Summary of June 2014 NRC Audit of FULL SPECTRUM LOCA (FSLOCA) Evaluation Model" (Non-Proprietary)

June 2014

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1.0 Introduction

In June 2014, the Nuclear Regulatory Commission (NRC) performed an audit of the FULL SPECTRUM™ LOCA (FSLOCA™) evaluation model (EM) submittal.

During the audit, Westinghouse presented information related to two main topics. The first presentation focused on an explanation of the evaluation model changes related to fuel rod models (including thermal conductivity degradation), burnup methodology, and axial power shape generation that resulted from the response to Requests for Additional Information (RAIs) 36 through 39 (LTR-NRC-14-17 [1-1]). That presentation is included later in this package.

The second presentation was focused on a limited number of miscellaneous changes to the FSLOCA methodology. Additional information describing the updates to the FSLOCA evaluation model and providing the associated technical basis is included in this attachment. Section 2.0 describes an update to [ ]a,c Section 3.0 describes an update to the accumulator elevation modeling and broken loop sampling.

During the discussion related to the burnup methodology and fuel rod models, more information regarding the initial stored energy was requested. Section 4.0 provides [ ]a,c

1.1 Reference(s)

1-1) LTR-NRC-14-17, "Submittal of Westinghouse Responses to 'WCAP-16996-P, 'Realistic LOCA Evaluation Methodology Applied to the Full Spectrum of Break Sizes (FULL SPECTRUM LOCA Methodology)' Request for Additional Information – RAIs 36-39' (Proprietary/Non-Proprietary), Project 700, TAC No. ME5244," March 24, 2014.

2.0 Downcomer Lateral Form Loss

The Nuclear Regulatory Commission (NRC) has previously questioned the modeling of lateral losses in the downcomer annulus for best-estimate evaluation models. One example occurred during the licensing of a plant-specific, ASTRUM analysis as described in AEP-NRC-2011-15 [2-1]. Physically, it is expected that the lateral losses could have competing effects on a Large Break LOCA (LBLOCA) transient. An increased loss could promote breakdown of bypass earlier in the transient, but could also serve to reduce mixing in the downcomer later in the transient.

Previously, [

]^{a,c} As such, the methodology is updated to more appropriately model the azimuthal loss through the downcomer annulus.

[

]^{a,c}

2.1 Reference(s)

2-1) AEP-NRC-2011-15, "Response to Second Request for Additional Information Regarding a License Amendment Request Associated With the Large-Break Loss-Of-Coolant Accident Analysis Methodology (TAC No. ME1017)," February 24, 2011. (ADAMS Accession Number ML110680210)

2-2) Idelchik, I. E., 1994, "Handbook of Hydraulic Resistance," 3rd Edition, CRC Press, Inc.

3.0 Modeling of Loop-to-Loop Differences

3.1 Background / Purpose

There are two differences from loop-to-loop that could impact the LOCA analysis for Westinghouse-designed plants. The first is the geometry of the accumulator lines, and the second is the location of the pressurizer. A modeling approach for LBLOCA analysis had been addressed in prior Westinghouse evaluation models.

In the context of the FSLOCA methodology, the loop-to-loop differences must not only be considered for the LBLOCA analysis but also for Small Break LOCA (SBLOCA) analysis. Rather than considering the applicability of the prior LBLOCA modeling approach for SBLOCA, it was proposed that [

]^{a,c}

However, during the licensing of the FSLOCA evaluation model, it was determined that a [

]^{a,c} (described in Section 3 of LTR-NRC-14-29 [3-3]). Additionally, a large number of SBLOCA sensitivity study results are available from the licensing of the evaluation model. As such, a [ ]^{a,c} is considered relative to the Region I analysis.

3.2 Prior Region II (LBLOCA) Modeling Approach

3.2.1 Accumulator Line Modeling

The treatment of the accumulator line modeling for the original Westinghouse Code Qualification Document (CQD) Best-Estimate LBLOCA evaluation model is discussed in Section 16-2-4 of WCAP-12945-P-A [3-1]. The following discussion is excerpted from therein:

"Although the accumulators are of the same design for all loops, the lines connecting the accumulator and the cold leg may vary from loop to loop. In the WCOBRA/TRAC PWR plant model, the accumulator and the connecting line in all loops are [

]^{a,c}

Figure 16-2-7 from WCAP-12945-P-A is included as Figure 3-1 herein. This figure compares the accumulator blowdown behavior [ ]^{a,c}

[

]a,c was appropriate for LBLOCA analysis. That same modeling approach was maintained for the Automated Statistical Treatment of Uncertainty Method (ASTRUM) LBLOCA evaluation model (WCAP-16009-P-A [3-2]).

3.2.2 Pressurizer Location Modeling

The modeling of the pressurizer location for the Westinghouse ASTRUM Best-Estimate LBLOCA evaluation model is discussed in Section 12-3-1 of WCAP-16009-P-A. The following discussion is excerpted from therein:

*"**Pressurizer Location**: Sensitivity studies have shown that locating the pressurizer [*

]a,c

To summarize, sensitivity studies indicated that the location of the pressurizer relative to the broken loop [

]a,c

3.3 Consideration of Region I (SBLOCA) Analysis

3.3.1 Accumulator Elevation Modeling

SBLOCA sensitivity studies for the accumulator elevation were included in Section 28.2.5 of the FSLOCA topical report [3-4]. These studies indicate that [

]a,c

The impact of accumulator elevation on driving head can influence both the initial actuation of the accumulator under SBLOCA transient conditions, as well as the periods of intermittent injection which occur after the initial injection. [

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The Region I analysis method is described in Section 4.0 of LTR-NRC-14-29. [

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3.3.2 Pressurizer Location Modeling

A large number of SBLOCA parametric studies were presented and discussed in Section 2 of LTR-NRC-13-70 [3-6]. A number of these studies were performed with the break initiated in all three different loops. The results of the studies show that [
]a,c This was also noted in the discussion in Section 3 of LTR-NRC-14-29, supported by the results shown on page P-110 therein.

In summary, the Region I (SBLOCA) analysis is [
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3.4 Conclusions and FSLOCA Modeling Approach

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[

]a,c

Given these considerations, the FSLOCA evaluation model is updated as follows: [

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3.5 Reference(s)

3-1) 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.

3-2) WCAP-16009-P-A, "Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment Of Uncertainty Method (ASTRUM)," January 2005.

3-3) LTR-NRC-14-29, "Summary of May 2014 NRC Audit of the FULL SPECTRUM LOCA (FSLOCA) Evaluation Model (Proprietary/Non-Proprietary), Project 700, TAC No. ME5244," June 5, 2014.

3-4) WCAP-16996-P, "Realistic LOCA Evaluation Methodology Applied to the Full Spectrum of Break Sizes (FULL SPECTRUM LOCA Methodology)," November 2010.

3-5) LTR-NRC-14-9, "Submittal of Westinghouse Responses to 'WCAP-16996-P, 'Realistic LOCA Evaluation Methodology Applied to the Full Spectrum of Break Sizes (FULL SPECTRUM LOCA Methodology)' Request for Additional Information – Set 8 RAIs 122-126, 128-131 and 136' (Proprietary/Non-Proprietary), Project 700, TAC No. ME5244," February 12, 2014.

3-6) LTR-NRC-13-70, "Summary of July 2013 NRC Code Workshop and August 2013 NRC Audit of the FULL SPECTRUM LOCA (FSLOCA) Evaluation Model (Proprietary/Non-Proprietary)," October 10, 2013.

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Figure 3-1: Comparison of Detailed Noding with Simplified PWR Noding Prediction of Accumulator Pressure (Figure 16-2-7 from WCAP-12945-P-A)

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Figure 3-2: Vessel Fluid Inventory and Integrated Accumulator Injection Flow for the 2.5-inch Hot Leg and Cold Leg Break (Figure 3.2-12 from LTR-NRC-14-9)

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Figure 3-3: Hot Rod PCT for the 2.5-inch and 3-inch Hot Leg and Cold Leg Breaks (Figure 3.2-16 from LTR-NRC-14-9)

4.0 Initial Stored Energy

RAI 37 asked for an explanation of the fuel rod initialization, calibration, and the modeling of fuel burnup effects. In the response provided in LTR-NRC-14-17 [4-1], [

]^{a,c} During the June audit, more information regarding stored energy was requested.

Table 4-1 provides [

]^{a,c}

Table 4-1: [ ]a,c

[			
			]a,c

4.1 Reference(s)

4-1) LTR-NRC-14-17, "Submittal of Westinghouse Responses to 'WCAP-16996-P, 'Realistic LOCA Evaluation Methodology Applied to the Full Spectrum of Break Sizes (FULL SPECTRUM LOCA Methodology)' Request for Additional Information – RAIs 36-39' (Proprietary/Non-Proprietary), Project 700, TAC No. ME5244," March 24, 2014.

Presentations from the June 2014 NRC Audit

RAI 36-39 Responses and Associated Method Updates

Michael Shockling
Westinghouse Electric Company

June 2014

Westinghouse

Overview

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Objective: Summarize RAI 36-39 Response Package (LTR-NRC-14-17)

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Figure RAI37-3 [ ]a,c Figure RAI37-4 [ ]a,c

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Figure 25.2-9 [ ]a,c

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Figure 29.4.1-5 [ ]a,c

Figure 29.4.1-8 [ ]a,c

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Figure 29.4.1-9 Example Bottom Skewed Axial Power Distribution [ ]a,c

Figure 29.4.1-10 Example Top Skewed Axial Power Distribution [ ]a,c

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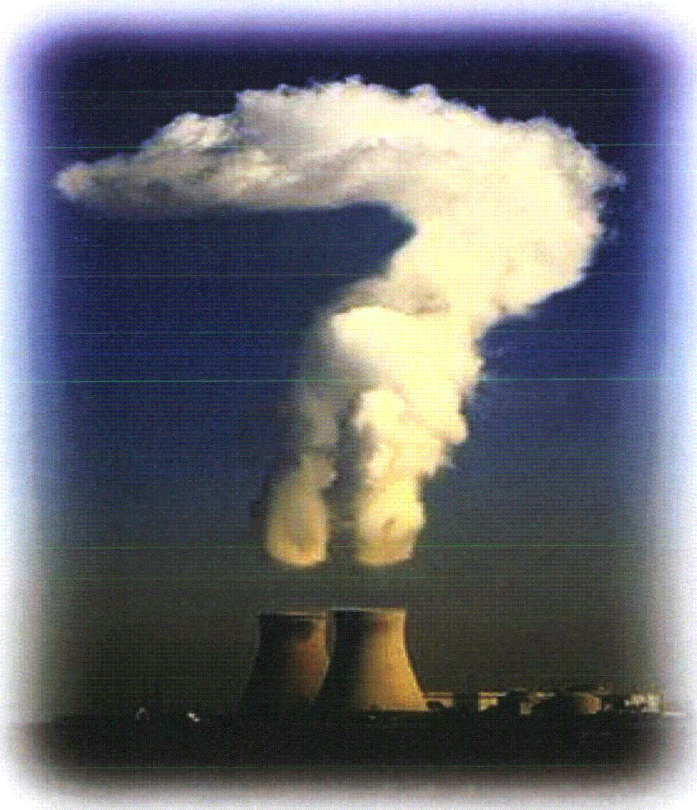
Questions / Backup



Fuel Rod Behavior vs Burnup

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Allowable Transient Oxidation

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Figure RAI37-6 [

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