at least two loop seals will be calculated to clear. However, ANF-RELAP will occasionally calculate that only one loop seal clears even though break sizes above and below this case predict two loop seals to clear, and

other calculations for the same break size show two loops to clear. Clearly, based on the S-RELAP5 results and the majority of the ANF RELAP results, two loop seals should be calculated to clear for any SBLOCA calculation of break sizes 0.05 ft^2 and greater in the CE 2x4 plant design. Therefore, any SBLOCA calculation for this situation which shows single loop clearing only should be considered anomalous.

Model Changes

The following changes to the currently approved ANF-RELAP based SBLOCA methodology have been made to correct such anomalous results from this model.

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 3-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 to be calculated. 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 caused the 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.

References

Ref.: 1. XN-NF-82-49(P)(A) Revision 1 Supplement 1, *Exxon Nuclear Company Evaluation Model Revised EXEM PWR Small Break Model*, Siemens Power Corporation, December 1994.

Ref.: 2. Letter, H. Donald Curet (SPC) to Document Control Desk (NRC), "96/97 – Annual Reporting of Changes and Errors in ECCS Evaluation Models," HDC:97:092, September 2, 1997.

Ref.: 3. EMF-2328(P) Revision 0, *PWR Small Break LOCA Evaluation Model, S-RELAP5 Based*, Siemens Power Corporation, January 2000.