PROJ. 702

SIEMENS

February 23, 2000
NRC:00:010

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

1999 – 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 January 1, 1999 to December 31, 1999.

SPC 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.

SPC 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 SPC to affected licensees. The licensees have the obligation under 10 CFR Part 50.46 to report the nature of changes and errors affecting PCT.

Very truly yours,

James F. Mallay, Director
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/arn

Attachment

cc: N. Kalyanam (w/Attachment)
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Annual Reporting of EXEM BWR Model Changes and Error Corrections (1999)

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: RELAX to compute the system and hot channel response during blowdown, FLEX to calculate the time for refill of the lower plenum and reflood of the core, HUXY to calculate the heatup of the peak power plane, and 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.

RELAX

Decay Heat Re-Normalization: A deviation was identified in the re-normalization of the decay heat at the initiation of the transient. The re-normalization incorrectly adjusted the fission product decay heat by slightly less than the required 1.2 multiplier on the decay heat equations. The actinides were still conservatively estimated but not by a factor as great as 1.2. The re-normalization was modified to maintain the required 1.2 multiplier on the decay heat equations.

The impact of this change on the PCTs for those plants for which SPC performs LOCA analyses ranged from about +8 °F to +10 °F.

Fuel Average Temperature: A deviation was identified in the calculation of the fuel average temperature. The fuel average temperature was incorrectly computed because one-half of the volume of the first gap node was used in calculating the fuel volume. The code was modified to use the correct fuel volume.

The impact of this change on the PCTs for those plants for which SPC performs LOCA analyses was +10 °F for each plant.

FLEX

No reportable code changes.

HUXY

No reportable code changes.

RODEX2

No reportable code changes.

Annual Reporting of PWR Small Break LOCA Model
Changes and Error Corrections (1999)

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

RODEX2 - Corrosion Model

An error was identified in the cladding corrosion calculation in the version of RODEX2 used for SBLOCA calculations. There were errors in the coding of the model and an error in the enhancement factor utilized in the corrosion model. The coding was corrected to implement the approved corrosion model and the input changed to use the correct enhancement factor. This deviation was identified and reported for the year 1998 for LBLOCA analyses.

The impact of this change on the PCTs for those plants for which SPC performs SBLOCA analyses was estimated to be +2 degrees F.

TOODEE2 – Nodalization

The core model used in the SPC SBLOCA methodology was found to be non-convergent with respect to the length of the node selected. SPC informed the NRC of this issue with a letter to Document Control from J. F. Mallay, NRC:99:015, dated April 26, 1999.

An in-depth investigation of the non-convergence was performed. It was found that convergence with respect to node length could be obtained by eliminating or reducing the magnitude of the flow oscillations observed in the core model. The oscillations were reduced by changing selected input parameters and not by changing the code itself. The significant changes consisted of specifying homogeneous cross flow and equal-sized nodes less than 7 inches in length.

Using smaller equal length node sizes is a standard method for improving convergence. In this case, the smaller nodes reduce variations attributed to the level model. The effect on plant calculations from using equal sized nodes is reduced variations between calculations where the flow field within the core model changes by an insignificant amount.

The net result from using short, equal length nodes combined with using homogeneous cross flow is a converged solution with reduced variance in level position, dry out location, and transient cladding temperature.

The impact of this change on the PCTs for those plants for which SPC performs SBLOCA analyses was estimated to range from about -150 to -330 degrees F.

TOODEE2 – Blockage Flow Diversion Model

An error was identified in the flow diversion model relating to fuel rod swelling used for SBLOCA analyses. The available flow area when a fuel rod was calculated to have ballooned sufficiently to touch adjacent rods was incorrectly computed. The TOODEE2 code was modified to correct the error. This error is also reported under the LBLOCA model changes.

The impact of this change on the PCTs for those plants for which SPC performs SBLOCA analyses was estimated to range from -8 to +1 degrees F.

Annual Reporting of PWR Large Break LOCA Model Changes and Error Corrections (1999)

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

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

Containment Heat Transfer

A number of errors were identified in the ICECON portion of the code RFPAC related to the calculation of containment heat transfer. ICECON is used in the PWR LBLOCA methodology to calculate the containment response. The errors were as follows:

1. The Uchida heat transfer coefficient was in error for a mass ratio of 0.5.

2. The species thermal conductivities, specific heats, viscosities, and molecular weights were reversed when calculating mixture values.

3. Two conversion factors used in calculating steam conductivity found to be in error and were corrected.

4. A parenthesis ")" was misplaced in calculating the mass transfer coefficient.

5. The correlation used to define saturation pressure as a function of temperature was not properly extended for low temperature ice condenser calculations.

6. An error in calculating the parameter UPOLF2 was corrected.

7. A units problem associated with the steam viscosity tables was corrected.

8. The energy transported into a compartment by normal leakage and penetration leakage was corrected.

These errors were evaluated together as a closely related group of errors. The impact of this group of changes on the PCTs for those plants for which SPC performs LBLOCA analyses was estimated to be 0 degrees F.

RFPAC - Fuel Temperature

An error was identified in the RFPAC calculation of the fuel rod temperature at the start of reflood. The error incorrectly computes the average core temperature at the start of reflood and the initial peak fuel rod temperature used in the FCTF reflood carryover rate fraction correlation. This error only affects plants with non-uniform axial nodalization input for the core in RELAP4.

The impact of this change on the PCTs for those plants for which SPC performs LBLOCA analyses was estimated to range from -2 to 0 degrees F.

Data Transfer Error

The SISPUNCH code creates data tables containing accumulator flows calculated by the RELAP4 Accumulator-SIS transient calculation. An error was identified in the SISPUNCH code version ujun98 which can cause the accumulator flow rates written by SISPUNCH in the data transfer file for input to the RFPAC code to be incorrect. Under certain conditions the accumulator flows placed in the data transfer file may extend beyond the time when the accumulator flows are shut off in the RELAP4 Accumulator-SIS transient calculation. This error affects plants where the low pressure safety injection initiation is delayed beyond the time the accumulators exhaust.

The impact of this change on the PCTs for those plants for which SPC performs LBLOCA analyses was estimated to be 0 degrees F.

Gadolinia-Bearing Fuel Rod Modeling

The modeling of gadolinia-bearing fuel rods was modified in the following manner.

- The pin-to-pin power distribution is taken from the 5x5 fuel rod array surrounding the highest power gadolinia-bearing rod at the exposure where the peak gadolinia-bearing rod to UO_2 rod power ratio occurs. Previously, the pin distribution was taken at EOC conditions since this is conservative for UO_2 rods.

- The power of the eight fuel rods surrounding the gadolinia-bearing rod is calculated from their average power with the highest of the eight rods assumed to be at the Technical Specification power level. Guide tubes are not included in the average. Previously, all eight surrounding rods were assumed to be at the Technical Specification limit power level.

- The maximum decay heat is used in the TOODEE2 heat-up calculation. The maximum product of the Gadolinia-bearing rod to UO_2 rod power ratio and the gamma-smearing factor over the cycle is found and normalized to the peak power ratio to provide an effective gamma-smearing factor. This value results in a bounding decay heat. Previously, the maximum gamma smearing factor and maximum power ratio were used rather than the maximum of their product. The maximum gamma smearing factor and maximum power ratio can occur at different burnups and thus using them independently is excessively conservative.

- The power history calculations assume an MOC axial shape for the purposes of finding the maximum stored energy. The previous calculations changed the spiked power shape from BOC to MOC and then to EOC as the exposure increased rather than using a constant MOC shape throughout. This has a negligible impact on the time of maximum stored energy. Using a constant axial shape simplified the power history calculation allowing it to be automated.

The impact of this change on the PCTs for those plants for which SPC performs LBLOCA analyses was estimated to be 0 degrees F.

The impact of this change on the limiting peak cladding temperature is zero since for current analyses the gadolinia-bearing fuel rod is never the limiting fuel rod. The reason for making this change is to ensure that, for future calculations performed with the SEM/PWR-98 evaluation model, the gadolinia-bearing fuel rod does not become the limiting rod from a peak cladding temperature perspective. The estimated peak cladding temperature impact on the gadolinia-bearing fuel rod itself is in excess of 50 degrees F in the negative direction.

TOODEE2 – Blockage Flow Diversion Model

An error was identified in the flow diversion model relating to fuel rod swelling used for LBLOCA analyses. The available flow area when a fuel rod was calculated to have ballooned sufficiently to touch adjacent rods was incorrectly computed. The TOODEE2 code was modified to correct the error. This error is also reported under the SBLOCA model changes.

The impact of this change on the PCTs for those plants for which SPC performs LBLOCA analyses was estimated to be 0 degrees F.

TOODEE2 – QMAX Calculation

A change was made to the TOODEE2 code related to the calculation of the variable QMAX above the 10.333 foot elevation. QMAX is used in the calculation of the heat transfer coefficients during the LBLOCA reflood period. In the original implementation of the variable QMAX into TOODEE2, an approximation was made in solving the equation defining QMAX. An exact solution to the equation defining QMAX is possible and the code has been modified to reflect this exact solution.

The impact of this change on the PCTs for those plants for which SPC performs LBLOCA analyses was estimated to be 0 degrees F.