Westinghouse

Westinghouse Electric Company
Engineering, Equipment and Major Projects
1000 Westinghouse Drive, Building 3
Cranberry Township, Pennsylvania 16066
USA

U.S. Nuclear Regulatory Commission
Document Control Desk
11555 Rockville Pike
Rockville, MD 20852

Direct tel: (412) 374-4643
Direct fax: (724) 940-8560
e-mail: greshaja@westinghouse.com

LTR-NRC-14-20

April 4, 2014

Subject: Supplemental Information on the Impacts of Errors in the Loss of Coolant Accident Evaluation Models (Non-Proprietary).

As part of WCAP-17524 Revision 0, "AP1000 Core Reference Report" the analyses for Large Break Loss of Coolant Accident (LBLOCA) and Small Break Loss of Coolant Accident (SBLOCA) were provided to the NRC for review and approval. Subsequent to the submittal of WCAP-17524 Revision 0, the LBLOCA and SBLOCA analyses were revised and the revised analyses are presented in WCAP-17524 Revision 1. The purpose of this letter is to provide supplemental information for the **AP1000®** plant LBLOCA and SBLOCA analyses presented in Revision 1 of the Core Reference Report (CRR).

If you have any questions or require additional information, please contact Keith Drudy at (412) 374-5841.

Very truly yours,

William J. Smoody / FOR

James A. Gresham, Manager

Regulatory Compliance

D107
NRO

COPYRIGHT NOTICE

Supplemental Information on the Impacts of Errors in the Loss of Coolant Accident Evaluation Models (Non-Proprietary)

April 2014

Westinghouse Electric Company
1000 Westinghouse Drive
Cranberry Township, PA 16066

Supplemental Information on the Impacts of Errors in the Loss of Coolant Accident Evaluation Models

As part of WCAP-17524 Revision 0, "AP1000 Core Reference Report" the analyses for Large Break Loss of Coolant Accident (LBLOCA) and Small Break Loss of Coolant Accident (SBLOCA) were provided to the NRC for review and approval. Subsequent to the submittal of WCAP-17524 Revision 0, the LBLOCA and SBLOCA analyses were revised and the revised analyses are presented in WCAP-17524 Revision 1.

The purpose of this letter is to provide supplemental information for the **AP1000®** plant LBLOCA and SBLOCA analyses presented in Revision 1 of the Core Reference Report (CRR). Errors have been identified in the evaluation models for the LBLOCA and SBLOCA analyses presented in Revision 1 of the CRR. To address these errors, as well as changes to the evaluation models, the process described in 10 CFR 50.46 has been utilized. The supplemental information provided in Attachment 1 consists of 10 CFR 50.46 reporting sheets and current peak cladding temperature (PCT) rackup sheets for the LBLOCA and SBLOCA analyses presented in Revision 1 of the CRR. The 10 CFR 50.46 reporting sheets describe known changes to or errors in the LOCA evaluation models applied in the CRR analyses, and the estimated PCT effect of each change or error.

For the LBLOCA ASTRUM evaluation model, the included 10 CFR 50.46 reporting sheets consist of changes and errors reported after the 2007 reporting year which are applicable to the LBLOCA CRR Revision 1 analysis. It is noted that applicable 10 CFR 50.46 reporting pages for the 1998 through 2007 reporting years were previously provided to the NRC via APP-GW-GLE-026, Revision 1 as part of the licensing of the ASTRUM evaluation model application to the **AP1000** plant.

For the LBLOCA evaluation model there are several 0 degree errors and 2 non-zero errors, with a cumulative estimated PCT impact of 34 °F relative to the PCT documented in CRR Revision 1.

For the SBLOCA NOTRUMP-AP600 evaluation model, the included 10 CFR 50.46 reporting sheets consist of changes and errors reported after the **AP1000** plant final safety evaluation report (NUREG-1793, Initial Report) was issued, for reporting years from 2004 through 2013, which are applicable to the SBLOCA CRR Revision 1 analysis.

For the SBLOCA evaluation model there are several 0 degree errors and 0 non-zero errors, with a cumulative estimated PCT impact of 0 °F relative to the analysis documented in CRR Revision 1.

Attachment 1

2008 REPORTING

NOTRUMP BUBBLE RISE/DRIFT FLUX MODEL INCONSISTENCIES

Background
The standard plant version of the NOTRUMP code was updated to resolve inconsistencies in several drift flux models as well as the nodal bubble rise/droplet fall models. In summary, these changes include:

- Bubble rise and droplet fall model calculations were made consistent with flow link calculations.
- Corrections were made to limits employed in the vertical counter-current flooding models.
- Checking logic was added to correct situations where drift flux model inconsistencies could result (i.e. prevent liquid flow from an all-vapor node and vapor flow from all-liquid node).

All of these changes represent a closely-related group of Non-Discretionary Changes in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Models
1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect
Due to the nature of the Advanced Plant SBLOCA response and the relative insensitivity of these corrections on the Standard Plant EM, it is estimated that the effect of these inconsistencies on PCT calculations is 0°F for 10 CFR 50.46 purposes for the Advanced Plant NOTRUMP EM calculations.

2008 REPORTING

NOTRUMP DRIFT FLUX MODEL INCONSISTENCIES

Background
The standard plant version of the NOTRUMP code was updated to resolve inconsistencies in the resetting of certain parameters in the drift flux models when single phase conditions are determined to exist. The previous coding had inadvertently omitted certain conditions on drift velocity and void fraction which are now included. Also, in the node boundary mixture level crossing logic, several partial derivatives for liquid and vapor volumetric fluxes with respect to mass flux in the void fraction model were erroneously set to zero. The correct partial derivative calculations were added to the code. In addition, several instances (stacking logic, accumulator empty logic and pump critical flow logic) where flow link specific volumes were incorrectly always based on saturated conditions were corrected. These changes represent a closely-related group of Non-Discretionary Changes in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Models
1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect
The subject changes involve logic that is seldom used in standard plant EM calculations. As such, the estimated effect of these inconsistencies on PCT calculations is 0°F for 10 CFR 50.46 reporting purposes for the Advanced Plant NOTRUMP EM calculations.

2008 REPORTING

NOTRUMP INVERTED T-NODE SIGN CONVENTION

Background
This change deals with the correction of the sign convention for inverted T-nodes, which was incorrectly applied via input into the EM. It can potentially impact the reactor vessel lower plenum node, Passive Residual Heat Removal (PRHR) inlet piping and ADS 1-3 discharge piping in the Advanced Plant EM. This change represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Models
1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect
The correction of this error can affect the mixture/vapor interfacial area within a fluid node. With respect to the potentially impacted areas of the model, this condition never exists in the reactor vessel lower plenum. It is judged that the impact of this error correction on the other areas is insignificant on the overall results. Based on this judgment, coupled with the fact that plant model calculations show this to be the case, the correction of this error will be assigned a 0°F PCT impact for 10 CFR 50.46 reporting purposes.

2008 REPORTING

NOTRUMP VAPOR REGION FORMATION LOGIC

Background
The logic governing formation of a vapor region within a fluid node in NOTRUMP was corrected in the standard plant code to allow superheated conditions where appropriate, instead of saturated conditions which may not exist at that instant. This change represents a Non-Discretionary Change in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Models
1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect
Typically, region formation conditions in standard plant EM calculations occur at saturation in all control volumes outside of the core model. If a region is formed at superheat conditions in these areas of the model, the amount of superheat is usually small. As such, the nature of these logic issues leads to an estimated PCT impact of 0°F for 10 CFR 50.46 reporting purposes for the Advanced Plant NOTRUMP EM calculations.

2008 REPORTING

CHECK VALVE IN SERIES WITH AN ISOLATION VALVE

Background
During review of preliminary analyses performed for the **AP1000**® plant analysis program, reverse flows were observed through the Core Makeup Tank (CMT) check valves under inappropriate conditions. The conditions where this behavior was observed occurred when a negative pressure differential across the check valves existed concurrent with the opening of the isolation valves. A review of the flow links in the NOTRUMP AP600 and **AP1000** plant models indicate that the following flow paths could be affected:

- Core Makeup Tank (CMT) Discharge lines. These paths are modeled with isolation valves in series with check valves w/drift flux.
- In-Containment Refueling Water Storage Tank (IRWST) Injection lines. These paths are modeled with isolation valves in series with check valves and no drift flux.
- Passive Residual Heat Removal (PRHR) discharge line. This path is modeled with an isolation valve w/drift flux.

A cursory review of both the AP600 and **AP1000** plant analyses indicates that only transients with a negative pressure differential across the check valves while the isolation valves are opening (i.e. 10-inch and Cold Leg Balance Line (CLBL) breaks) exhibit the potential to predict a period of negative flow. Due to the coding logic utilized, the concern only exists while the isolation valves are opening which occurs for a short duration and will not likely have a significant impact on results of the SBLOCA analyses.

When drift flux is applied to a variable area flow path (i.e., a path containing a check valve, isolation valve, or a combination) the code may predict flow behavior not appropriate for the actual conditions. A temporary workaround of modeling the flow paths as homogenous is acceptable due to the subcooled nature of the affected flow paths (CMT discharge and PRHR heat exchanger discharge).

These changes represent a closely related group of Non-Discretionary Changes in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Model(s)
1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect
The potential for negative flow through a check valve in series with an isolation valve only exists during the short period over which the isolation valve is opening and as such the impact on transient results is minimal. The subcooled nature of the flow through the variable area flow paths with drift flux applied is expected to lead to inappropriate flow having a minimal change in the overall transient results. Thus, for Advanced Plant small break LOCA analysis results, the estimated PCT impact is 0°F for 10 CFR 50.46 reporting purposes.

2008 REPORTING

GENERAL CODE MAINTENANCE

Background
Various changes have been made to enhance the usability of the codes and to help preclude errors in analyses. This includes items such as modifying input variable definitions, units, and defaults; improving the input diagnostic checks; enhancing the code output; optimizing active coding; and, eliminating inactive coding. These changes represent Discretionary Changes that will be implemented on a forward-fit basis in accordance with Section 4.1.1 of WCAP-13451.

Affected Evaluation Model(s)
1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

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

2009 REPORTING

ERROR IN ASTRUM PROCESSING OF AVERAGE ROD BURNUP AND ROD INTERNAL PRESSURE

Background
An error was discovered in the processing of the burnup and rod internal pressure inputs for average core rods in ASTRUM analyses. The correction of this error has been evaluated for impact on current licensing-basis analyses and will be incorporated into the ASTRUM method at a future time. These changes represent a closely-related group of Non-Discretionary Changes 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
This error was evaluated to have a negligible impact on PCT, leading to an estimated impact of 0°F for 10 CFR 50.46 reporting purposes.

2011 REPORTING

GENERAL CODE MAINTENANCE

Background
Various changes have been made to enhance the usability of codes and to streamline future analyses. Examples of these changes include modifying input variable definitions, units and defaults; improving the input diagnostic checks; enhancing the code output; optimizing active coding; and eliminating inactive coding. These changes represent Discretionary Changes that will be implemented on a forward-fit basis in accordance with Section 4.1.1 of WCAP-13451.

Affected Evaluation Model(s)
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 nature of these changes leads to an estimated PCT impact of 0°F.

2011 REPORTING

ERROR IN VARIOUS REGION ELEVATIONS AND SUBSEQUENT RELATED CALCULATIONS

Background

Several closely related errors associated with component elevations were discovered in the **AP1000®** plant data collection. Some of these component elevations are subsequently utilized in the calculation of region volumes, surface areas and metal masses which are used in safety analyses.

This represents a Non-Discretionary Change to the Evaluation Model as described at Section 4.1.2 of WCAP-13451.

Affected Evaluation Model(s)

1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect

This issue was judged to have a negligible impact on existing analyses, leading to an estimated Peak Cladding Temperature (PCT) impact of 0°F.

2012 REPORTING

GENERAL CODE MAINTENANCE

Background
Various changes have been made to enhance the usability of codes and to streamline future analyses. Examples of these changes include modifying input variable definitions, units and defaults; improving the input diagnostic checks; enhancing the code output; optimizing active coding; and eliminating inactive coding. These changes represent Discretionary Changes that will be implemented on a forward-fit basis in accordance with Section 4.1.1 of WCAP-13451.

Affected Evaluation Model(s)
1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
1999 Westinghouse Best Estimate Large Break LOCA Evaluation Model for Application to PWRs with Upper Plenum Injection
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect
The nature of these changes leads to an estimated Peak Cladding Temperature (PCT) impact of 0°F.

2012 REPORTING

HOTSPOT BURST TEMPERATURE CALCULATION FOR ZIRLO CLADDING

Background
A problem was identified in the calculation of the burst temperature for **ZIRLO®** cladding in the HOTSPOT code when the cladding engineering hoop stress exceeds 15,622 psi. This problem results in either program failure or an invalid extrapolation of the burst temperature vs. engineering hoop stress table. 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 Model(s)
1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
1999 Westinghouse Best Estimate Large Break LOCA Evaluation Model for Application to PWRs with Upper Plenum Injection
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect
The evaluation of existing analyses demonstrated no impact on the overall Peak Cladding Temperature (PCT) results, leading to an estimated effect of 0°F.

2012 REPORTING

HOTSPOT ITERATION ALGORITHM FOR CALCULATING THE INITIAL FUEL PELLET AVERAGE TEMPERATURE

Background
The HOTSPOT code has been updated to incorporate the following corrections to the iteration algorithm for calculating the initial fuel pellet average temperature: (1) bypass the iteration when the input value satisfies the acceptance criterion; (2) prevent low-end extrapolation of the gap heat transfer coefficient; (3) prevent premature termination of the iteration that occurred under certain conditions; and (4) prevent further adjustment of the gap heat transfer coefficient after reaching the iteration limit. These changes represent a closely-related group of Non-Discretionary Changes in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Model(s)
1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
1999 Westinghouse Best Estimate Large Break LOCA Evaluation Model for Application to PWRs with Upper Plenum Injection
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect
Sample calculations and engineering judgment lead to an estimated Peak Cladding Temperature (PCT) impact of 0°F.

2012 REPORTING

WCOBRA/TRAC AUTOMATED RESTART PROCESS LOGIC ERROR

Background

A minor error was identified in the WCOBRA/TRAC Automated Restart Process (WARP) logic for defining the Double-Ended Guillotine (DEG) break tables. The error has been evaluated for impact on current licensing-basis analysis results and will be incorporated into the plant-specific analyses on a forward-fit basis. These changes represent a closely-related group of Non-Discretionary Changes in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Model(s)

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

Estimated Effect

These errors were evaluated to have a negligible impact on the Large Break LOCA analysis results, leading to an estimated Peak Cladding Temperature (PCT) impact of 0°F.

2012 REPORTING

ROD INTERNAL PRESSURE CALCULATION

Background
Several issues which affect the calculation of rod internal pressure (RIP) have been identified for certain Best-Estimate (BE) Large-Break Loss-of-Coolant Accident (LBLOCA) evaluation models (EMs). These issues include the sampling of rod internal pressure uncertainties, updating HOTSPOT to consider the effect of transient RIP variations in the application of the uncertainty, and generating RIPs at a consistent rod power. These issues have been evaluated to estimate the impact on existing LBLOCA analysis results. The 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 Model(s)
1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect
The effects described above are either judged to have a negligible effect on existing LBLOCA analysis results or have been adequately incorporated into the thermal conductivity degradation evaluations, leading to an estimated Peak Cladding Temperature (PCT) impact of 0°F.

2012 REPORTING

WCOBRA/TRAC THERMAL-HYDRAULIC HISTORY FILE DIMENSION USED IN HSDRIVER

Background

A problem was identified in the dimension of the WCOBRA/TRAC thermal-hydraulic history file used in HSDRIVER. The array that is used to store the information from the WCOBRA/TRAC thermal-hydraulic history file is dimensioned to 3000 in HSDRIVER. It is possible for this file to contain more than 3000 curves. If that is the case, it is possible that the curves would not be used correctly in the downstream HOTSPOT execution. An extent-of-condition review indicated that resolution of this issue does not impact the Peak Cladding Temperature (PCT) calculation for prior Large Break Loss-of-Coolant Accident (LBLOCA) analyses. This represents a Discretionary Change in accordance with Section 4.1.1 of WCAP -13451.

Affected Evaluation Model(s)

1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
1999 Westinghouse Best Estimate Large Break LOCA Evaluation Model for 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 PCT calculation for prior LBLOCA analyses, which leads to a PCT impact of 0°F.

2012 REPORTING

ERRORS IN VARIOUS COMPONENT ELEVATIONS AND METAL MASSES

Background
Several closely related errors associated with various component elevations and metal masses were discovered in the **AP1000®** plant calculations. These errors have been evaluated and will be corrected in the future. These changes represent a closely-related group of Non-Discretionary Changes in accordance with Section 4.1.2 of WCAP-13451.

Affected Evaluation Model(s)
1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect
These errors were evaluated as having a negligible impact on existing analyses, leading to an estimated Peak Cladding Temperature (PCT) impact of 0°F.

2013 REPORTING

GENERAL CODE MAINTENANCE

Background
Various changes have been made to enhance the usability of codes and to streamline future analyses. Examples of these changes include modifying input variable definitions, units and defaults; improving the input diagnostic checks; enhancing the code output; optimizing active coding; and eliminating inactive coding. These changes represent Discretionary Changes that will be implemented on a forward-fit basis in accordance with Section 4.1.1 of WCAP-13451.

Affected Evaluation Model(s)
1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect
The nature of these changes leads to an estimated Peak Cladding Temperature (PCT) impact of 0°F.

2013 REPORTING

BURST ELEVATION SELECTION

Background

It is stated on page 11-20 of WCAP-16009-P-A that the burst option is applied at the elevation corresponding to the (WCOBRA/TRAC) burst elevation for the hot assembly rod. This approach was modified to apply the burst option at the HOTSPOT predicted burst elevation as described on page 19 of Attachment 1 to LTR-NRC-06-8. The HOTSPOT code has been updated to incorporate the following changes to the burst elevation selection logic if multiple nodes burst at the same time: (1) the node that has the highest cladding temperature at the time of burst is selected; (2) if multiple nodes have the same burst time and cladding temperature at the time of burst, the lowest ordered elevation of those nodes is selected. These changes represent a closely-related group of Discretionary Changes in accordance with Section 4.1.1 of WCAP-13451.

Affected Evaluation Model(s)

2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect

This improvement in burst elevation selection is a forward-fit change, leading to an estimated Peak Cladding Temperature (PCT) impact of 0°F.

2013 REPORTING

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 Model(s)
1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
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.

2013 REPORTING

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 Model(s)

1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
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.

2013 REPORTING

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 Model(s)

1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
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.

2013 REPORTING

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 Model(s)

1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
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.

2013 REPORTING

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 Model(s)

1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
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.

2013 REPORTING

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 Model(s)
1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
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.

2013 REPORTING

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 Model(s)
1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
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.

2013 REPORTING

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 WCAP-12945-P-A 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 Model(s)
1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
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.

2013 REPORTING

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 Model(s)

1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
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.

2013 REPORTING

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 Model(s)
1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
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.

2013 REPORTING

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 Model(s)
1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
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.

2013 REPORTING

GRID HEAT TRANSFER ENHANCEMENT CALCULATION

Background
An issue was identified which could affect the calculation of the heat transfer at gridded elevations for Best-Estimate (BE) Large-Break Loss-of-Coolant Accident (LBLOCA) Evaluation Models (EMs). For a specific input condition, the grid heat transfer enhancement factor is calculated based on an erroneous core geometry, which can cause an over-prediction of the heat transfer coefficient at gridded elevations. This issue has been evaluated to estimate the impact on existing 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)
1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model
2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect
The effect described above was judged to have a negligible effect on existing LBLOCA analysis results, leading to an estimated Peak Cladding Temperature (PCT) impact of 0°F.

2013 REPORTING

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 **AP1000®** 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 **AP1000**, an estimated PCT effect of +11°F has been established for 10 CFR 50.46 reporting purposes for the **AP1000** Core Reference Report analysis.

2013 REPORTING

ERROR IN BURST STRAIN APPLICATION

Background

An error in the application of the burst strain was discovered in HOTSPOT. The equation for the application of the burst strain is given as Equation 7-69 in WCAP-16009-P-A and in WCAP-12945-P-A. The outer radius of the cladding after burst occurs should be calculated based on the burst strain, and the inner radius of the cladding should be calculated based on the outer radius. In HOTSPOT, the burst strain is applied to the calculation of the cladding inner radius. The cladding outer radius is then calculated based on the inner radius. As such, the burst strain is incorrectly applied to the inner radius rather than the outer radius, which impacts the resulting cladding geometry at the burst elevation after burst occurs. Correction of the erroneous calculation results in thinner cladding at the burst node and more fuel relocating into the burst node, leading to an increase in the Peak Cladding Temperature (PCT) at the burst node. This issue has been evaluated to estimate the impact on existing Best-Estimate (BE) Large-Break Loss-of-Coolant Accident (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 Models

1996 Westinghouse Best Estimate Large Break LOCA Evaluation Model

2004 Westinghouse Realistic Large Break LOCA Evaluation Model Using ASTRUM

Estimated Effect

The issue described above was evaluated by executing the most limiting plant-specific HOTSPOT runs with a HOTSPOT version that includes the correction of this error. This plant-specific sensitivity study resulted in an estimated PCT impact of 23°F for the Core Reference Report (CRR) analysis for the **AP1000®** plant.

2013 REPORTING

CHANGES TO GRID BLOCKAGE RATIO AND POROSITY

Background
A change in the methodology used to calculate grid blockage ratio and porosity for Westinghouse fuel resulted in a change to the grid inputs used in the **AP1000®** plant large break loss-of-coolant accident (LBLOCA) analysis. Grid inputs affect heat transfer in the core during a LBLOCA. This change 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 updates to the methodology to calculate grid blockage ratio and porosity used as input in Westinghouse LBLOCA models resulted in a negligible change to heat transfer in the core for the fuel type used in the **AP1000** plant Core Reference Report LBLOCA analysis. The estimated penalty associated with the changes is 0°F for 10 CFR 50.46 reporting purposes.

2013 REPORTING

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 in agreement per Footnote 10 to Table 25-4-11 of WCAP-12945-P-A. However, the initial fuel pellet average temperature uncertainty range analyzed at higher burnups in the ASTRUM EM is inconsistent with the uncertainty range predicted by the PAD code. 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.

2013 REPORTING

AUTOMATIC DEPRESSURIZATION SYSTEM STAGE 4 VALVE SINGLE FAILURE ASSUMPTION

Background
The failure of an automatic depressurization system stage 4 (ADS-4) valve is the limiting single failure for the **AP1000®** plant small break loss-of-coolant accident analyses. Historically, that failure has been assumed to be on the pressurizer side of the reactor coolant system (RCS). However, experimental results indicate that the failure on the non-pressurizer side of the RCS is the limiting failure. Analysis work was completed with the most recent **AP1000** plant SBLOCA analysis model to determine the impact of this change. The period of interest with respect to ADS-4 performance is the transition from core makeup tank (CMT) injection to in-containment refueling water storage tank (IRWST) injection. Reduced ADS-4 performance may cause a delay in the onset of IRWST injection, causing or extending a gap in the direct vessel injection (DVI) line make-up water injection.

This represents a Non-Discretionary Change to the Evaluation Model as described at Section 4.1.2 of WCAP-13451.

Affected Evaluation Model(s)
1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect
The limiting break size for SBLOCA in the **AP1000** plant design control document (DCD) is the 10 inch cold leg break with the peak cladding temperature (PCT) occurring very early in the transient. The 10 inch cold leg break analysis with the most recent model demonstrates that the change in failure assumption has little impact on the transient results for this break size since the break itself alleviates some of the demand on the ADS-4 system. The analysis of smaller breaks with the most recent model shows that while the impact of the single failure assumption change is larger, the resulting PCT is significantly lower than the PCT for the 10 inch cold leg break presented for the DCD. As such, the estimated effect of the change in single failure assumption on the PCT is 0°F for the DCD SBLOCA analysis.

The **AP1000** plant Core Reference Report SBLOCA analysis includes the correction of this error leading to a PCT impact of 0°F.

2013 REPORTING

CORE MAKEUP TANK DISCHARGE PIPING MODELING ERROR

Background

Since AP600 analyses, a failure in one of the core makeup tank (CMT) parallel discharge paths has been accounted for in the calculation of loss coefficients input into the **AP1000®** plant small break loss-of-coolant accident (SBLOCA) analysis NOTRUMP model. This is an additional failure and is incorrect as the limiting single failure assumption for **AP1000** plant SBLOCA analyses is the failure of an automatic depressurization system stage 4 (ADS-4) valve. When a failure in the CMT discharge piping is assumed, the higher resistance slows tank draining during injection and extends the CMT injection period. With the elimination of this failure, both CMT parallel discharge paths are open resulting in lower resistance, which causes higher CMT discharge flow rates and faster tank draining. An earlier emptying of the CMTs can lead to a gap or increase the duration of a gap between the end of CMT injection and the beginning of in-containment refueling water storage tank (IRWST) injection.

This represents a Non-Discretionary Change to the Evaluation Model as described in Section 4.1.2 of WCAP-13451.

Affected Evaluation Model(s)

1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect

The limiting break size for SBLOCA in the **AP1000** plant design control document (DCD) is the 10 inch cold leg break with the peak cladding temperature (PCT) occurring very early in the transient. Analysis work was completed with the most recent **AP1000** plant SBLOCA analysis model and demonstrates that the CMT discharge loss coefficient change results in slightly earlier ADS actuation times for the 10 inch break, but negligibly impacts the overall 10 inch cold leg break transient response. The updated analysis of smaller breaks shows that while this change has an impact, the resulting PCT is significantly lower than the PCT for the 10 inch cold leg break presented for the DCD. As such, the estimated effect of the change in CMT discharge piping modeling on the PCT is 0°F for the DCD SBLOCA analysis.

The **AP1000** plant Core Reference Report SBLOCA analysis includes the correction of this error leading to a PCT impact of 0°F.

2013 REPORTING

FLOAD4 TEE MODEL ERROR

Background
The FLOAD4 code calculation results supplies the automatic depressurization system stage 4 (ADS-4) loss coefficient adjustment factor for use in the **AP1000**® plant small break loss-of-coolant accident (SBLOCA) NOTRUMP model at the transition to non-critical flow. The calculation was updated to correct an error in the tee model after the **AP1000** plant design control document (DCD) analyses were completed. The result of the error correction is a larger adjustment factor than previously used for the DCD analyses.

This represents a Non-Discretionary Change to the Evaluation Model as described at Section 4.1.2 of WCAP-13451.

Affected Evaluation Model(s)
1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect
The increase in the loss coefficient adjustment factor impacts transient response only after the ADS-4 valves have opened and the flow paths have transitioned to non-critical flow. Thus, the currently limiting peak cladding temperature (PCT) for the 10 inch cold leg break is not directly impacted by this error as the PCT occurs before ADS-4 actuation. Analysis work was completed with the most recent **AP1000** plant SBLOCA analysis model to further assess the impact of this error. The simulation of the 10 inch cold leg break shows that the overall transient behavior following ADS-4 actuation is very similar when considering this error. The updated analysis simulations completed for smaller breaks indicate that the PCT remains far below the currently limiting PCT for the 10 inch cold leg break. As such, the estimated effect of the change in loss coefficient adjustment factor as a result of the FLOAD4 tee model error on the PCT is 0°F for the DCD SBLOCA analysis.

The **AP1000** plant Core Reference Report SBLOCA analysis includes the correction of this error leading to a PCT impact of 0°F.

2013 REPORTING

AUTOMATIC DEPRESSURIZATION SYSTEM STAGE-4 NON-CRITICAL LOSS COEFFICIENT ADJUSTMENT ERROR

Background
The FLOAD4 model considers the entire automatic depressurization system stage 4 (ADS-4) flow path from the hot leg to the ADS-4 valves. The loss coefficient adjustment calculations, for the ADS-4 path on the pressurizer side of the reactor coolant system, as performed in the **AP1000**® plant design control document (DCD) small break loss-of-coolant accident (SBLOCA) analyses only consider a portion of the piping for the ADS-4 path branching from the passive residual heat removal (PRHR) heat exchanger inlet piping rather than the piping starting from the hot leg. Correction of this error leads to a slightly higher loss coefficient for input into NOTRUMP after the ADS-4 flow paths have transitioned to non-critical flow

This represents a Non-Discretionary Change to the Evaluation Model as described at Section 4.1.2 of WCAP-13451.

Affected Evaluation Model(s)
1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect
The increase in loss coefficient for the affected path is relatively small and impacts transient response only after the ADS-4 valves have opened and the flow paths have transitioned to non-critical flow. Thus, the currently limiting peak cladding temperature (PCT) for the 10 inch cold leg break is not impacted by this error as the PCT occurs before ADS-4 actuation. Analysis work was completed with the most recent **AP1000** plant SBLOCA analysis model to further assess the impact of this error. The simulation of the 10 inch cold leg break shows that the overall transient behavior following ADS-4 actuation is very similar when considering this error. The updated analysis simulations completed for smaller breaks indicate that the PCT remains far below the currently limiting PCT for the 10 inch cold leg break. As such, the estimated effect of the change in the ADS-4 non-critical loss coefficient adjustment calculations on the PCT is 0°F for the DCD SBLOCA analysis.

The **AP1000** plant Core Reference Report SBLOCA analysis includes the correction of this error leading to a PCT impact of 0°F.

2013 REPORTING

ERROR IN PASSIVE RESIDUAL HEAT REMOVAL HEAT EXCHANGER/AUTOMATIC DEPRESSURIZATION SYSTEM STAGE-4 INLET PIPING LOSS COEFFICIENTS

Background

The **AP1000®** plant small break loss-of-coolant accident (SBLOCA) analysis model for the design control document (DCD) double accounted for loss coefficients in the passive residual heat removal (PRHR) heat exchanger inlet common piping with the automatic depressurization system stage 4 (ADS-4). As such, the loss coefficient for the ADS-4 piping path from the hot leg to the valves was modeled higher than designed for **AP1000** SBLOCA analysis results.

This represents a Non-Discretionary Change to the Evaluation Model as described at Section 4.1.2 of WCAP-13451.

Affected Evaluation Model(s)

1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect

With respect to the limiting 10 inch cold leg break, the error in resistance only occurs while ADS-4 is discharging reactor coolant system (RCS) inventory which is significantly after the peak cladding temperature (PCT) time for the 10 inch cold leg break. Analysis work was completed with the most recent **AP1000** plant SBLOCA analysis model to further assess the impact of this error correction. The simulation of the 10 inch cold leg break shows that the overall transient behavior following ADS-4 actuation is very similar when considering this error correction. The updated analysis simulations completed for smaller breaks indicate that the PCT remains far below the currently limiting PCT for the 10 inch cold leg break. As such, the estimated effect of the change in the PRHR heat exchanger/ADS-4 inlet piping loss coefficients on the PCT is 0°F for the DCD SBLOCA analysis.

The **AP1000** plant Core Reference Report SBLOCA analysis includes the correction of this error leading to a PCT impact of 0°F.

2013 REPORTING

SBLOCTA CLADDING STRAIN REQUIREMENT FOR FUEL ROD BURST

Background
An error was discovered in the minimum local strain required for burst for **ZIRLO®** cladding in the SBLOCTA code. The coding does not enforce reaching the minimum percent local strain threshold prior to calculating fuel rod burst. However, a review of licensing basis analyses revealed no instances of this error impacting calculated results. Resolution of this issue represents a Non-Discretionary Change to the Evaluation Model as described in Section 4.1.2 of WCAP-13451.

Affected Evaluation Model(s)
1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect
The SBLOCTA code is not used for the **AP1000®** Design Control Document (DCD) small break LOCA analysis. The SBLOCTA code is used for the **AP1000** plant Core Reference Report (CRR) analysis but no fuel rod burst is calculated to occur. As a result, the estimated peak cladding temperature (PCT) impact is 0°F.

2013 REPORTING

GENERAL CODE MAINTENANCE

Background
Various changes have been made to enhance the usability of the codes and to help preclude errors in analyses. This includes items such as modifying input variable definitions, units, and defaults; improving the input diagnostic checks; enhancing the code output; optimizing active coding; and, eliminating inactive coding. These changes represent Discretionary Changes that will be implemented on a forward-fit basis in accordance with Section 4.1.1 of WCAP-13451.

Affected Evaluation Model(s)
1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

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

2013 REPORTING

CORE SHROUD MODELING UPDATE

Background
The **AP1000®** plant core barrel-shroud region of the reactor vessel is modeled in a simplified manner for the NOTRUMP-AP600 evaluation model. Flow communication into and out of the region is not modeled. The volume of this region is no longer being accounted for, consistent with the approach to the flow communication modeling and to ensure model conservatism.

This change 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 Model(s)
1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect
This change in core barrel-shroud volume modeling has the potential to provide a more realistic prediction of thermal hydraulic behavior in the active fuel region but overall is expected to have little impact on transient behavior. Past transient simulations performed with this change and various design changes and the **AP1000** plant Core Reference Report (CRR) simulations confirm that the impact is minimal. As a result, the estimated PCT impact is 0°F.

2013 REPORTING

INADVERTENT ADS TRANSIENT SPARGER MODELING UPDATE

Background
For the **AP1000®** plant inadvertent automatic depressurization system (ADS) transient simulations the discharge from the ADS 1-3 flow path is choked for only a short period of time. Historically, for AP600 plant analyses the flow path type was changed from a "break" flow path to a "normal" flow path in this process to improve computational performance. As a simplification **AP1000** plant analyses did not make this flow path change. For the **AP1000** plant Core Reference Report (CRR) analyses and moving forward the flow path is modeled as a "break" flow path and changed to a "normal" flow path when warranted.

This change 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 Model(s)
1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect
Based upon multiple transient simulations and the **AP1000** plant CRR analysis this change has a negligible impact on results and mostly serves to improve computational performance. As such, the estimated PCT impact is 0°F.

2013 REPORTING

PRHR HEAT EXCHANGER OUTLET PIPING INITIAL TEMPERATURE

Background

The passive residual heat removal (PRHR) heat exchanger outlet piping in the **AP1000®** plant small break LOCA NOTRUMP model was previously set to a generic temperature and is now being modeled at a temperature more consistent with the plant design and analyses.

This change 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 Model(s)

1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect

This change only impacts the PRHR outlet piping initial temperature; transient simulations in the **AP1000** plant Core Reference Report (CRR) confirm that this change has a negligible impact on the transient results. As a result, the estimated PCT impact is 0°F.

2013 REPORTING

IRWST VENT AND OVERFLOW MODELING

Background

The in-containment refueling water storage tank (IRWST) in the **AP1000®** plant small break LOCA NOTRUMP model has historically only contained a generic tank overflow and no tank vents. As a result, the IRWST was observed to experience unrealistic pressure variations. In order to more realistically capture the IRWST tank behavior during a small break LOCA transient, a vent path has been added to the model and the generic overflow data has been replaced with **AP1000** plant specific data.

This change 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 Model(s)

1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect

This change prevents unrealistic pressure variations in the IRWST. This change has a negligible impact on the overall transient results as confirmed in the **AP1000** plant Core Reference Report (CRR) simulations. As a result, the estimated PCT impact is 0°F.

2013 REPORTING

IRWST CHECK VALVE CRACKING/OPENING PRESSURE UPDATE

Background
Historically, a generic value for the cracking/opening pressure of the check valves between the in-containment refueling water storage tank (IRWST) and direct vessel injection (DVI) line was used in the **AP1000®** plant small break LOCA analyses. It was recently determined that the generic value was not supported by the current **AP1000** plant design and as such a higher check valve cracking pressure reflective of the plant design will be used.

This change 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 Model(s)
1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect
This forward fit change was implemented in the **AP1000** plant Core Reference Report (CRR) analysis leading to an estimated PCT impact is 0°F.

2013 REPORTING

DIRECT VESSEL INJECTION LINE MODELING

Background
The direct vessel injection (DVI) line model in the **AP1000**® plant small break LOCA NOTRUMP model has been updated to allow for a more physical representation of the piping and more closely reflect the modeling used for the integral effects test (IET) validation for the **AP1000** plant. This update includes modeling fluid node boundaries at physical pressure boundaries such as check valves and updating input parameters to ensure appropriate behavior.

This change 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 Model(s)
1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect
This forward fit change was implemented in the **AP1000** plant Core Reference Report (CRR) analysis leading to an estimated PCT impact is 0°F.

2013 REPORTING

STEAM GENERATOR OUTLET PLENUM AND REACTOR COOLANT PUMP NOZZLE MODELING UPDATE

Background

The fluid nodes and flow paths representing the steam generator outlet plenum and reactor coolant pump (RCP) inlet nozzle in the **AP1000**® plant small break LOCA NOTRUMP model have been updated to allow for a more realistic representation of the **AP1000** plant design. This update better captures the inside bottom of the steam generator outlet plenum and the connection with the RCP inlet nozzles.

This change 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 Model(s)

1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect

This forward fit change was implemented in the **AP1000** plant Core Reference Report (CRR) analysis leading to an estimated PCT impact is 0°F.

2013 REPORTING

UNAPPROVED DRAWING USED IN AP1000 PLANT CORE REFERENCE REPORT SMALL BREAK LOCA MODEL DEVELOPMENT

Background

It was discovered that an unapproved piping drawing related to the Automatic Depressurization System (ADS) Stages 1-3 was used during the **AP1000®** plant small break LOCA model development for the Core Reference Report (CRR).

Resolution of this issue represents a Non-Discretionary Change to the Evaluation Model as described in Section 4.1.2 of WCAP-13451.

Affected Evaluation Model(s)

1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect

Based upon review of an approved version of the drawing, the resulting input changes were judged to have a negligible impact on the small break LOCA analysis results. As such, the estimated peak cladding temperature (PCT) impact is 0°F for the **AP1000** plant CRR analysis.

2013 REPORTING

CODE UPDATE FOR THE APPLICATION OF TIME DEPENDENT CONTAINMENT BACKPRESSURE IN THE AP1000 PLANT CORE REFERENCE REPORT SMALL BREAK LOCA ANALYSIS

Background

An updated version of the NOTRUMP-AP600 code was used for certain small break LOCA analysis transient simulations presented in Revision 1 of the **AP1000®** plant Core Reference Report (CRR). This code version allows for the use of a time dependent containment backpressure curve as input. The use of this input is discussed in Revision 1 of the **AP1000** plant Core Reference Report (CRR).

This change represents a Discretionary Change that is implemented for the CRR SBLOCA analysis in accordance with Section 4.1.1 of WCAP-13451.

Affected Evaluation Model(s)

1985 Westinghouse Advanced Plant Small Break LOCA Evaluation Model with NOTRUMP

Estimated Effect

This change was implemented in the **AP1000** plant Core Reference Report (CRR) analysis and is reflected in the results where applicable.

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

Future

Plant Name: AP1000
Utility Name: Westinghouse Nuclear Power Plants
Revision Date: 3/17/2014

Analysis Information

EM:	ASTRUM (2004)	**Analysis Date:**	12/11/2012	**Limiting Break Size:**	DEG
FQ:	2.6	**FdH:**	1.72		
Fuel:	17x17 AP1000	**SGTP (%):**	10		

Notes: Plant specific adaptation of the ASTRUM EM which explicitly accounts for effects of thermal conductivity degradation and peaking factor burndown.

	Clad Temp (°F)	Ref.	Notes
LICENSING BASIS			
Analysis-Of-Record PCT	**1936**	**1**	**(a)**
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	11	2	
2 . Error in Burst Strain Application	23	3	
D. OTHER*			
1 . None	0		
LICENSING BASIS PCT + PCT ASSESSMENTS **PCT =**	1970		

* 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 . LTR-NRC-12-86, "Westinghouse Response to NRC RAIs on WCAP-17524, "AP1000 Core Reference Report," (Proprietary / Non-Proprietary)," January 2, 2013.

2 . LTR-LIS-13-357, "AP1000 Plant 10 CFR 50.46 Report for Revised Heat Transfer Multiplier Distributions," July 2013.

3 . LTR-LIS-14-41, "AP1000 Plant 10 CFR 50.46 Report for the HOTSPOT Burst Strain Error Correction," January 2014.

Notes:

(a) Value contains 2°F bias for PCT sensitivity to PRHR isolation, per Reference 1 response to CRR-008, Table 2 and Table 15.6.5-8.

Westinghouse LOCA Peak Clad Temperature Summary for Appendix K Small Break

Future

Plant Name: AP1000
Utility Name: Westinghouse Nuclear Power Plants
Revision Date: 2/27/2014

Analysis Information

EM:	NOTRUMP-AP	**Analysis Date:**	8/26/2013	**Limiting Break Size:**	2 Inch
FQ:	2.6	**FdH:**	1.75		
Fuel:	RFA	**SGTP (%):**	10		
Notes:					

	Clad Temp (°F)	Ref.	Notes
LICENSING BASIS			
Analysis-Of-Record PCT	**663.5**	**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 . None	0		
D. OTHER*			
1 . None	0		
LICENSING BASIS PCT + PCT ASSESSMENTS **PCT =**	663.5		

* 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 . LTR-LIS-13-459, "10 CFR 50.46 Report for the AP1000 Plant Core Reference Report (CRR) Small Break LOCA (SBLOCA) Analysis," October 2013.

Notes:

(a) None