AP1000DCDFileNPEm Resource

From: Loza, Paul G. [lozapg@westinghouse.com]
Sent: Wednesday, November 12, 2008 10:04 AM
To: Phyllis Clark
Cc: Eileen McKenna; Perry Buckberg; Rhonda Carmon
Subject: FW: RAI on AP1000 Large-Break LOCA analysis using ASTRUM
Attachments: AP1000 LBLOCA1 RAIs.doc

Hi Phyllis,

(Please replace the previous 2 acknowledgements with this one.)

I acknowledge receipt of the attached RAIs on SRP15.6.5.

I will let you know as soon as possible if a clarification call is necessary.

Thanks.

Paul Loza

From: Phyllis Clark [mailto:Phyllis.Clark@nrc.gov]
Sent: Monday, November 10, 2008 5:08 PM
To: Loza, Paul G.
Cc: Eileen McKenna
Subject: RAI on AP1000 Large-Break LOCA analysis using ASTRUM

Hi Paul,

A review of Westinghouse's technical report APP-GW-GLE-026, "Application of ASTRUM Methodology for Best Estimate Large Break LOCA Analysis for AP1000" and Revision 17 to AP1000 DCD 15.6.5.4A as part of P1B - 15.6.5 is in progress. As a result of the review the attached RAIs have been generated. Please acknowledge the receipt of the RAIs and let me know if conference calls are needed to discuss the RAIs.

Thanks,

Phyllis

Hearing Identifier: AP1000_DCD_Review
Email Number: 132

Mail Envelope Properties (E501235702183E47BF44683A3B6A192901385BFC8280)

Subject: FW: RAI on AP1000 Large-Break LOCA analysis using ASTRUM
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From: Loza, Paul G.

Created By: lozapg@westinghouse.com

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Files	**Size**	**Date & Time**
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AP1000 LBLOCA1 RAIs.doc	62528	

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REQUEST FOR ADDITIONAL INFORMATION
AP1000 LARGE BREAK LOCA ANALYSIS USING ASTRUM

RAI – SRP 15.6.5 – SRSB – 01

10 CFR 50.46(a)(1)(i) specifies that ECCS cooling performance must be calculated in accordance with an acceptable evaluation model. The NRC safety evaluation report (SER) for WCAP-16009-P-A approved WCOBRA/TRAC version MOD7 Revision 6. A version identified as M7AR4_AP was modified to create version M7AR7_AP with the incorporation of the code modifications documented in APP-GW-GLE-026, "Application of ASTRUM Methodology for Best Estimate Large Break Loss of Coolant Accident Analysis for AP1000."

Provide a reference for the NRC approval of the M7AR4_AP version of WCOBRA/TRAC, and clarify the "2004 ASTRUM Evaluation Model," as identified in Appendix A of APP-GW-GLE-026, e.g., which code versions were used and when were they approved by the NRC. Also clarify the "2000 formulation", used for the AP600 SSAR analyses as identified on page 2-4 of WCAP-15664-P, Rev. 2, "AP1000 Code Applicability Report," with respect to its application to AP1000.

RAI – SRP 15.6.5 – SRSB - 02

10 CFR 50.46 specifies that each applicant for a standard design certification shall estimate the effect of any change to or error in an acceptable evaluation model to determine if the change or error is significant, and provide a report (annually or within 30 days depending on its significance) to NRC with a proposed schedule for providing a reanalysis or taking other action as may be needed to show compliance with 10 CFR 50.46 requirements. Appendix A of APP-GW-GLE-026 indicates that the non-discretionary errors regarding the "Oxidation Thickness Index Error for Best Estimate WCOBRA/TRAC," and "Neutronics Calculation Moderator Density Weighting Factor Error," (10 CFR 50.46 letter LTR-NRC-02-10), will be corrected during the next revision of the Best Estimate WCOBRA/TRAC code.

Verify that WCOBRA/TRAC M7AR7_AP has been properly revised, and that the version used for AP1000 best-estimate large-break LOCA analyses has incorporated all non-discretionary changes described in Appendix A of APP-GW-GLE-026.

RAI-SRP 15.6.5 – SRSB – 03

The non-discretionary change "Revised Blowdown Heatup Uncertainty Distribution" described in Westinghouse's 10 CFR 50.46 Annual Notification and Reporting for 2004, LTR-NRC-05-20, April 11, 2005 (page 82 of APP-GW-GLE-026), describes a correction of modeling inconsistencies and input errors in the LOFT input decks that results in a change to WCOBRA/TRAC and HOTSPOT codes regarding a revised blowdown heatup heat transfer coefficient and a revised cumulative distribution function (CDF). The LTR-NRC-05-02 report indicated that the revised CDF was previously reported to NRC in Westinghouse letter LTR-NRC-04-11. The information provided in this letter was preliminary in nature.

Provide a detailed description on this error including the following information:

(a) Identify the input errors in the LOFT model and the process used to find these errors;

(b) Provide the results of the revised LOFT analyses along with the previous ORNL analyses results, in a tabular form for the predicted, the measured, and the predicted-to-measured ratio for the PCT for each case, and in a graphical form for the predicted-to-measured ratio for the PCT for each case.

(c) Describe the process, and results, used to evaluate the new data set to determine the heat transfer coefficients and modeling uncertainly distribution, as presented in Table 2 of APP-GW-GLE-026;

(d) Provide a plot of the cumulative distribution function (CDF) for the blowdown heatup heat transfer multiplier, similar to Figure 1-3 in WCAP-16009-P-A.

RAI – SRP 15.6.5 – SRSB – 04

The discretionary change “Improved Automation of End of Blowdown Time” described in Westinghouse 10 CFR 50.46 letter LTR-NRC-06-8, (Page 88 of APP-GW-GLE-026) states that the automated end of blowdown is based on the time when the collapsed liquid level in the lower plenum reaches a minimum and begins to increase again. As observed in Figure 18 in APP-GW-GLE-026, the level oscillates around the time period of interest. On page 165 of APP-GW-GLE-026, it is stated that “The blowdown phase of the transient ends when the reactor coolant system pressure (initially assumed at 2250 psia) falls to a value approaching that of the containment atmosphere.”

Describe the automated procedure used to determine the specific end of blowdown time, and clarify which definition is used for the AP1000 best-estimate large-break LOCA analyses.

RAI – SRP 15.6.5 – SRSB - 05

The AP1000 WCOBRA/TRAC loop model is described in Section C.4 of APP-GW-GLE-026, and shown in Figure C-3.

Describe components 301, 302 and 303 shown in Figure C-3. The text should identify these components and the fourth-stage ADS valves, for completeness. The core makeup tanks (CMT), accumulators and passive residual heat removal (PRHR) heat exchanger are noted on the figure, and should be referred to in the text.

RAI – SRP 15.6.5 – SRSB - 06

Technical report (TR) 29, APP-GW-GLN-012-NP, Revision 2, WCAP-16716-NP, Rev. 2, “AP1000 Reactor Internals Design Changes,” describes the proposed AP1000 design changes regarding (1) a relocation of the radial support keys and tapered peripheral on the lower core support plate (LCSP); (2) the addition of flow skirt to the reactor pressure vessel (RPV) lower head; and (3) addition of neutron panels in the downcomer annulus.

Describe the procedure and modeling changes to the AP1000 RPV model to account for the change in the geometry in the LCSP region to reflect the spherical radius to the sloped change on the outer diameter of the LCSP and the location of the radial support keys. Include a discussion for the flow path(s) model (gap(s)), including the area, forward and reverse losses and inertia terms. Address the model acceptability since the radial support keys are skewed within the azimuthal sectors regions, that is not located on cell centers. Confirm that the steady-state flow and pressure drop for the region are consistent with the computational fluid dynamics (CFD) analysis.

RAI – SRP 15.6.5 – SRSB - 07

Describe the procedure and modeling changes to the AP1000 RPV model to account for the flow skirt. Include a discussion for the flow path(s) model (gaps(s)), including the area, forward and reverse losses and inertia terms. Confirm that the steady-state flow and pressure drop for the region are consistent with the CFD analysis.

RAI – SRP 15.6.5 – SRSB – 08

Revision 15 of DCD subsection 3.9.2.3 states that "The coolant velocity in the downcomer annulus between the core barrel and the reactor vessel wall is lower in the AP1000 design than in previous three-loop plants because the AP1000 has no thermal shield or neutron pads in the annulus to restrict this flow." On page 4-3 of WCAP-16716, Rev. 2, the statement "because the AP1000 has no thermal shield or neutron pads in the annulus to restrict this flow" is deleted.

(a) Is this statement still true with the addition of the neutron panels? Since the neutron panels were added to the AP1000 design, it would be expected that the coolant velocity would now be increased. Explain why the coolant velocity in AP1000 downcomer annulus is still lower.

(b) Confirm that the neutron panels have been included in the fuel deformation analysis due to combined LOCA/seismic loads to demonstrate compliance with 10 CFR 50.46(b)(4) acceptance criterion of coolable geometry.

RAI – SRP 15.6.5 – SRSB - 09

Appendix C to APP-GW-GLE-26 describes the AP1000 WCOBRA/TRAC vessel and loop models.

(a) Describe the procedure and modeling changes to the AP1000 RPV model to account for the addition of neutron panels. Provide a description of the arc length for each azimuthal sector modeled. A review of WCAP-16009-P-A did not reveal any guidelines for selecting the number of azimuthal sectors based on relationships to the vessel cold leg nozzles, and the reference case in Section 12 did not provided any further insights. However, in previous models the cold leg nozzles were apparently centrally located within sectors. Include a discussion for the flow path(s) model (gap(s)), including the area, forward and reverse losses and inertia terms.

(b) Address the model acceptability since two of the neutron panels are located on gaps, between sectors, and address the potential impact on the assessment of local downcomer boiling.

(c) Provide the rationale and justification for not considering a revised nodalization scheme that would capture the full impact of the cumulative reactor internal changes by developing a model with eight sectors in the downcomer, each a 45° arc centered on each neutron panel and each cold leg nozzle. This would result in vessel connections to the downcomer region and internals being located at cell centers and a more understandable means for defining the gap characteristics. Alternatively, perform a study with eight sectors to justify the currently proposed model and describe the model inputs for the azimuthal sectors and gaps.

RAI – SRP 15.6.5 – SRSB - 10

In Section 6.5.2 of the response to RAI-TR29-SRSB-01 (Westinghouse letter DCP/NRC2128, April 29, 2008), Westinghouse provides an assessment of pressure loss due to flow skirt and neutron panel addition. It states that the steady state pressure drop increase due to the flow skirt and neutron panel addition is mostly offset by the reduction in pressure drop through the inlet nozzle. The change that results in the reduction of the inlet nozzle pressure loss (from 10.72 psi to 5 psi) is not identified in APP-GW-GLE-026, and appears to be a post-DCD Revision 15 change.

Provide a discussion of how the revised inlet nozzle pressure drop was obtained. Confirm that this change is included in the WCOBRA/TRAC model for DCD revision 16, and that there are no other design changes that could impact the modeling of the AP1000 for best-estimate LBLOCA analyses for the proposed revision to DCD Revision 16.

RAI – SRP 15.6.5 – SRSB - 11

Section 6.5.3 of the response to RAI-TR29-SRSB-01 provides an assessment of the beneficial effect of flow skirt on blowdown de-entrainment, and states that no credit of this phenomenon is taken and so the BE LBLOCA analysis of DCD, Revision 15, is bounding.

Confirm that the potential benefit of de-entrainment on the flow skirt is not considered for AP1000 BE LBLOCA analyses.

RAI – SRP 15.6.5 – SRSB - 12

The NRC SER for the AP1000 (NUREG-1793), Section 15.2.6.5.2 “Large Breaks,” addressed the peak cladding temperature (PCT) limitation concerning the elimination of the CMT and the PRHR system to identify the PCT sensitivities, and to add the blowdown and reflood PCT impacts as a bias to their respective 95-percent PCT results. Revision 17 of AP1000 DCD section 15.6. 5.4A.5 states that the AP1000 large-break LOCA analysis complies with the restrictions in NUREG-1512 and WCAP-16009-A, and that: “Previous AP1000 sensitivity calculations evaluated the sensitivity to modeling of the CMT and PRHR relative to a baseline case. A case in which the CMT was isolated from the rest of the AP1000 was analyzed, and the calculated PCT was lower than the PCT of the baseline case. Also, a case in which the PRHR was isolated from the rest of the AP1000 was analyzed, and the calculated PCT was lower than the PCT of the baseline case. The ASTRUM methodology samples the parameters ranged in the global model matrix of calculations, and the final 95% uncertainty calculations have been performed for AP1000. Further, local and core –wide cladding oxidation values have been determined using the methodology approved in Reference 32 [WCAP-16009-A].” It is not clear if the proposed model described in Appendix C of APP-GW-GLE-026 was used for these studies, and the maximum local oxidation (MLO) and core-wide oxidation (CWO) biases are not addresses.

Address this limitation for the proposed AP1000 model and include the MLO and CWO sensitivities and resulting biases. Perform additional analyses, as necessary, to establish the MLO and CWO biases.

RAI – SRP 15.6.5 – SRSB - 13

Table 15.6.5-4 of Revision 17 to AP1000 DCD provides the major plant parameter assumptions used in the best-estimate large break LOCA analysis. Please address the following apparent inconsistencies:

(a) Accumulator pressure (P_{ACC}): 670.0 psia ≤ P_{ACC} ≤ 765.8 psia against DCD technical specification (TS) 3.5.1 "nitrogen cover gas pressure in each accumulator is ≥ 637 psig (651.7 psia) and ≤ 769 psig (783.7 psia)."

(b) Accumulator water volume (V_{ACC}): 1680 ft^3 ≤ V_{ACC} ≤ 1720 ft^3 against TS 3.5.1 "borated water volume in each accumulator is ≥ 1667 cu. ft., and ≤ 1732 cu. ft."

(c) The accumulator volume range, presented in Table 4 of APP-GW-GLE-026), is not included in Table 15.6.5-4. Since this range is specified in the TS, this table should be updated to include the range to support the LCO.

RAI – SRP 15.6.5 – SRSB - 14

Revision 17 of DCD Section 15.6.5.4A.5 states that the limiting PCT/MLO case in the AP1000 ASTRUM analysis was a split break.

(a) Explain why the break type changes from the double-ended guillotine break to the split break and discuss the implication on determining the reference conditions for the plant parameters.

(b) Verify that the availability of offsite power remains limiting and that the reference case used to determine this limiting case remains appropriate.

(c) Verify that the PCT for all cases occurs during reflood and does not move to the blowdown phase as a result of the AP1000 design changes. Provide a graph, similar to Figure 6-4 in Westinghouse's "AP1000 COL Response to Request for Additional Information (TR29)," DCP/NRC2128 dated April 29, 2008, which only shows the PCT without the changes, comparing the PCT with and without the changes as part of this confirmation.

RAI – SRP 15.6.5 – SRSB – 15

Revision 17 of DCD Subsection 15.6.5.4A.6 states that at 2.2 seconds, credit is taken for receipt of an "S" signal due to High-2 containment pressure. DCD Table 15.0-4a indicates a time delay of 2.2 seconds for "S" signal on High-2 containment pressure assumed for LBLOCA analysis.

(a) It appears that the LBLOCA analyses assume the containment pressure reaches the high-2 pressure setpoint coincident with the initiation of the event. Is it a correct interpretation?

(b) Verify that the minimum containment backpressure and the coincident High-2 signal timing are applicable to the entire break spectrum. Given the lower mass and energy releases for smaller breaks it would seem that these parameters would vary with the break size and type.

RAI - SRP 15.6.5 –SRSB – 16

Revision 17 of DCD Table 15.6.5-6 shows that the reactor coolant pumps trip at 8.2 seconds into the transient for the LBLOCA limiting PCT/MLO case, and Revision 17 of DCD Subsection

15.6.5.4A.6 states that the reactor coolant pumps automatically trip after a 4 s delay from the actuation of the core makeup tank isolation valves at 8.2 seconds into the transient. This time line appears to be inconsistent with DCD Table 15.0-4a, Revision 17, and Table 5 of APP-GW-GLE-026, which indicate that a time delay of 4.0 seconds of LBLOCA for the reactor coolant pump trip following “S”, and therefore the RCPs would trip at 6.2 seconds.

Clarify and update the RCS pump trip delay description as necessary in Table 5, Table 15.0-4a , and Section 15.6.5.4A.6, accordingly.

RAI – SRP 15.6.5 – SRSB - 17

In Revision 17 of DCD Table 15.6.5-4, “Major Plant parameters Assumptions Used in the Best-Estimate Large Break LOCA Analysis,” the hot rod assembly power ($F\Delta H$) has been increased to 1.75 from 1.65, which was stated to be bounding for DCD Revision 15. It also appears that the hot assembly power, P_{HA}, has also been increased to 1.683 from 1.586, which was labeled in Revision 15 of Table 15.6.5-4 as hot assembly ($F\Delta H$). It is also not clear if the previous Table 15.6.5-4 was in error using $F\Delta H$ for both the hot rod assembly power and the hot assembly, or if the table should have identified this as “hot assembly power (P_{HA})”.

Clarify and explain the increases in both hot rod assembly power and hot assembly power for Revision 17.

RAI – SRP 15.6.5 – SRSB - 18

(a) In Revision 17 of DCD Section 15.6.5.4A, it is stated that “Results from the 124 calculations are ranked by PCT from highest to lowest. A similar procedure is repeated for maximum local oxidation (MLO) and core wide oxidation (CWO).”

Describe the procedure used to identify the hot assemble rod case used to establish the CWO limit. Identify the case.

(b) On page 20 of APP-GW-GLE-026 it is stated “a CWO calculation is not needed ….” In Revision 17 of DCD Section 15.6.5.4A.4 it is stated “Further, local and core-wide cladding oxidation values have been determined using the methodology approved in Reference 32 [WCAP-16009-P-A].”

The statement in the DCD section is misleading and should be revised to describe the actual method used.

RAI – SRP 15.6.5 – SRSB – 19

Documentation discrepancies:

(a) APP-GW-GLE-026 makes reference to CCTF Test 58 (page 95, Section B.2), however the stated reference is for Test 78 Run 058 and the following text and comparison curves are identified as Run 58

(b) On page 18 of APP-GW-GLE-026, the text refers to Appendix 3. It is understood that the text is referring to Appendix C.

(c) On page 173 of APP-GW-GLE-026, line 5, the word “containment” should be “containing.”

(d) Even though it may be considered to be a caricature, the lower left side Figure on page 150 of APP-GW-GLE-026 is misleading and needs to be corrected; the cold leg nozzle locations are disingenuous.

These should be corrected when the document is revised.