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RC-03-0099

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U. S. Nuclear Regulatory Commission  
Washington, DC 20555

Dear Sir / Madam:

Subject: VIRGIL C. SUMMER NUCLEAR STATION  
DOCKET NO. 50/395  
OPERATING LICENSE NO. NPF-12  
ECCS EVALUATION MODEL REVISIONS ANNUAL REPORT

Attached is the 2003 Emergency Core Cooling System (ECCS) Evaluation Model Revisions Annual Report for the Virgil C. Summer Nuclear Station (VCSNS). This report is being submitted pursuant to 10CFR50.46, which requires licensees to notify the NRC on at least an annual basis of corrections to or changes in the ECCS Evaluation Models.

Summary sheets describing changes and enhancements to the ECCS evaluation models for 2002 are included in Attachment I.

Loss of Coolant Accident (LOCA) Peak Clad Temperature (PCT) rackup sheets are included in Attachment II. All necessary revisions for any non-zero, non-discretionary, PCT change to Section C have been included. Plant specific errors in the application of the model for 2002 are also provided in Section C.

Two previously reported issues (LOCBART NUREG-0630 Coding Errors from 2002 and LOCBART Rod-Average Oxidation Error from 2001) that were evaluated as negligible or conservative and deferred to a future code release have now been incorporated in LOCBART. The existing assessments for the issues remain applicable, and the changes are treated as having 0°F PCT effect for 10 CFR 50.46 reporting purposes.

If you have any questions, please call Mr. Amie J. Cribb, Jr. at (803) 345-4346.

Very truly yours,

A handwritten signature in dark ink, appearing to read "S.A. Byrne".

Stephen A. Byrne

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AJC/SAB  
Attachments

C: N. O. Lorick  
N. S. Cams  
T. G. Eppink (w/o attachment)  
R. J. White  
L. A. Reyes  
K. R. Cotton

K. M. Sutton  
NRC Resident Inspector  
NSRC  
RTS (0-L-99-0152)  
File (818.02-17, RR 8375)  
DMS (RC-03-0099)

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## **Attachment 1**

### **Changes and Enhancements to the ECCS Evaluation Models for 2002**

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**Non-Discretionary Changes with PCT Impact**

BASH-EM Transient Termination  
LOCBART Radiation to Liquid Logic  
LOCBART ZIRLO™ Cladding Specific Heat Model

**Non-Discretionary Changes with No PCT Impact**

BASHER Calculation of Flow Link Inputs  
LOCBART Pellet-to-Cladding Gap Conductance Model  
LOCBART Time Step Selection Logic  
LOCBART Cladding Surface Heat Transfer Logic  
LOCBART ZIRLO™ Cladding Creep Constants  
SBLOCTA Time Step Selection Logic  
SBLOCTA ZIRLO™ Cladding Specific Heat Model

**Enhancements/Forward-Fit Discretionary Changes**

Simplified Isothermal Solution for SBLOCTA Subroutine RATE  
General Code Maintenance

## **BASH-EM TRANSIENT TERMINATION**

### **Background**

A method has been developed to extend BASH-EM transients beyond the point at which downcomer boiling is predicted to occur in BASH, by correlating the boiling induced reduction in downcomer driving head to a corresponding reduction in the core inlet flooding rate. This approach, which is referred to as the LOCBART transient extension method, is used to ensure adequate termination of the fuel rod cladding temperature and oxidation transients predicted by LOCBART, as required to demonstrate compliance with the pertinent acceptance criteria of 10 CFR 50.46. In accordance with Reference 1, the LOCBART transient extension method is being submitted to the USNRC for review and approval, and 10 CFR 50.46 assessments have been completed to ensure adequate transient termination for the BASH-EM analyses within Westinghouse Pittsburgh cognizance. This represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451.

### **Affected Evaluation Models**

1981 Westinghouse Large Break LOCA Evaluation Model with BASH

### **Estimated Effect**

The estimated effect of this issue was determined on a plant-specific basis. For cases where transient termination can be demonstrated prior to downcomer boiling, no further action is considered necessary. For other cases, transient termination has been demonstrated by applying the LOCBART transient extension method, and the effects of downcomer boiling are considered to be implicit in the analysis results. In all cases, it was concluded that the pertinent acceptance criteria of 10 CFR 50.46 are satisfied.

A review of the BASH-EM large break LOCA analysis for V. C. Summer determined that transient termination was demonstrated prior to downcomer boiling. For this case, there is no need to apply the LOCBART transient extension method, and no further action is considered necessary at this time.

### **References**

1. Letter from S. Dembek (USNRC) to H. Sepp (Westinghouse), "Potential Non-Conservative Modeling of Downcomer Boiling in the Approved Westinghouse 1981 Evaluation Model Using BASH", March 27, 2002.

## **LOCBART RADIATION TO LIQUID LOGIC**

### **Background**

A review of the LOCBART cladding-to-fluid heat transfer logic found that radiation to liquid could occur after the core inlet flooding rate dropped below 1 in/s, if the channel blockage fraction was simultaneously equal to zero. This logic was modified by deleting the check for a channel blockage fraction greater than zero in Subroutine HTSORT, such that radiation to liquid is now ignored whenever the core inlet flooding rate is less than (or equal to) 1 in/s. This represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451.

### **Affected Evaluation Models**

1981 Westinghouse Large Break LOCA Evaluation Model with BASH

### **Estimated Effect**

A review of existing analyses within Westinghouse Pittsburgh cognizance determined that the situation described above does not occur for most PWR licensing calculations, in which case the subject modification has no effect on existing analysis results. For analyses where this situation did occur, representative plant calculations using the LOCBART code showed that the revised logic generally produced a small-to-moderate increase in peak cladding temperature, and plant-specific assessments were derived from the representative calculations in a conservative manner.

A review of LOCBART Radiation to Liquid large break LOCA analysis for V. C. Summer determined that the modification has no effect. Therefore, no further action is considered necessary at this time.

## **LOCBART ZIRLO™ CLADDING SPECIFIC HEAT MODEL**

### **Background**

The ZIRLO™ cladding specific heat model in LOCBART has been revised to reflect data collected at the Thermophysical Properties Research Laboratory. This change was made to resolve differences between the model and data that could produce an increase in peak cladding temperature for some transients. This represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451.

### **Affected Evaluation Models**

1981 Westinghouse Large Break LOCA Evaluation Model with BASH

### **Estimated Effect**

Representative plant calculations using the LOCBART code showed that this change results in a moderate PCT penalty for early-reflood-PCT plants, a small-to-moderate PCT penalty for mid-reflood-PCT plants, and a negligible PCT effect for late-reflood-PCT plants. Additional BASH-EM sensitivity calculations indicated that the reduction in initial pellet average temperatures due to PAD Version 4.0 provides a PCT benefit that more than offsets any PCT penalty due to the change in specific heat. For VCSNS, this PCT benefit was applied (listed on PCT Rackup Sheet as "PAD 4.0 Initial Pellet Temperatures") as a separate, offsetting credit.

## **BASHER CALCULATION OF FLOW LINK INPUTS**

### **Background**

BASHER is used to generate the plant-specific input models for BASH. Some minor errors were discovered in the calculation of elevation and length terms for the flow link that connects the upper head and upper plenum. As discussed below, it was determined that correcting these errors would have a negligible effect on results, so BASHER updates will be deferred to a future code release. When corrected, these changes will represent a closely-related group of Non-Discretionary Changes in accordance with Section 4.1.2 of WCAP-13451.

### **Affected Evaluation Models**

1981 Westinghouse Large Break LOCA Evaluation Model with BASH

### **Estimated Effect**

A sample BASH calculation demonstrated that these changes have a negligible effect on the core inlet flooding rate, which is consistent with the expected result given the minimal importance of the affected flow path during a PWR reflood transient. These changes will be deferred to a future code release and are treated as having a 0°F PCT effect for 10 CFR 50.46 reporting purposes.



## **LOCBART PELLET-TO-CLADDING GAP CONDUCTANCE MODEL**

### **Background**

An error was discovered in a generic LOCBART input value used with the pellet-to-cladding gap conductance model. This error affected calculations performed using fuel rod initial conditions from PAD Version 4.0, and led to an underprediction of the gap heat transfer coefficients. The input guidance was corrected to reflect the appropriate value. This represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451.

### **Affected Evaluation Models**

1981 Westinghouse Large Break LOCA Evaluation Model with BASH

### **Estimated Effect**

Representative plant calculations using the LOCBART code demonstrated that this change leads to a small-to-moderate PCT benefit that will conservatively be treated as a 0°F PCT change for 10 CFR 50.46 reporting purposes.

## **LOCBART TIME STEP SELECTION LOGIC**

### **Background**

LOCBART was updated to resolve some inconsistencies in the time step selection logic, pertaining to the use of the fluid vs. fuel rod time step. This represents a closely-related group of Non-Discretionary Changes in accordance with Section 4.1.2 of WCAP-13451.

### **Affected Evaluation Models**

1981 Westinghouse Large Break LOCA Evaluation Model with BASH

### **Estimated Effect**

Representative plant calculations using the LOCBART code demonstrated that this change produces a negligible effect on results that will be treated as a 0°F PCT effect for 10 CFR 50.46 reporting purposes.

## **LOCBART CLADDING SURFACE HEAT TRANSFER LOGIC**

### **Background**

Some recent LOCBART calculations showed anomalous behavior in the cladding surface heat transfer coefficients, when the local void fraction was high and the cladding surface temperature had decreased to the temperature at which a return to nucleate boiling is permitted to occur. This behavior was resolved by adding a void fraction criterion to the return-to-nucleate boiling logic in Subroutine HTSORT. This represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451.

### **Affected Evaluation Models**

1981 Westinghouse Large Break LOCA Evaluation Model with BASH

### **Estimated Effect**

A sample LOCBART calculation demonstrated that this change produces a negligible effect on results that will be treated as a 0°F PCT effect for 10 CFR 50.46 reporting purposes.

## **LOCBART ZIRLO™ CLADDING CREEP CONSTANTS**

### **Background**

LOCBART was updated to correct two of the constants in the high-temperature creep model for ZIRLO™ cladding, which were found to disagree with the basis documentation. This represents a closely-related group of Non-Discretionary Changes in accordance with Section 4.1.2 of WCAP-13451.

### **Affected Evaluation Models**

1981 Westinghouse Large Break LOCA Evaluation Model with BASH

### **Estimated Effect**

The changes identified above lead to a small change in the creep rate over a limited range of temperatures, which is considered to have a negligible effect on results and will be treated as a 0°F PCT effect for 10 CFR 50.46 reporting purposes.

## **SBLOCTA TIME STEP SELECTION LOGIC**

### **Background**

SBLOCTA was updated to resolve some inconsistencies in the time step selection logic, pertaining to the use of the fluid vs. fuel rod time step. This represents a closely-related group of Non-Discretionary Changes in accordance with Section 4.1.2 of WCAP-13451.

### **Affected Evaluation Models**

1985 Westinghouse Small Break LOCA Evaluation Model with NOTRUMP

### **Estimated Effect**

Representative plant calculations using the SBLOCTA code demonstrated that this change produces a small PCT benefit for cases modeling Zircaloy-4 cladding that are predicted to burst, and a negligible effect on results for Zirlo, which is used at VCSNS. Accordingly, this change will be treated as a 0°F PCT effect for 10 CFR 50.46 reporting purposes.

## **SBLOCTA ZIRLO™ CLADDING SPECIFIC HEAT MODEL**

### **Background**

For consistency with the change made to LOCBART (as described previously), the ZIRLO™ cladding specific heat model in SBLOCTA has been revised to reflect data collected at the Thermophysical Properties Research Laboratory. This represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451.

### **Affected Evaluation Models**

1985 Westinghouse Small Break LOCA Evaluation Model with NOTRUMP

### **Estimated Effect**

Sensitivity calculations using the SBLOCTA code demonstrated that this change produces a negligible effect on results that will be treated as a 0°F PCT effect for 10 CFR 50.46 reporting purposes.

## **SIMPLIFIED ISOTHERMAL SOLUTION FOR SBLOCTA SUBROUTINE RATE**

### **Background**

As discussed in Reference 1, LOCBART was revised in 1999 to correct a logic error that caused the Baker-Just metal-water reaction calculations to be performed three times per time step. During the review of the corresponding code logic, it was determined that the complicated solution technique described in Section 3.3.2 of Reference 2 could be replaced with a simplified isothermal solution, with only a minimal effect on results. This change was made in LOCBART per Reference 3, and has also been implemented in SBLOCTA which uses similar logic. This represents a Discretionary Change that will be implemented on a forward-fit basis, in accordance with Section 4.1.1 of WCAP-13451.

### **Affected Evaluation Models**

1985 Westinghouse Small Break LOCA Evaluation Model with NOTRUMP

### **Estimated Effect**

Representative plant calculations using the SBLOCTA code demonstrated that this change produces a negligible effect on results that will be treated as a 0°F PCT effect for 10 CFR 50.46 reporting purposes.

### **References**

1. Westinghouse Letter NSBU-NRC-00-5970, "1999 Annual Notification of Changes to the Westinghouse Small Break LOCA and Large Break LOCA ECCS Evaluation Models, Pursuant to 10 CFR 50.46 (a)(3)(ii)", May 12, 2000.
2. WCAP-8301, "LOCTA-IV Program: Loss-of-Coolant Transient Analysis", June 1974.
3. Westinghouse Letter LTR-NRC-01-6, "U. S. Nuclear Regulatory Commission, 10 CFR 50.46 Annual Notification and Reporting for 2000", March 13, 2001.

## **GENERAL CODE MAINTENANCE**

### **Background**

Various changes in code input and output format have been made to enhance usability and help preclude errors in analyses. This includes both input changes (e.g., more relevant input variables defined and more common input values used as defaults) and input diagnostics designed to preclude unreasonable values from being used, as well as various changes to code output which have no effect on calculated results. In addition, various blocks of coding were rewritten to eliminate inactive coding, optimize the active coding, and improve commenting, both for enhanced usability and to facilitate code debugging when necessary. These represent Discretionary Changes that will be implemented on a forward-fit basis, in accordance with Section 4.1.1 of WCAP-13451.

### **Affected Evaluation Models**

1981 Westinghouse Large Break LOCA Evaluation Model with BASH

1985 Westinghouse Small Break LOCA Evaluation Model with NOTRUMP

### **Estimated Effect**

The nature of these changes leads to an estimated PCT impact of 0°F.



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## **Attachment 2**

### **LOCA PCT Rackups for Virgil C. Summer Nuclear Station**

## Westinghouse LOCA Peak Clad Temperature Summary for Large Break

Plant Name: V. C. Summer  
Utility Name: South Carolina Electric & Gas  
Revision Date: 2/25/03

### Analysis Information

EM: BASH Analysis Date: 10/1/95 Limiting Break Size: Cd = 0.4  
FQ: 2.4 FdH: 1.62  
Fuel: Vantage + SGTP (%): 10  
Notes: Analysis-Of-Record was done with FQ=2.50 and FdH = 1.70.

	Clad Temp (°F)	Ref.	Notes
<b>LICENSING BASIS</b>			
<b>Analysis-Of-Record PCT</b>	2099	1	(a)
<b>MARGIN ALLOCATIONS (Delta PCT)</b>			
<b>A. PRIOR PERMANENT ECCS MODEL ASSESSMENTS</b>			
1 . SI Error Reanalysis (Plant Specific)	-90	2	(a,b)
2 . Accumulator Line/Pressurizer Surge Line Data, LOCBART Spacer Grid Single-Phase Heat Transfer Error, LOCBART Zirc-Water Oxidation Error, and Reanalysis of Limiting AOR Case	153	2	(a,c)
3 . LOCBART Vapor Film Flow Regime Heat Transfer Error	-15	3	
4 . LOCBART Cladding Emissivity Errors	-10	4	
<b>B. PLANNED PLANT CHANGE EVALUATIONS</b>			
1 . None	0		
<b>C. 2002 PERMANENT ECCS MODEL ASSESSMENTS</b>			
1 . LOCBART ZIRLO™ Cladding Specific Heat Model	40	5	
2 . PAD 4.0 Initial Pellet Temperatures	-40	5	
<b>D. TEMPORARY ECCS MODEL ISSUES</b>			
1 . None	0		
<b>E. OTHER</b>			
1 . None	0		
<b>LICENSING BASIS PCT + MARGIN ALLOCATIONS</b>	<b>PCT = 2137</b>		

### References:

- 1 CGE-95-0009-SGUL, "Revised Large Break LOCA Results for Upgrading Submittal," October 24, 1995.
- 2 CGE-99-044, "South Carolina Electric and Gas Company, Virgil C. Summer Nuclear Station, 10 CFR 50.46 BART/BASH Evaluation Model, Mid-Year Notification and Reporting for 1999," September 17, 1999.
- 3 CGE-00-044, "South Carolina Electric and Gas Company, Virgil C. Summer Nuclear Station, 10 CFR 50.46 Appendix K (BART/BASH/NOTRUMP) Evaluation Model, Mid-Year Notification and Reporting for 2000," June 30, 2000.
- 4 CGE-00-112, "South Carolina Electric and Gas Company, Virgil C. Summer Nuclear Station, 10 CFR 50.46 BART/BASH Evaluation Model Mid-Year Notification and Reporting for 2000," December 2000.
- 5 CGE-03-12, "10CFR 50.46 Annual Notification and Reporting for 2002," March 2003.

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## **Westinghouse LOCA Peak Clad Temperature Summary for Large Break**

**Plant Name:** V. C. Summer  
**Utility Name:** South Carolina Electric & Gas  
**Revision Date:** 2/25/03

### **Notes:**

- (a) Analysis was done for Delta-75 steam generators and core power at 2900 MWt.
- (b) This plant specific reanalysis addressed the correction of Safety Injection Performance Inputs. These results incorporate the SATAN/LOCTA Fluid Conditions Translation Error and the Accumulator Pressure and Water Volume Uncertainties evaluation, so these PCT penalties are no longer applicable. IFBA fuel is limiting compared to non-IFBA fuel.
- (c) This reanalysis was based on the SI Error reanalysis; modelled a reduction in FQ from 2.5 to 2.4, a reduction in FdH from 1.70 to 1.62, and a reduction in P-bar-HA from 1.514 to 1.443; and addressed the following issues: Accumulator Line/Pressurizer Surge Line Data, LOCBART Spacer Grid Single-Phase Heat Transfer Error, and LOCBART Zero-Water Oxidation Error. IFBA fuel is limiting compared to non-IFBA fuel.

## Westinghouse LOCA Peak Clad Temperature Summary for Small Break

Plant Name: V. C. Summer  
Utility Name: South Carolina Electric & Gas  
Revision Date: 2/25/03

### Analysis Information

EM: NOTRUMP      Analysis Date: 2/1/94      Limiting Break Size: 2 inch  
FQ: 2.4      FdH: 1.62  
Fuel: Vantage +      SGTP (%): 10  
Notes: Limiting Break Size shifted from 2 inch to 3 inch (b,d) and FQ reduced from 2.45 to 2.40 (f)

Clad Temp (°F) Ref. Notes

### LICENSING BASIS

#### Analysis-Of-Record PCT

1823 1 (a)

### MARGIN ALLOCATIONS (Delta PCT)

#### A. PRIOR PERMANENT ECCS MODEL ASSESSMENTS

1 . LUCIFER Error Corrections	-16	3	
2 . Effect of SI in Broken Loop	150	3	
3 . Effect of Improved Condensation Model	-150	3	
4 . Axial Nodalization, RIP Model Revision and SBLOCTA Error Corrections Analysis	96	4	
5 . Boiling Heat Transfer Correlation Error	-6	5	
6 . Steam Line Isolation Logic Error	18	5	
7 . NOTRUMP Specific Enthalpy Error	20	6	
8 . SALIBRARY Double Precision Error	-15	6	
9 . SBLOCTA Fuel Rod Initialization Error	10	7	
10 . NOTRUMP Mixture Level Tracking / Region Depletion Errors	13	9	

#### B. PLANNED PLANT CHANGE EVALUATIONS

1 . Increased Accumulator Pressure and Water Volume Uncertainties	34	2	(b)
2 . Annular Blankets	10	2	
3 . Main Feedwater Temperature Increase Evaluation	0	10	

#### C. 2002 PERMANENT ECCS MODEL ASSESSMENTS

1 . None	0		
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#### D. TEMPORARY ECCS MODEL ISSUES

1 . None	0		
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#### E. OTHER

1 . Burst and Blockage/Time in Life	245	9	(c,e)
2 . Margin Recovery (SI Performance Inputs Evaluation)	-36	8	(d)
3 . GEDM Evaluation	0	11	(f)

### LICENSING BASIS PCT + MARGIN ALLOCATIONS

PCT = 2196

## Westinghouse LOCA Peak Clad Temperature Summary for Small Break

Plant Name: V. C. Summer

Utility Name: South Carolina Electric & Gas

Revision Date: 2/25/03

### References:

- 1 CGE-93-0054-SGUL, "SECL-93-036, Rev. 1," March 9, 1994.
- 2 CGE-99-008, "South Carolina Electric and Gas Company, Virgil C. Summer Station, 10 CFR 50.46 Annual Notification and Reporting for 1998," March 5, 1999.
- 3 CGE-94-205, "South Carolina Electric and Gas Company, Virgil C. Summer Station, 10 CFR 50.46 Notification and Reporting Information," February 8, 1994.
- 4 CGE-94-228, "South Carolina Electric and Gas Company, Virgil C. Summer Station, SBLOCA Axial Nodalization," October 27, 1994.
- 5 CGE-95-201, "South Carolina Electric and Gas Company, Virgil C. Summer Station, 10 CFR 50.46 Notification and Reporting Information," February 3, 1995.
- 6 CGE-96-202, "South Carolina Electric and Gas Company, Virgil C. Summer Station, 10 CFR 50.46 Annual Notification and Reporting," February 9, 1996.
- 7 CGE-96-213, "South Carolina Electric and Gas Company, Virgil C. Summer Station, 10 CFR 50.46 Small Break LOCA Notification and Reporting," July 8, 1996.
- 8 CGE-00-006, "South Carolina Electric and Gas Company, Virgil C. Summer Nuclear Station, 10 CFR 50.46 Annual Notification and Reporting for 1999," February 25, 2000.
- 9 CGE-00-044, "South Carolina Electric and Gas Company, Virgil C. Summer Nuclear Station, 10 CFR 50.46 Appendix K (BART / BASH / NOTRUMP) Evaluation Model, Mid-Year Notification and Reporting for 2000," June 30, 2000.
- 10 CGE-00-063, "Safety Evaluation for Increased Main Feedwater Temperature (SECL-00-118)," August 25, 2000.11.CAB-02-64/NF-CG-02-16, "Cycle 14 Reload Safety Evaluation," March 2002.
- 11 CAB-02-64/NF-CG-02-16, "Cycle 14 Reload Safety Evaluation," March 2002.

### Notes:

- (a) AOR performed for core power = 2900 MWt and Delta-75 steam generators.
- (b) The SBLOCA evaluation for increased accumulator pressure and water volume uncertainties causes the limiting break equivalent diameter to shift from 2-inch to 3-inch. The 34°F value does not include the effect on SBLOCA burst/blockage behavior.
- (c) This assessment is a function of base PCT plus margin allocation and as such will increase/decrease with margin allocation changes.
- (d) The Margin Recovery (SI Performance Evaluation) resulted in a 36 °F PCT benefit. Note that the evaluation considered the 2 inch and 3 inch break and resulted in the limiting break equivalent diameter to remain shifted from 2 inch to 3 inch.
- (e) Value includes previous Burst and Blockage / Time in Life penalty SPIKE Correlation Revision penalty (1999 Annual Report), and consideration of a new penalty due to item C.1 (NOTRUMP Mixture Level Tracking / Region Depletion).
- (f) The reduced AOR GEDMs have been violated during the CGE Cycle 14 Reload Process. An evaluation was performed using default GEDMs and taking credit for a lower PHA of 1.42 and FQ of 2.40. Analysis-of-record was done with FQ=2.45 and PHA=1.443. The evaluation concluded a net zero PCT effect to the Small Break LOCA Analysis.