TVA

Tennessee Valley Authority, Post Office Box 2000, Spring City, Tennessee 37381-2000

August 28, 2013

10 CFR 50.46(a)(3)(i)
10 CFR 50.46(a)(3)(ii)

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555-0001

Watts Bar Nuclear Plant, Unit 2
NRC Docket No. 50-391

Subject: Watts Bar Nuclear Plant, Unit 2 – Emergency Core Cooling System Evaluation Model Changes – 30 Day Report – 10 CFR 50.46 Notification

The purpose of this letter is to provide a 30-day report of changes to the calculated peak cladding temperature (PCT) for the Watts Bar Nuclear Plant (WBN), Unit 2, Emergency Core Cooling System (ECCS) analysis performed with the 2004 Westinghouse Realistic Large Break Loss of Cooling Accident (LBLOCA) Evaluation Model Using ASTRUM. This submittal satisfies the reporting requirements for a significant change or error in accordance with 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors," paragraph (a)(3)(ii). The enclosed reports provide a summary of the changes to the calculated PCT for the limiting ECCS analysis.

As indicated in Enclosures 1 and 2, calculations representative of WBN Unit 2 transient behavior were performed with the latest version of WCOBRA/TRAC. Using this transient, a matrix of HOTSPOT calculations was performed to estimate the effect of the heat transfer multiplier distribution changes. Using these results and considering the heat transfer multiplier uncertainty attributes from limiting cases for WBN Unit 2, an estimated PCT effect of -55°F has been established for 10 CFR 50.46 reporting purposes for WBN Unit 2.

The PCT changes identified for WBN Unit 2, when expressed as the cumulative sums of the absolute magnitudes, exceed the 50 degrees Fahrenheit (°F) threshold for a significant change or error as defined in 10 CFR 50.46(a)(3)(i). Accordingly, this 30-day report is being submitted as required by 10 CFR 50.46(a)(3)(ii) to report the impact of heat transfer multiplier uncertainty distributions on the PCT calculation for WBN Unit 2.

A002
NRR

In accordance with 10 CFR 50.46(a)(3)(ii), changes to the ECCS LBLOCA model are required to be reported to the NRC within 30 days when the cumulative sum of the absolute magnitudes of the resulting PCT changes exceeds 50 °F. The licensee is also required to include a proposed schedule for providing a reanalysis or taking other action as may be needed to demonstrate compliance with the 10 CFR 50.46 requirements.

In addition to the error above, other identified changes or errors are summarized in Enclosures 1 and 3. The remaining identified changes or errors did not result in any additional penalties to the ECCS evaluation model.

Compliance with the 10 CFR 50.46 requirements is demonstrated by the calculated LBLOCA PCT for WBN Unit 2 remaining below the 2200°F limit. The analysis of record PCT for the LBLOCA PCT is 1766 °F. As presented in the enclosed report, the updated (net) licensing basis LBLOCA PCT is 1711°F. Hence, the LBLOCA PCT remains below the 2200°F limit with a large margin, and compliance with the requirements of 10 CFR 50.46 is thereby demonstrated. TVA has, therefore, concluded that no proposed schedule for providing a reanalysis or other action is required.

There are no new commitments in this letter. If you have any questions, please contact me at (423) 365-1260 or Gordon Arent at (423) 365-2004.

I declare under penalty of perjury that the foregoing is true and correct to the best to my knowledge. Executed on the 28th day of August, 2013.

Respectfully,

R. A. Hruby, Jr.

Raymond A. Hruby, Jr.
General Manager, Technical Services
Watts Bar Unit 2

Enclosures:

1. Westinghouse Electric Company LLC letter LTR-LIS-13-401 "LBLOCA TCD PCT Sheet and Associated 10 CFR 50.46 Reports for Revised Heat Transfer Multiplier Distributions and Initial Fuel Pellet Average Temperature Uncertainty Calculation", dated August 2, 2013
2. Westinghouse Electric Company LLC letter LTR-LIS-13-406 "Additional Information on the Evaluation of Revised Heat Transfer Multiplier Distributions", dated August 14, 2013
3. Westinghouse Electric Company LLC letter LTR-LIS-13-346 "10 CFR 50.46 Notification and Reporting for WCOBRA/TRAC Changes and Error Corrections", dated July 30, 2013

cc: See page 4

cc (Enclosures):

U. S. Nuclear Regulatory Commission
Region II
Marquis One Tower
245 Peachtree Center Ave., NE Suite 1200
Atlanta, Georgia 30303-1257

NRC Resident Inspector Unit 2
Watts Bar Nuclear Plant
1260 Nuclear Plant Road
Spring City, Tennessee 37381

ENCLOSURE 1
Tennessee Valley Authority
Watts Bar Nuclear Plant, Unit 2

WESTINGHOUSE ELECTRIC COMPANY LLC LETTER LTR-LIS-13-401 "LBLOCA TCD PCT SHEET AND ASSOCIATED 10 CFR 50.46 REPORTS FOR REVISED HEAT TRANSFER MULTIPLIER DISTRIBUTIONS AND INITIAL FUEL PELLET AVERAGE TEMPERATURE UNCERTAINTY CALCULATION", DATED AUGUST 2, 2013

Westinghouse Electric Company
Engineering, Equipment and Major Projects
1000 Westinghouse Drive
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USA

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Our ref: LTR-LIS-13-401

August 2, 2013

Watts Bar Unit 2
LBLOCA TCD PCT Sheet and Associated 10 CFR 50.46 Reports for Revised Heat Transfer Multiplier Distributions and Initial Fuel Pellet Average Temperature Uncertainty Calculation

Dear Sir or Madam:

The attachment documents the initial LBLOCA PCT Sheet for the Watts Bar Unit 2 TCD Project, and associated 10 CFR 50.46 reports for the evaluation of the two Subject issues.

Please contact your LOCA Plant Cognizant Engineer if there are any questions concerning this information.

Author: (Electronically Approved)*
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LOCA Integrated Services I

Verifier: (Electronically Approved)*
Sonny Nguyen
LOCA Integrated Services I

Approved: (Electronically Approved)*
Amy J. Colussy, Manager
LOCA Integrated Services I

Attachment : Watts Bar Unit 2 10 CFR 50.46 Reports and Peak Cladding Temperature Rackup Sheet (4 Pages)

**Electronically approved records are authenticated in the electronic document management system.*

Attachment

Watts Bar Unit 2
10 CFR 50.46 Reports and Peak Cladding Temperature Rackup Sheet

(4 pages, including this cover page)

Revised Heat Transfer Multiplier Distributions

Background

Several changes and error corrections were made to WCOBRA/TRAC and the impacts of these changes on the heat transfer multiplier uncertainty distributions were investigated. During this investigation, errors were discovered in the development of the original multiplier distributions, including errors in the grid locations specified in the WCOBRA/TRAC models for the G2 Refill and G2 Reflood tests, and errors in processing test data used to develop the reflood heat transfer multiplier distribution. Therefore, the blowdown heatup, blowdown cooling, refill, and reflood heat transfer multiplier distributions were redeveloped. For the reflood heat transfer multiplier development, the evaluation time windows for each set of test experimental data and each test simulation were separately defined based on the time at which the test or simulation exhibited dispersed flow film boiling heat transfer conditions characteristic of the reflood time period. The revised heat transfer multiplier distributions have been evaluated for impact on existing analyses. Resolution of these issues represents a closely related group of Non-Discretionary Changes in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Models

2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect

A plant transient calculation representative of Watts Bar Unit 2 transient behavior was performed with the latest version of WCOBRA/TRAC. Using this transient, a matrix of HOTSPOT calculations was performed to estimate the effect of the heat transfer multiplier distribution changes. Using these results and considering the heat transfer multiplier uncertainty attributes from limiting cases for Watts Bar Unit 2, an estimated PCT effect of -55°F has been established for 10 CFR 50.46 reporting purposes for Watts Bar Unit 2.

INITIAL FUEL PELLET AVERAGE TEMPERATURE UNCERTAINTY CALCULATION

Background
In the Automated Statistical Treatment of Uncertainty Method (ASTRUM) Best-Estimate (BE) Large-Break Loss-of-Coolant Accident (LBLOCA) Evaluation Model (EM), uncertainties are applied to the gap heat transfer coefficient and pellet thermal conductivity to capture the uncertainty in the initial fuel pellet average temperature. This approach was compared to the initial fuel pellet average temperature uncertainties predicted by the PAD code at beginning-of-life conditions and found to be conservative in Section 25-4-2-4 of WCAP-12945-P-A. However, the initial fuel pellet average temperature uncertainty range analyzed at higher burnups in the ASTRUM EM is much wider than the uncertainty range predicted by the PAD code, which may result in excessively low or high analyzed initial fuel pellet average temperatures. This issue has been evaluated to estimate the impact on existing ASTRUM LBLOCA analysis results. The resolution of this issue represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Model(s)
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect
The issue described above was evaluated with plant-specific sensitivity studies resulting in an estimated Peak Cladding Temperature (PCT) impact of 0°F.

Westinghouse LOCA Peak Clad Temperature Summary for ASTRUM Best Estimate Large Break

Future

Plant Name: Watts Bar Unit 2
Utility Name: Tennessee Valley Authority
Revision Date: 8/1/2013

Analysis Information

EM:	ASTRUM (2004)	**Analysis Date:**	5/29/2013	**Limiting Break Size:**	DEG
FQ:	2.5	**FdH:**	1.65		
Fuel:	RFA-2	**SGTP (%):**	10		

Notes: PAD4.0+TCD; 2nd Cycle Limiting; peaking factor burndown applied to 2nd Cycle

	Clad Temp (°F)	Ref.	Notes
LICENSING BASIS			
Analysis-Of-Record PCT	1766	1	
PCT ASSESSMENTS (Delta PCT)			
A. PRIOR ECCS MODEL ASSESSMENTS			
1 . None	0		
B. PLANNED PLANT MODIFICATION EVALUATIONS			
1 . None	0		
C. 2013 ECCS MODEL ASSESSMENTS			
1 . Revised Heat Transfer Multiplier Distributions	-55	2	
D. OTHER*			
1 . None	0		
LICENSING BASIS PCT + PCT ASSESSMENTS **PCT =**	1711		

* It is recommended that the licensee determine if these PCT allocations should be considered with respect to 10 CFR 50.46 reporting requirements.

References:

1 . WCAP-17093-P, Revision 1, "Best-Estimate Analysis of the Large-Break Loss-of-Coolant Accident for Watts Bar Unit 2 Nuclear Power Plant Using the ASTRUM Methodology," June 2013.

2 . LTR-LIS-13-401, "Watts Bar Unit 2 LBLOCA TCD PCT Sheet and Associated 10 CFR 50.46 Reports for Revised Heat Transfer Multiplier Distributions and Initial Fuel Pellet Average Temperature Uncertainty Calculation," August 2013.

Notes:

None.

ENCLOSURE 2

Tennessee Valley Authority
Watts Bar Nuclear Plant Unit 2

WESTINGHOUSE ELECTRIC COMPANY LLC LETTER LTR-LIS-13-406 "ADDITIONAL INFORMATION ON THE EVALUATION OF REVISED HEAT TRANSFER MULTIPLIER DISTRIBUTIONS", DATED AUGUST 14, 2013

Westinghouse

From: LOCA Integrated Services I
Phone: (412) 374-5241
Date: August 14, 2013
Our Ref: LTR-LIS-13-406
Subject: **Additional Information on the Evaluation of Revised Heat Transfer Multiplier Distributions**

Attachments:
1. Additional Information on the Evaluation of Revised Heat Transfer Multiplier Distributions for Plants Licensed with the CQD EM (7 pages, including cover page)
2. Additional Information on the Evaluation of Revised Heat Transfer Multiplier Distributions for Plants Licensed with the ASTRUM EM (7 pages, including cover page)

References:
1. LTR-LIS-13-346, "10 CFR 50.46 Notification and Reporting for WCOBRA/TRAC Changes and Error Corrections," July 2013.

Plants which are licensed with Best Estimate Large Break LOCA methodologies (both CQD and ASTRUM evaluation models (EMs)) recently received 10 CFR 50.46 reporting text for a group of error corrections to WCOBRA/TRAC in Reference [1]. In addition, each plant received a plant-specific letter which included 10 CFR 50.46 reporting text for revised heat transfer multiplier distributions. Subsequent to the release of this information, some utilities requested additional information to better understand the evaluation of the heat transfer multiplier distributions. Additional information for plants licensed with the CQD EM is included in Attachment 1, and additional information for plants licensed with the ASTRUM EM is included in Attachment 2.

Since the WCOBRA/TRAC calculations for the heat transfer multiplier distribution evaluations used the latest released code versions which incorporated correction of the errors identified in Reference [1], it is recommended that the reporting pages included in Reference [1] be submitted at the time the 10 CFR 50.46 report for the revised heat transfer multiplier distributions is submitted.

Please contact the undersigned if there are any questions concerning this information.

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LOCA Integrated Services I

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Mitchell E. Nissley
Safety Analysis and Licensing

Approved: *(electronically approved)* *
Amy J. Colussy
LOCA Integrated Services I

**Electronically approved records are authenticated in the electronic document management system.*

Attachment 1 Omitted
Not Applicable to Watts Bar Unit 2

Attachment 1:

Additional Information on the Evaluation of Revised Heat Transfer Multiplier Distributions for Plants Licensed with the CQD EM

(7 pages, including cover page)

Attachment 2:

Additional Information on the Evaluation of Revised Heat Transfer Multiplier Distributions for Plants Licensed with the ASTRUM EM

(7 pages, including cover page)

1.0 Background on Error Identification and Reporting

As a result of code development and maintenance, several errors in the WCOBRA/TRAC code used for best estimate large break loss of coolant (BELOCA) analysis in the Code Qualification Document (CQD, Reference [1]) and ASTRUM (Reference [2]) evaluation models (EMs) were identified. Some of the errors affected the WCOBRA/TRAC heat transfer models, the heat transfer node initialization or the heat transfer renoding logic, as well as other models. These changes to WCOBRA/TRAC were described in Reference [3].

As a result of these changes, the following uncertainty distributions used in the CQD and ASTRUM EMs were investigated for potential impact:

- Critical flow
- Downcomer condensation
- Upper plenum drain distribution (condensation and interfacial drag for upper plenum injection)
- Blowdown heatup heat transfer
- Blowdown cooling heat transfer
- Refill heat transfer
- Reflood heat transfer

The results for the Separate Effects Tests (SETs) and Integral Effects Tests (IETs) used to determine each of the potentially impacted uncertainty distributions were examined, comparing results between the latest version of WCOBRA/TRAC (Version MOD7A Revision 8, with all of the errors listed in Reference [3] corrected) and WCOBRA/TRAC Version MOD7A Revision 6 (which was used in the licensing of the ASTRUM EM in Reference [2]). It was determined that the results for the SETs and IETs used to develop the critical flow, downcomer condensation, and upper plenum drain uncertainty distributions were sufficiently similar; therefore, those distributions did not require changes. It was also confirmed that emergency core cooling (ECC) bypass predictions remain conservative. However, it was determined that the heat transfer multiplier distributions required additional investigation.

During the investigation into the potential impact on the heat transfer multiplier distributions, errors were identified in the development of the original multiplier distributions, including errors in the grid locations specified in the WCOBRA/TRAC models for the G2 Refill and G2 Reflood SETs, and errors in processing test data used to develop the reflood heat transfer multiplier distribution. These errors were also corrected and, using latest released version of WCOBRA/TRAC, the revised blowdown heatup, blowdown cooling, refill and reflood heat transfer multiplier distributions were determined.

2.0 Revised Distributions and Expected Effects

2.1 Background on Heat Transfer Multiplier Sampling

In order to sample heat transfer multipliers, a percentile for each time period heat transfer multiplier is sampled. That point is then converted to the heat transfer multiplier value based on the cumulative distribution function (CDF) of the time period heat transfer multiplier. Figure 1 illustrates this concept for a change from an old distribution to a new one (note that this CDF does not represent any actual CDF for the heat transfer multipliers, but is used simply for demonstration). For example, if the 25th percentile is sampled, Figure 1 shows that a multiplier of about 0.65 would be obtained for the old distribution. For the new distribution, the sampled 25th percentile would result in a multiplier of about 1.15.

2.2 Changes to the Heat Transfer Multiplier Distributions

The CDFs of the heat transfer multipliers changed as follows:

- Blowdown heatup heat transfer multipliers increased for low multipliers and across most of the middle of the sampling range, and were mostly unchanged for the highest multipliers
- Blowdown cooling heat transfer multipliers decreased slightly from the top of the range through the middle, and were mostly unchanged for low multipliers
- Refill heat transfer multipliers decreased considerably at the top end of the range and gradually reduced to a slight decrease at the bottom end of the range. Although the magnitude of the change to the refill multiplier distribution was larger than that observed in the other distributions, the PCT impact is small because heat transfer rates are low during the nearly adiabatic refill time period.
- Reflood heat transfer multipliers increased at the bottom end of the range and the middle, and then decreased at the top end of the range.

The implications of these changes are strongly dependent on the behavior of individual transients. For the assessment, plants were classified as follows:

- Blowdown limited: A limiting PCT typically within the first 20 seconds of the transient.
- Early reflood limited: A limiting PCT after the end of the refill time period, but within about the first 70 seconds of the transient.
- Mid reflood limited: A limiting PCT that is between the early and late reflood time periods.
- Late reflood limited: A limiting PCT generally after about 200 seconds.

The impacts from the changes to the heat transfer multiplier CDFs on each of these transient types are discussed in the following subsections.

2.3 Blowdown Limited

Blowdown limited plants are only affected by the changes to the blowdown heatup heat transfer multiplier CDF. The increased heat transfer multipliers have a small benefit on PCT since the blowdown heatup time period is short.

2.4 Early Reflood Limited

Early reflood limited plants are affected by the changes to all of the heat transfer multiplier CDFs. The effects of the changes to the blowdown heatup and blowdown cooling heat transfer multiplier CDFs are limited since much of their effect diminishes through refill and the beginning of reflood. The effects of the changes to the refill heat transfer multiplier CDF are more pronounced since the early reflood PCT occurs shortly after the end of refill. The effects of the changes to the reflood heat transfer multiplier CDF are limited since the run spends very little time in the reflood time period prior to the PCT time.

2.5 Mid Reflood Limited

Mid reflood limited plants are affected by the changes to all of the heat transfer multiplier CDFs. The effects of the changes to the blowdown heatup and blowdown cooling heat transfer multiplier CDFs are very limited since most of their effect diminishes through refill and early reflood. The effects of the changes to the refill heat transfer multiplier CDF are limited since most of their effect diminishes through early reflood. The effects of the changes to the reflood heat transfer multiplier CDF are more pronounced due to the time over which the multiplier is applied prior to the PCT time.

2.6 Late Reflood Limited

Late reflood limited plants are predominately affected by the change to the reflood heat transfer multiplier CDF. The effects of the changes to the blowdown heatup, blowdown cooling, and refill heat transfer multiplier CDFs are negligible since their effect diminishes entirely throughout the lengthy reflood period. The effect of the change to the reflood heat transfer multiplier CDF can be significant due to the longer time over which the multiplier is applied prior to the PCT time.

3.0 Methodology for the Estimate of Effect

3.1 Selection and Description of Representative Transients

Representative PCT transients were used in determining the estimated PCT effect due to the revised heat transfer multiplier distributions. Heat transfer multipliers are applied in HOTSPOT; the HOTSPOT code performs a one-dimensional conduction calculation modeling the effect of local uncertainties on the hot rod, using thermal hydraulic boundary conditions taken from WCOBRA/TRAC. Plant characteristics determine the typical PCT transient behavior for the plant. Transients from different plants with similar PCT behavior tend to have fairly consistent thermal hydraulic characteristics around the hot rod. As a result, the choice of representative plant was based on PCT transient behavior for the evaluation of the revised heat transfer multiplier distributions. The representative transients chosen were early reflood limited, mid reflood limited, or late reflood limited. The blowdown PCT impact was taken from the most conservative results of the representative transients.

The representative transients discussed above were performed with the latest released version of WCOBRA/TRAC, which incorporated correction of all of the errors listed in Reference [3]. The representative transients were similar to Reference Transient calculations. Fuel performance data which explicitly reflects burnup-dependent effects of thermal conductivity degradation (TCD), calculated as described in Reference 4, was used for the representative calculations.

3.2 Background of the ASTRUM EM

For each calculation in the ASTRUM uncertainty analysis, the blowdown cooling, blowdown heatup, refill, and reflood heat transfer multipliers are independently sampled using the methodology discussed in Section 2.1. With the new CDFs, then, for a given analysis with an associated seed, the randomly sampled percentile for each heat transfer multiplier in each run is the same, but it is translated to a different multiplier based on the new distributions.

The revised heat transfer multiplier CDFs changed in different ways, such that PCT penalties or benefits would be expected, depending on the nature of the PCT transient and where the multipliers were sampled for a given run, as described in Section 2.

3.3 Estimates of Effect

Three representative plants were identified and a representative WCOBRA/TRAC calculation was performed for each representative plant (as described in Section 3.1). These WCOBRA/TRAC calculations provided the boundary condition input for a matrix of representative HOTSPOT calculations. The matrix of HOTSPOT calculations was developed by dividing each heat transfer multiplier distribution into a discrete number of bins. The heat transfer multipliers representative of that bin for the old distribution and the new distribution were identified. Then a pair of HOTSPOT calculations was performed, where the only difference between the two was that heat transfer multiplier. For example, in the reflood multiplier representing the 30-50% bin, the value of the old multiplier might be 0.8 while the new multiplier is 0.9. Those reflood multipliers are specified in the two different HOTSPOT calculations while the other heat transfer multipliers are set at nominal values. This process was performed for each heat transfer multiplier distribution (blowdown cooling, blowdown heatup, refill, reflood).

This matrix of HOTSPOT calculations produced a table of PCT deltas that were estimates of an individual change for a bin of each multiplier distribution. The limiting runs for each plant analysis were identified, including consideration of the TCD effects and other evaluations on the analysis of record (AOR) which substantially impacted the ranking or PCTs of the limiting cases. The set of limiting runs for each plant were selected such that less limiting runs which were not explicitly considered would not become limiting due to the estimated PCT impact from the change in heat transfer multipliers. The heat transfer multipliers for each run were used to identify which bin that multiplier falls into, and an estimated PCT impact for that individual multiplier was assigned. The individual estimated PCT impacts for the run (based on the four multipliers) were summed to estimate the overall impact on the run. Finally, the run results were re-ranked based on the estimated impacts on each run. The change between the estimated 95/95 PCT before and after this process was reported as the estimate of effect for each plant analysis.

It is noted that for some analyses, the limiting runs were a mixture of different transient behaviors (some limiting runs were early reflood, some mid, etc.). In these cases, results from the appropriate representative transient were used on a case-by-case basis.

4.0 Summary of Effects and Observed Trends

For plants licensed with the ASTRUM EM, it is noted that these discussions give observable trends and expected behavior, but the ultimate estimates of effect for some plants did deviate. For example, a limiting case that had a high sampled reflood heat transfer multiplier for a late reflood transient would have a penalty, whereas a more typical limiting case with a low sampled multiplier would have a benefit. In addition, the limiting runs in some analyses were a mixture of different transient behaviors. In those cases, these descriptions will generally apply on a run-by-run basis, but the overall PCT estimate of effect may vary.

For blowdown limited plants licensed with the ASTRUM EM, limiting runs typically do not have high blowdown heatup heat transfer multipliers; therefore, the blowdown limited plants received benefits from the change to the heat transfer multiplier CDFs.

For early reflood limited plants licensed with the ASTRUM EM, the heat transfer multipliers sampled in the various time periods of the limiting runs can vary. In addition, the impacts for each heat transfer multiplier CDF are of similar magnitude due to similar time spent in each time period, though the penalties tended to be slightly higher than the benefits. As a result, small penalties were generally observed for early reflood limited plants for the change to the heat transfer multiplier CDFs. All estimates of effect were small.

For mid reflood limited plants licensed with the ASTRUM EM, limiting runs tend to sample low reflood heat transfer multipliers. In addition, the impact of the reflood heat transfer multiplier CDF on mid-reflood limited plants was higher than the impact of the other heat transfer multiplier CDFs. As a result, mid reflood plants tended to receive small to moderate benefits from the change to the heat transfer multiplier CDFs.

For late reflood limited plants licensed with the ASTRUM EM, limiting runs tend to sample low reflood heat transfer multipliers. As a result, late reflood plants tended to receive large benefits from the change to the heat transfer multiplier CDFs.

5.0 References

1. WCAP-12945-P-A, Volume 1, Revision 2, and Volumes 2 through 5, Revision 1, "Code Qualification Document for Best Estimate LOCA Analysis," March 1998.
2. WCAP-16009-P-A, "Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment Of Uncertainty Method (ASTRUM)," January 2005.
3. LTR-LIS-13-346, "10 CFR 50.46 Notification and Reporting for WCOBRA/TRAC Changes and Error Corrections," July 2013.
4. LTR-NRC-12-27, "Westinghouse Input Supporting Licensee Response to NRC 10 CFR 50.54(f) Letter Regarding Nuclear Fuel Thermal Conductivity Degradation (Proprietary/Non-Proprietary)," March 2012.

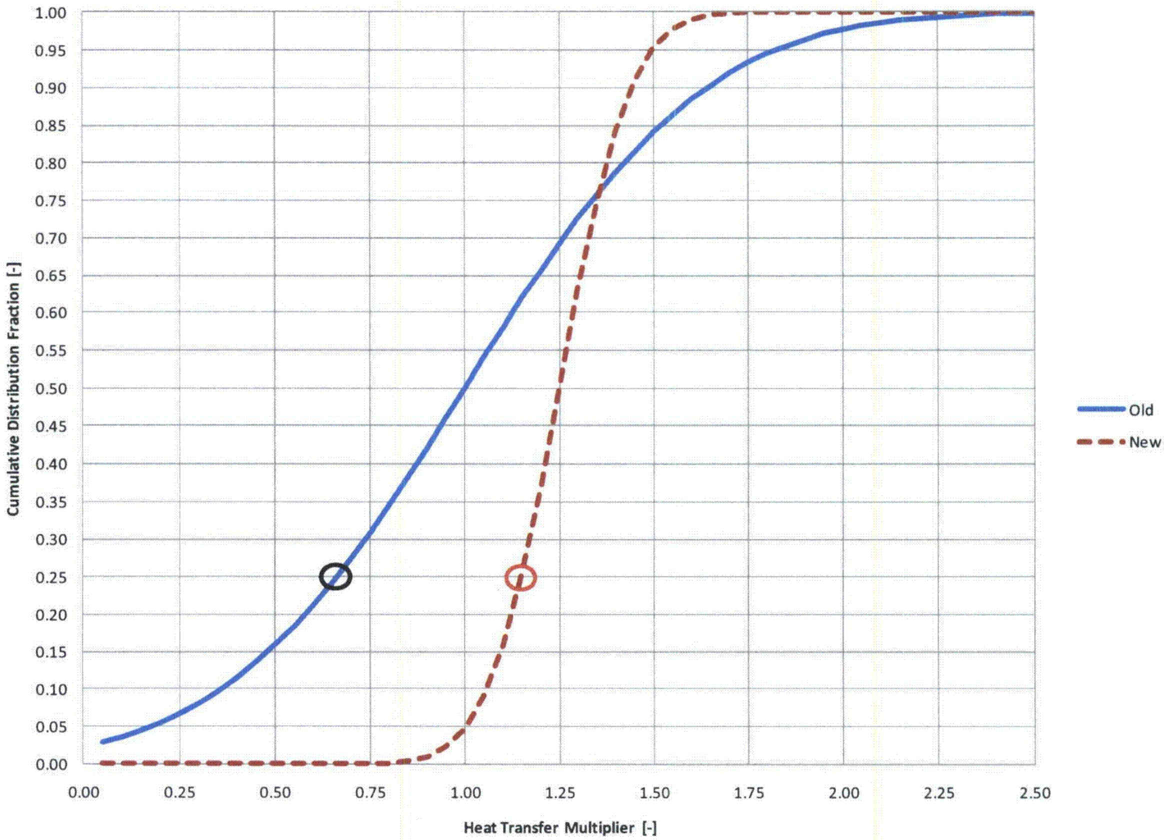

Figure 1: Example Heat Transfer Multiplier Cumulative Distribution Function

(Note that this CDF does not represent any actual CDF for the heat transfer multipliers, but is used simply for illustrative purposes)

ENCLOSURE 3

Tennessee Valley Authority
Watts Bar Nuclear Plant Unit 2

WESTINGHOUSE ELECTRIC COMPANY LLC LETTER LTR-LIS-13-346 "10 CFR 50.46 NOTIFICATION AND REPORTING FOR WCOBRA/TRAC CHANGES AND ERROR CORRECTIONS", DATED JULY 30, 2013

Westinghouse Electric Company
Engineering, Equipment and Major Projects
1000 Westinghouse Drive
Cranberry Township, Pennsylvania 16066
USA

Direct tel: (412) 374-2202
Direct fax: (724) 720-0857
e-mail: teoliscd@westinghouse.com

Our ref: LTR-LIS-13-346

July 30, 2013

10 CFR 50.46 Notification and Reporting for
WCOBRA/TRAC Changes and Error Corrections

Dear Sir or Madam:

The attachment documents 10 CFR 50.46 reports for several evaluations of WCOBRA/TRAC code changes and error corrections.

Please contact your LOCA Plant Cognizant Engineer if there are any questions concerning this information.

Author: (Electronically Approved)*
Carmen D. Teolis
LOCA Integrated Services I

Verifier: (Electronically Approved)*
Jeffrey R. Kobelak
(Methodology only)
LOCA Integrated Services I

Verifier: (Electronically Approved)*
Katsuhiro Ohkawa, EM Lead
LOCA Integrated Services I

Author: (Electronically Approved)*
Meghan E. Leslie
LOCA Integrated Services I

Verifier: (Electronically Approved)*
Joshua M. Borromeo
LOCA Integrated Services I

Approved: (Electronically Approved)*
Amy J. Colussy, Manager
LOCA Integrated Services I

Attachment: 10 CFR 50.46 Reporting Text (11 Pages)

**Electronically approved records are authenticated in the electronic document management system.*

ELEVATIONS FOR HEAT SLAB TEMPERATURE INITIALIZATION

Background

An error was discovered in WCOBRA/TRAC whereby an incorrect value would be used in the initial fuel rod temperature calculation for a fuel rod heat transfer node if that node elevation was specified outside of the bounds of the temperature initialization table. This problem has been evaluated for impact on existing analyses and its resolution represents a Discretionary Change in accordance with Section 4.1.1 of WCAP-13451.

Affected Evaluation Models

1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
1999 Westinghouse Best Estimate Large Break LOCA Evaluation Model, Application to PWRs with Upper Plenum Injection
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect

Based on inspection of plant analysis input, it was concluded that the input decks for existing analyses are not impacted by this error, leading to an estimated peak cladding temperature impact of 0°F.

HEAT TRANSFER MODEL ERROR CORRECTIONS

Background

Several related changes were made to WCOBRA/TRAC to correct errors discovered which affected the heat transfer models. These errors included calculation of the entrained liquid fraction used in calculation of the drop wall heat flux, application of the grid enhancement factor for grid temperature calculation, calculation of the Reynold's number used in the Wong-Hochrieter correlation for the heat transfer coefficient from fuel rods to vapor, fuel rod initialization and calculation of cladding inner radius with creep, application of grid and two phase enhancement factors and radiation component in single phase vapor heat transfer, and reset of the critical heat flux temperature when J=2. These errors have been evaluated to estimate the impact on existing LBLOCA analysis results. Correction of these errors represents a closely-related group of Non-Discretionary Changes in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Models

1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
1999 Westinghouse Best Estimate Large Break LOCA Evaluation Model, Application to PWRs with Upper Plenum Injection
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect

Based on the results of representative plant calculations, separate effects and integral effects test simulations, it is concluded that the error corrections have a negligible local effect on heat transfer, leading to an estimated peak cladding temperature impact of 0°F.

CORRECTION TO HEAT TRANSFER NODE INITIALIZATION

Background
An error was discovered in the heat transfer node initialization logic in WCOBRA/TRAC whereby the heat transfer node center locations could be inconsistent with the geometric node center elevations. The primary effects of this issue are on the interpolated fluid properties and grid turbulent mixing enhancement at the heat transfer node. This problem has been evaluated for impact on existing analyses and its resolution represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Models
1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
1999 Westinghouse Best Estimate Large Break LOCA Evaluation Model, Application to PWRs with Upper Plenum Injection
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect
Based on engineering judgment and the results from a matrix of representative plant calculations, it is concluded that the effect of this error is within the code resolution, leading to an estimated peak cladding temperature impact of 0°F.

MASS CONSERVATION ERROR FIX

Background

It was identified that mass was not conserved in WCOBRA/TRAC one-dimensional component cells when void fraction values were calculated to be slightly out of the physical range (greater than 1.0 or smaller than 0.0). This was observed to result in artificial mass generation on the secondary side of steam generator components. Correction of this problem represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Models

1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
1999 Westinghouse Best Estimate Large Break LOCA Evaluation Model, Application to PWRs with Upper Plenum Injection
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect

This error was observed to primarily affect the mass on the secondary side of the steam generator. This issue was judged to have a negligible impact on existing LBLOCA analysis results, leading to an estimated peak cladding temperature impact of 0°F.

CORRECTION TO SPLIT CHANNEL MOMENTUM EQUATION

Background

An error was discovered in the momentum equation calculations for split channels in WCOBRA/TRAC. This error impacts the (1) continuity area of the phantom/boundary bottom cell; (2) bottom and top continuity area correction factors for the channel inlet at the bottom of a section and for the channel outlet at the top of a section; and (3) drop entrainment mass rate per unit volume and drop de-entrainment mass rate per unit volume contributions to the momentum calculations for split channels. This problem has been evaluated for impact on existing analyses and its resolution represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Models

1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
1999 Westinghouse Best Estimate Large Break LOCA Evaluation Model, Application to PWRs with Upper Plenum Injection
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect

Based on the results from a matrix of representative plant calculations, it is concluded that the effect of this error on the quantities directly impacted by the momentum equation calculations for split channels (velocities, flows, etc.) is negligible, leading to an estimated peak cladding temperature impact of 0°F.

HEAT TRANSFER LOGIC CORRECTION FOR ROD BURST CALCULATION

Background
A change was made to the WCOBRA/TRAC coding to correct an error which had disabled rod burst in separate effect test simulations. This change represents a Discretionary Change in accordance with Section 4.1.1 of WCAP-13451.

Affected Evaluation Models
1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
1999 Westinghouse Best Estimate Large Break LOCA Evaluation Model, Application to PWRs with Upper Plenum Injection
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect
Based on the nature of the change and the evaluation model requirements for plant modeling in Westinghouse best estimate large break LOCA analyses with WCOBRA/TRAC, it is judged that existing analyses are not impacted by this change, leading to an estimated peak cladding temperature impact of 0°F.

CHANGES TO VESSEL SUPERHEATED STEAM PROPERTIES

Background

Several related changes were made to the WCOBRA/TRAC coding for the vessel super-heated water properties, including updating the HGAS subroutine coding to be consistent with Reference 1 Equation 10-6, updating the approximation of the enthalpy in the TGAS subroutine to be consistent with the HGAS subroutine coding, and updating the temperature iteration method and convergence criteria in the TGAS subroutine. These changes represent a closely-related group of Non-Discretionary Changes in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Models

1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
1999 Westinghouse Best Estimate Large Break LOCA Evaluation Model, Application to PWRs with Upper Plenum Injection
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect

The updates to the calculations of the superheated steam properties had generally less than 1°F impact on the resulting steam temperature values, leading to an estimated peak cladding temperature impact of 0°F.

Reference

1. WCAP-12945-P-A, Volume 1, Revision 2, and Volumes 2 through 5, Revision 1, "Code Qualification Document for Best Estimate LOCA Analysis," 1998.

UPDATE TO METAL DENSITY REFERENCE TEMPERATURES

Background
It was identified that for one-dimensional components in which heat transfer to stainless steel 304 or 316 is modeled, the reference temperature for the metal density calculation was allowed to vary; as a result the total metal mass was not preserved. Correction of this problem represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Models
1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
1999 Westinghouse Best Estimate Large Break LOCA Evaluation Model, Application to PWRs with Upper Plenum Injection
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect
This change primarily impacts the reactor coolant system loop piping modeled in the large break loss-of-coolant accident (LBLOCA) WCOBRA/TRAC models. It was judged that the effect of this change on the peak cladding temperature results was negligible, leading to an estimated peak cladding temperature impact of 0°F.

DECAY HEAT MODEL ERROR CORRECTIONS

Background
The decay heat model in the WCOBRA/TRAC code was updated to correct the erroneously coded value of the yield fraction directly from fission for Group 19 of Pu-239, and to include the term for uncertainty in the prompt energy per fission in the calculation of the decay heat power uncertainty. Correction of these errors represents a closely-related group of Non-Discretionary Changes in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Models
1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
1999 Westinghouse Best Estimate Large Break LOCA Evaluation Model, Application to PWRs with Upper Plenum Injection
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect
These changes have a negligible impact on the calculated decay heat power, leading to an estimated peak cladding temperature impact of 0°F.

CORRECTION TO THE PIPE EXIT PRESSURE DROP ERROR

Background
An error was discovered in WCOBRA/TRAC whereby the frictional pressure drop at the split break TEE connection to the BREAK component was incorrectly calculated using the TEE hydraulic diameter instead of the BREAK component length input. This error has been evaluated for impact on existing analyses and its resolution represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Models
1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
1999 Westinghouse Best Estimate Large Break LOCA Evaluation Model, Application to PWRs with Upper Plenum Injection
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect
Based on the results from a matrix of representative plant calculations, it is concluded that the effect of this error on the pressure at the break and the break flow is negligible, leading to an estimated peak cladding temperature impact of 0°F.

WCOBRA/TRAC U19 FILE DIMENSION ERROR CORRECTION

Background

A problem was identified in the dimension of an array used to generate the u19 file in WCOBRA/TRAC. The u19 file is read during HSDRIVER execution and provides information needed to generate the HOTSPOT thermal-hydraulic history and user input files. The array used to write the desired information to the u19 file is dimensioned to 2000 in WCOBRA/TRAC. It is possible, however, for more than 2000 curves to be written to the u19 file. If that is the case, it is possible that the curves would not be stored correctly on the u19 file. A survey of current Best Estimate Large Break LOCA analyses indicated that the majority of plants had less than 2000 curves in their u19 files; therefore these plants are not affected by the change. For those plants with more than 2000 curves, plant-specific sensitivity calculations indicated that resolution of this issue does not impact the peak cladding temperature (PCT) calculation for prior analyses. This represents a Discretionary Change in accordance with Section 4.1.1 of WCAP-13451.

Affected Evaluation Models

1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
1999 Westinghouse Best Estimate Large Break LOCA Evaluation Model, Application to PWRs with Upper Plenum Injection
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect

As discussed in the Background section, resolution of this issue does not impact the peak cladding temperature calculation for prior LBLOCA analyses, leading to an estimated peak cladding temperature impact of 0°F.