ArevaEPRDCPEm Resource

From: WELLS Russell D (AREVA NP INC) [Russell.Wells@areva.com]
Sent: Thursday, January 29, 2009 5:08 PM
To: Getachew Tesfaye
Cc: Pederson Ronda M (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); SLIVA Dana (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 147, FSAR Ch 15
Attachments: RAI 147 Response US EPR DC.pdf

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 147 Response US EPR DC.pdf," provides technically correct and complete responses to Parts a and b of the one question in this RAI.

The following table indicates the respective pages in the response document, ""RAI 147 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 147 — 15.06.05-26a	2	17
RAI 147 — 15.06.05-26b	18	20
RAI 147 — 15.06.05-26c	21	21

A complete answer is not provided for Part c. of the one question in this RAI. The schedule for a technically correct and complete response to this question is provided below.

Question #	Response Date
RAI 147 — 15.06.05-26c	April 14, 2009

Sincerely,

(Russ Wells on behalf of)
Ronda Pederson
ronda.pederson@areva.com
Licensing Manager, U.S. EPR Design Certification
New Plants Deployment
AREVA NP, Inc.
An AREVA and Siemens company
3315 Old Forest Road
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From: Getachew Tesfaye [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Friday, December 19, 2008 12:32 PM
To: ZZ-DL-A-USEPR-DL
Cc: Fred Forsaty; Shanlai Lu; Joseph Donoghue; Prosanta Chowdhury; Jason Carneal; Joseph Colaccino; John Rycyna; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 147 (1653), FSARCh. 15

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on November 20, 2008, and discussed with your staff on December 8 and 18, 2008. No change was

made to the draft RAI as a result of those discussions. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs, excluding the time period of **December 20, 2008 thru January 1, 2009, to account for the holiday season** as discussed with AREVA NP Inc. For any RAIs that cannot be answered **within 45 days**, it is expected that a date for receipt of this information will be provided to the staff within the 45-day period so that the staff can assess how this information will impact the published schedule.

Thanks,
Getachew Tesfaye
Sr. Project Manager
NRO/DNRL/NARP
(301) 415-3361

Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 180

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Subject: Response to U.S. EPR Design Certification Application RAI No. 147, FSAR Ch 15
Sent Date: 1/29/2009 5:08:18 PM
Received Date: 1/29/2009 5:08:26 PM
From: WELLS Russell D (AREVA NP INC)

Created By: Russell.Wells@areva.com

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"Pederson Ronda M (AREVA NP INC)" <Ronda.Pederson@areva.com>
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Tracking Status: None

Post Office: AUSLYNCMX02.adom.ad.corp

Files	**Size**	**Date & Time**
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RAI 147 Response US EPR DC.pdf	745063	

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:
Recipients Received:

Response to

Request for Additional Information No.147, Revision 0

12/19/2008

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 15.06.05 - Loss of Coolant Accidents Resulting From Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary
Application Section: FSAR Ch. 15

QUESTIONS for Reactor System, Nuclear Performance and Code Review (SRSB)

Question 15.06.05-26:

a) The response to FSAR RAI 15.06.05-21 indicates that a finer nodalization of the steam generators (SGs) can increase the limiting case's PCT by 50 degree F, yet it is concluded that a coarser nodalization is adequate. This conclusion is not supported by the analysis. Provide justification for the SG nodalization used for SBLOCA and the non-LOCA analyses.

b) Refer to FSAR Fig. 15.6-55 in FSAR Section 15.6, and provide an explanation of the break flow increase seen in between 100 and 200 seconds.

c) Provide explanation on why the PCT versus break size plots presented in ANP-10291 and in response to FSAR RAI 15.06.05-20 do not change smoothly as break size increases, and why there are dips in the curve.

Response to Question 15.06.05-26:

Part a)

The Response to RAI 30, Supplement 1, Question 15.06.05-21 (ADAMS Accession No., ML082740370) states that a detailed S-RELAP5 axial nodalization analysis of the steam generator (SG) tubes produces consistent results with the coarser nodalization of the SG tubes presented in the U.S. EPR Tier 2 FSAR. It was concluded that the SG model presented in the U.S. EPR Tier 2 FSAR is adequate for small break loss of coolant accident (SBLOCA) analyses.

To support this conclusion, an SBLOCA break spectrum analysis was performed, assuming no loss of offsite power (LOOP) and using the detailed SG nodalization model presented in ANP-10291P, "Small Break LOCA and Non-LOCA Sensitivity Studies and Methodology Technical Report," which has previously been submitted to the NRC. This analysis shows that the limiting break size switched from the 6.0 inch break to the 6.5 inch break, and the limiting peak cladding temperature (PCT) increased by 42˚F, from 1585˚F to 1627˚F, as shown in Table 15.06.05-26-1. Therefore, the increase in the limiting PCT due to the detailed SG axial nodalization is less than 50˚F.

In addition, the comparison of the phenomena characteristic to the SBLOCA event shows consistent behavior between the two SG models. The following key parameters were compared and show no significant differences:

- Primary and secondary systems pressure response for the 6.0 inch and 6.5 inch breaks, as shown in Figures 15.06.05-26-1 and 15.06.05-26-2.
- Primary system mass inventory for the 6.0 inch and 6.5 inch breaks, as shown in Figures 15.06.05-26-3 and 15.06.05-26-4.
- Break flow and break void fraction for the 6.0 inch and 6.5 inch breaks, as shown in Figures 15.06.05-26-5, 15.06.05-26-6, 15.06.05-26-7, and 15.06.05-26-8.
- Loop seal clearing pattern for the 6.0 inch and 6.5 inch breaks, as shown in Figures 15.06.05-26-9, 15.06.05-26-10, 15.06.05-26-11, and 15.06.05-26-12.
- Hot rod cladding temperature for the 6.0 inch and 6.5inch breaks, as shown in Figures 15.06.05-26-13 and 15.06.05-26-14. The 50°F increase in PCT for the 6.5 inch break is attributed to the later loop 3 seal clearing time (Δ~110 seconds, as shown in Table 15.06.05-26-1).

Figure 15.06.05-26-14 shows a 50˚F increase in PCT for the 6.5 inch break with the detailed SG model. This increase is attributed to the later loop 3 seal clearing time (Δ~110 seconds, as shown in Table 15.06.05-26-1).

Although the PCT for the 6.5 inch break shows a 50˚F increase with the detailed SG model, the limiting PCT variation stayed within the 50˚F margin, and the expected SBLOCA phenomena was preserved. Based on these results, it is concluded that the existing SG axial nodalization model for the SBLOCA analyses presented in the U.S. EPR Tier 2 FSAR is acceptable.

The justification for the SG nodalization used in the non-LOCA analyses is provided in the ANP-10291P technical report. This report summarizes sensitivity calculations which were performed by varying the nodalization of SG downcomer heat structures, nodalization of the SG boiler region, and nodalization of the SG downcomer volumes. The study concluded that there are no significant differences in the results with the different nodalizations and that the SG nodalization presented in the U.S. EPR Tier 2 FSAR is acceptable for non-LOCA applications.

Therefore, based on the SG tube nodalization sensitivity studies, it is concluded that the SG axial nodalization used in the U.S. EPR SBLOCA and non-LOCA base models is adequate for design certification analyses.

Table 15.06.05-26-1—Analysis Results for the 6.0 inch ID and 6.5 inch ID Breaks without LOOP

Break Size (in)	Case	PCT(ºF)*	PCT Time (sec)	PCT Node	Loop Seal Clearing Times (sec)			
					Loop 1	Loop 2	Loop 3	Loop 4
6.0	FSAR	**1585**	428.02	33	426	280	280	280
	Detailed SG Model	1604	424.48	33	430	270	270	270
6.5	FSAR	1577	358.17	31	360	240	240	240
	Detailed SG Model	**1627**	351.6	31	350	250	350	250

*Note: The bolded values are the limiting PCT in the spectrum of breaks with that particular model.

Figure 15.06.05-26-1—6.0 inch ID SBLOCA without LOOP – Primary and Secondary Pressure

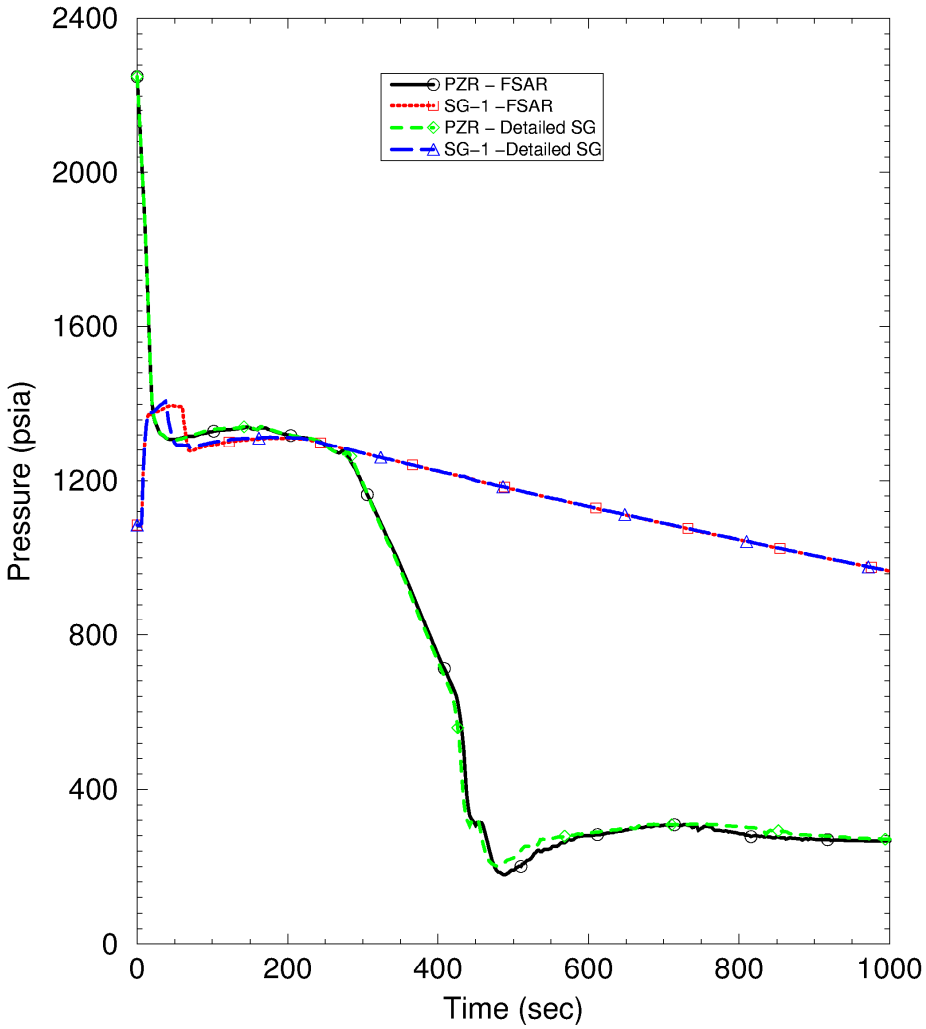

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Figure 15.06.05-26-2—6.5 inch ID SBLOCA without LOOP – Primary and Secondary Pressure

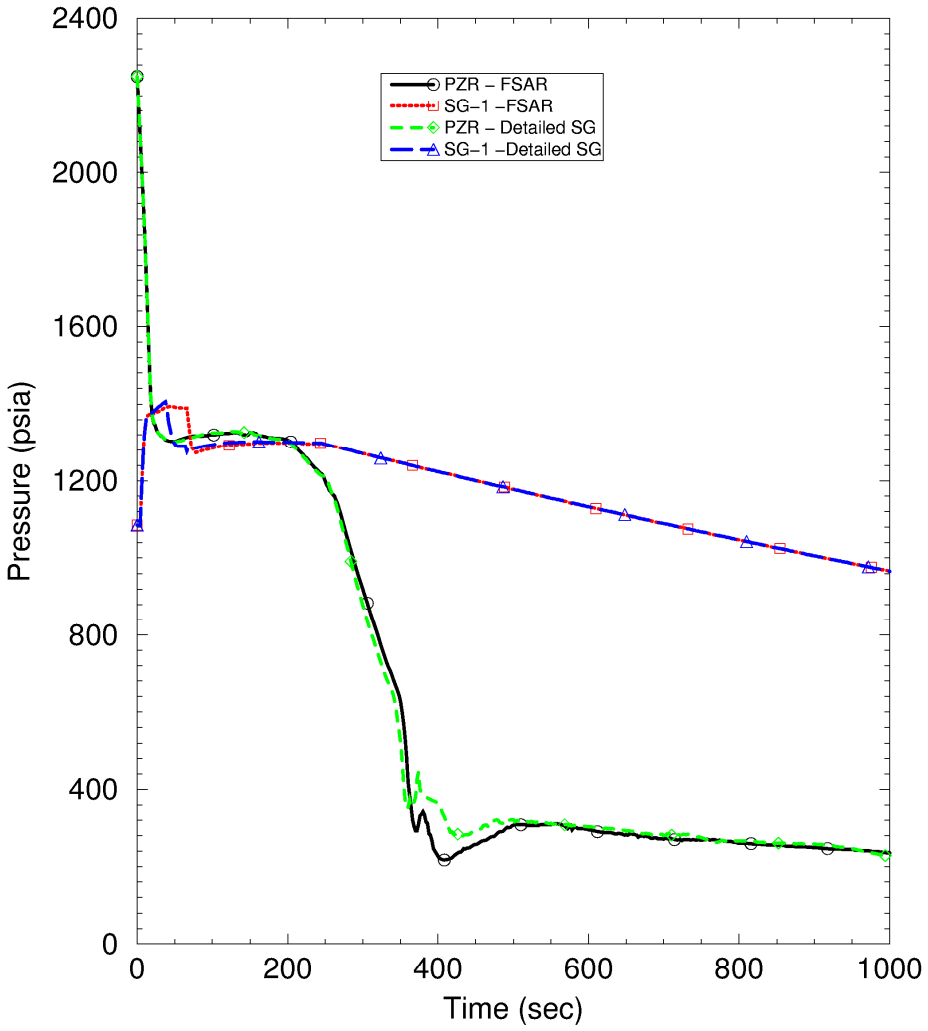

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Figure 15.06.05-26-3—6.0 inch ID SBLOCA without LOOP – Reactor Vessel (RV) and Reactor Coolant System (RCS) Mass Inventories

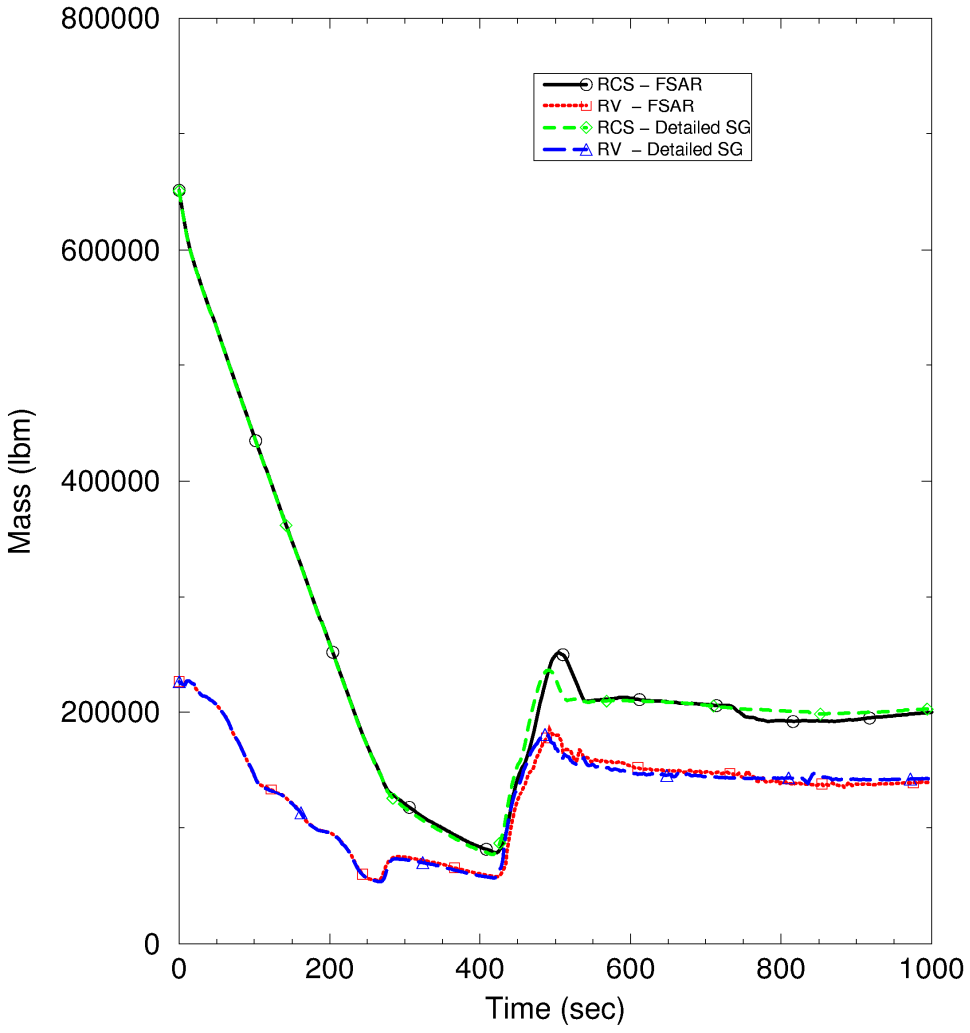

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Figure 15.06.05-26-4—6.5 inch ID SBLOCA without LOOP – Reactor Vessel (RV) and Reactor Coolant System (RCS) Mass Inventories

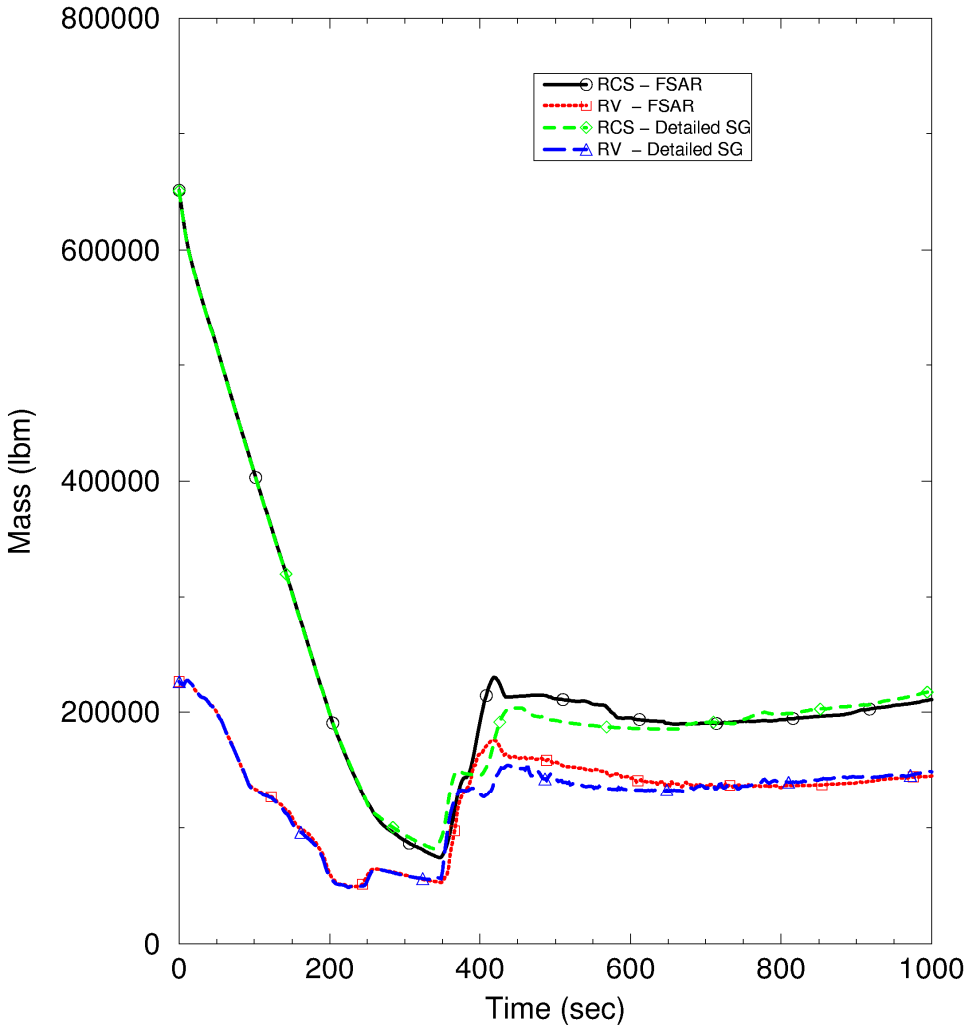

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Figure 15.06.05-26-5—6.0 inch SBLOCA without LOOP – Break Flow Rate

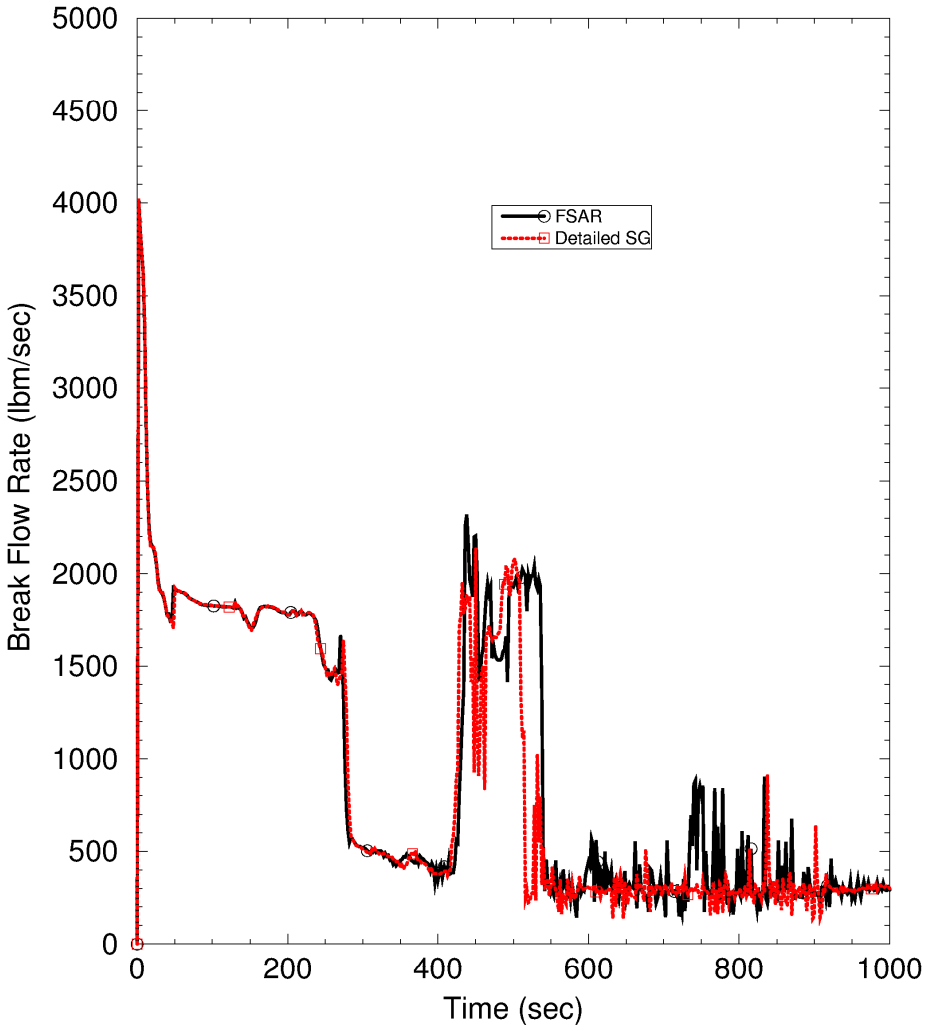

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Figure 15.06.05-26-6—6.5 inch SBLOCA without LOOP – Break Flow Rate

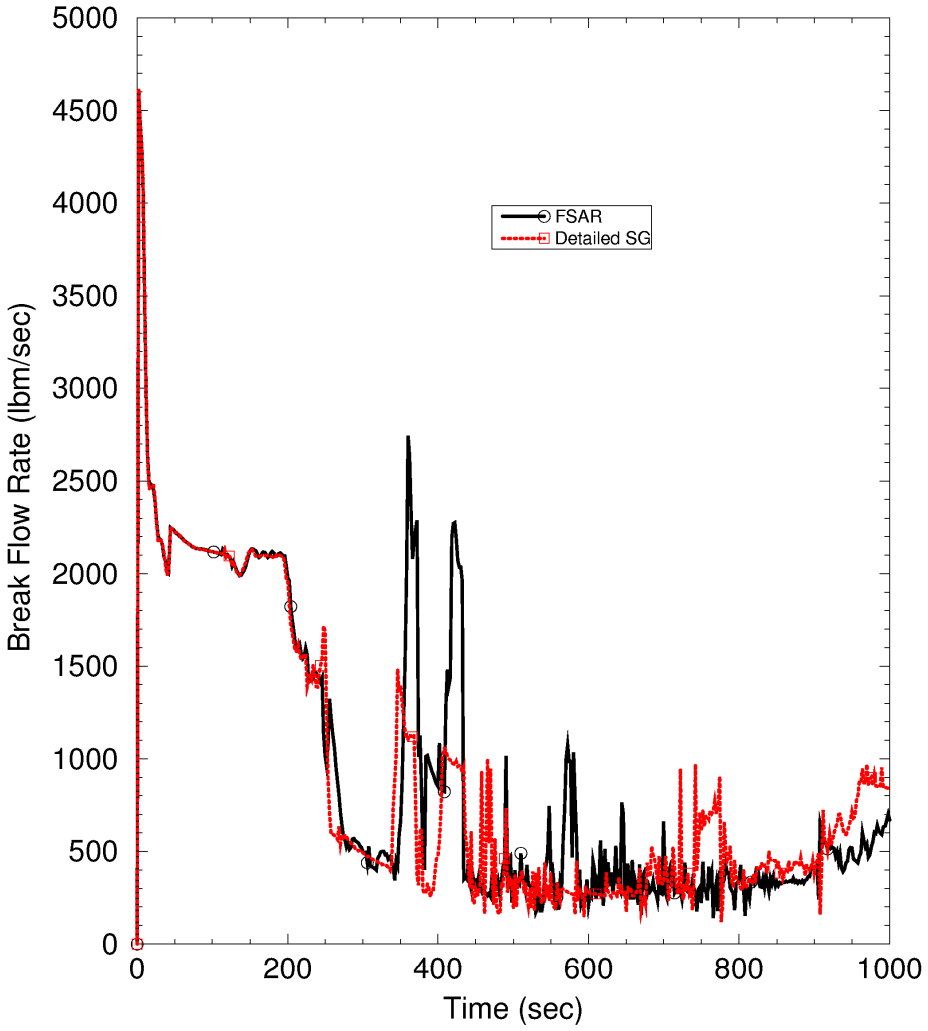

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Figure 15.06.05-26-7—6.0 inch SBLOCA without LOOP – Break Volume Void Fraction

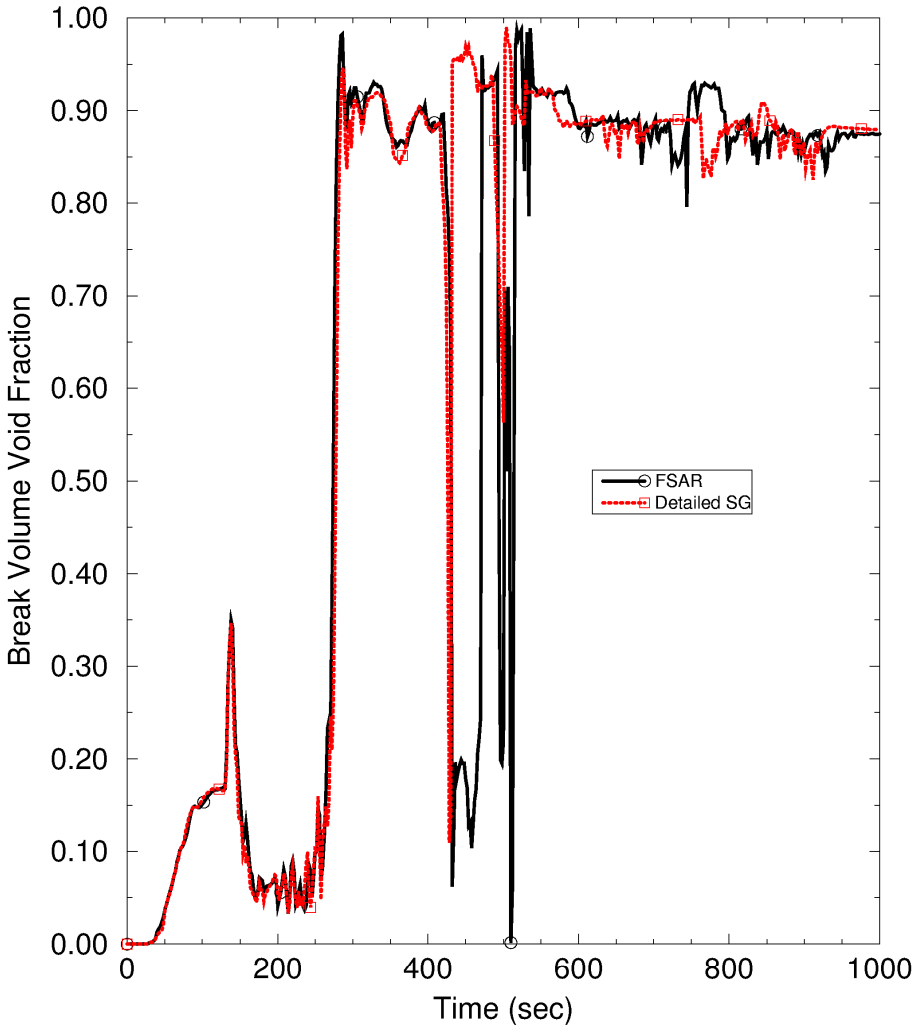

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Figure 15.06.05-26-8—6.5 inch SBLOCA without LOOP – Break Volume Void Fraction

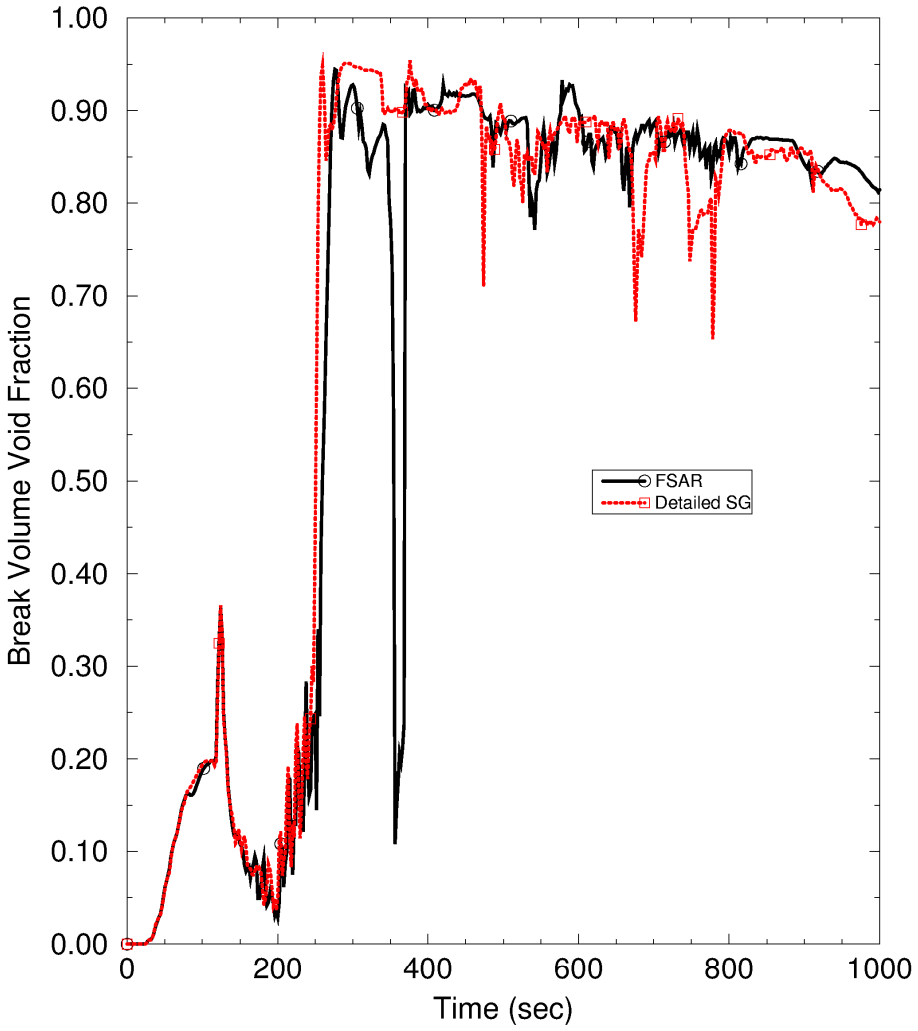

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Figure 15.06.05-26-9—6.0 inch SBLOCA FSAR Model without LOOP – Loop Seal Void Fractions

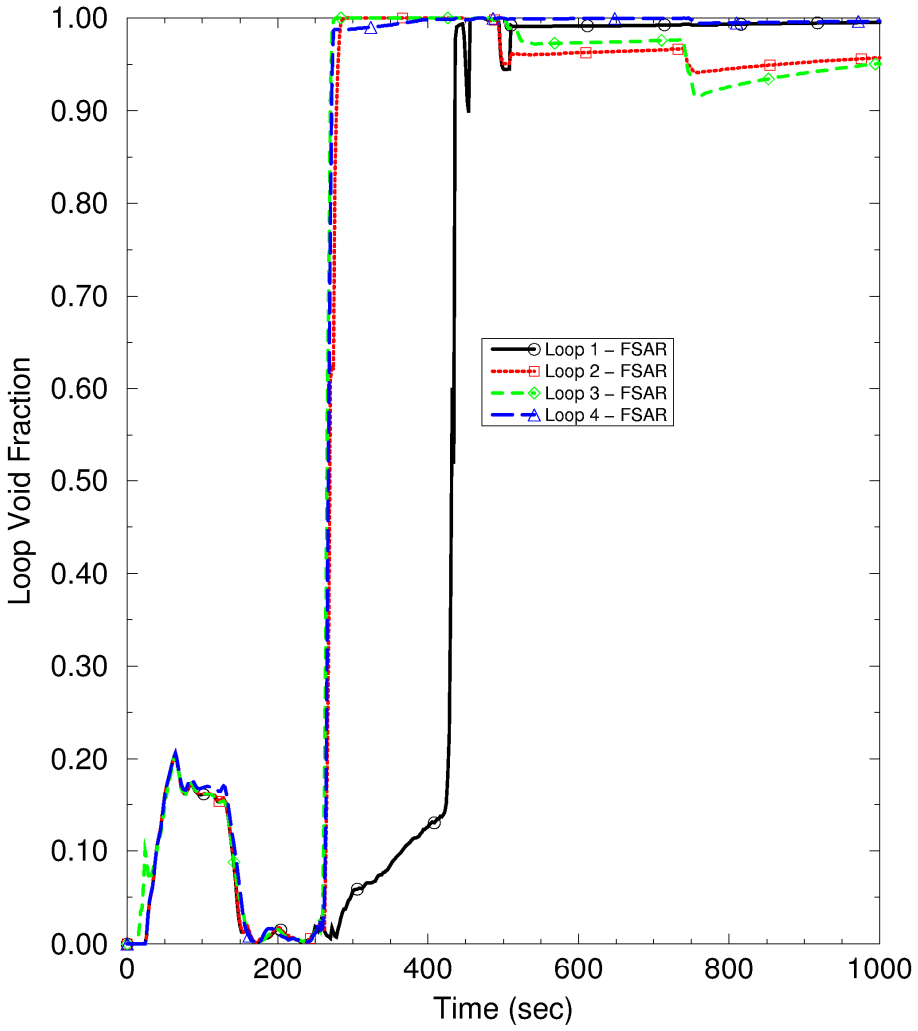

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**Figure 15.06.05-26-10—6.0 inch SBLOCA Detailed SG Model without LOOP–
Loop Seal Void Fractions**

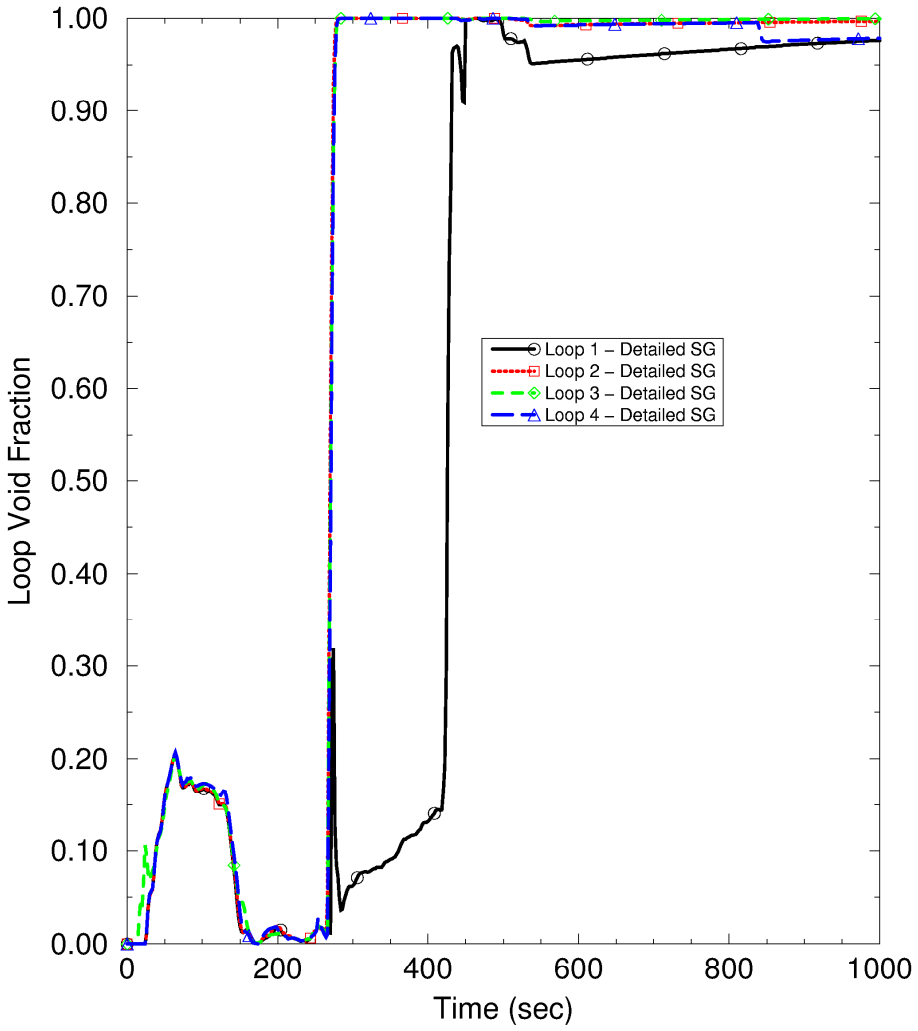

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Figure 15.06.05-26-11—6.5 inch SBLOCA FSAR Model without LOOP – Loop Seal Void Fractions

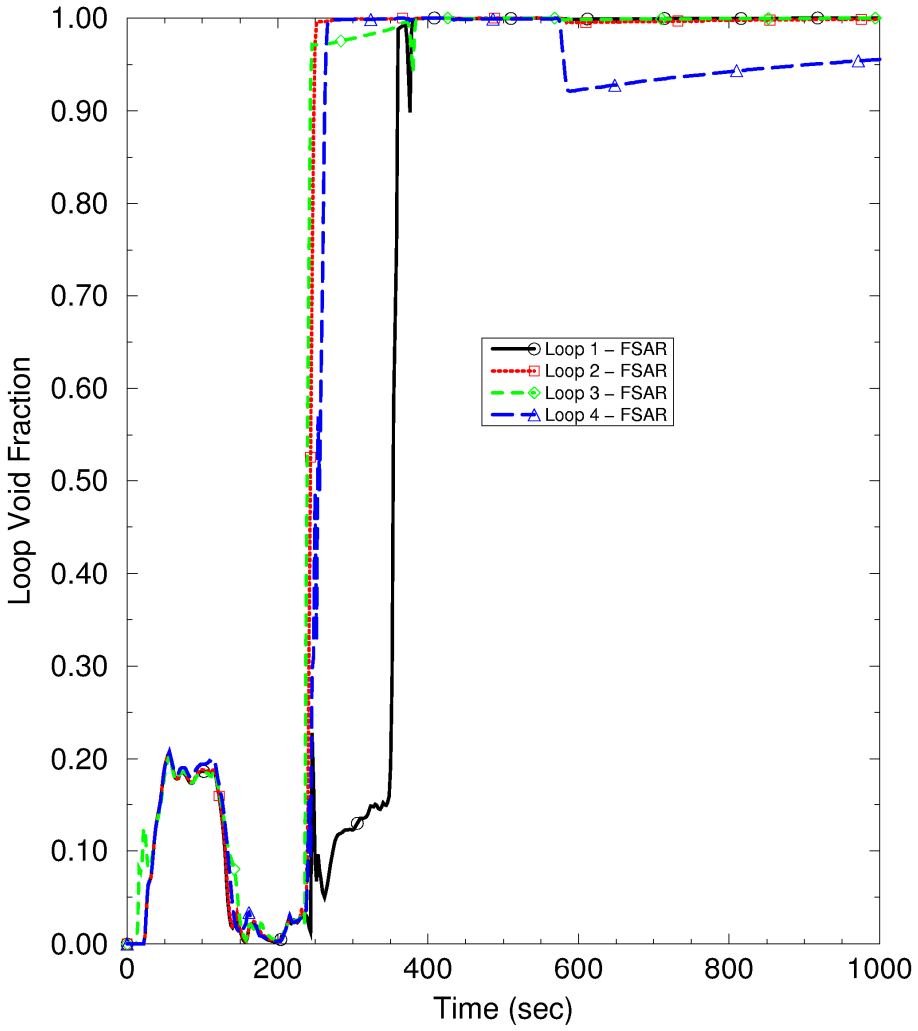

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**Figure 15.06.05-26-12—6.5 inch SBLOCA Detailed SG Model without LOOP–
Loop Seal Void Fractions**

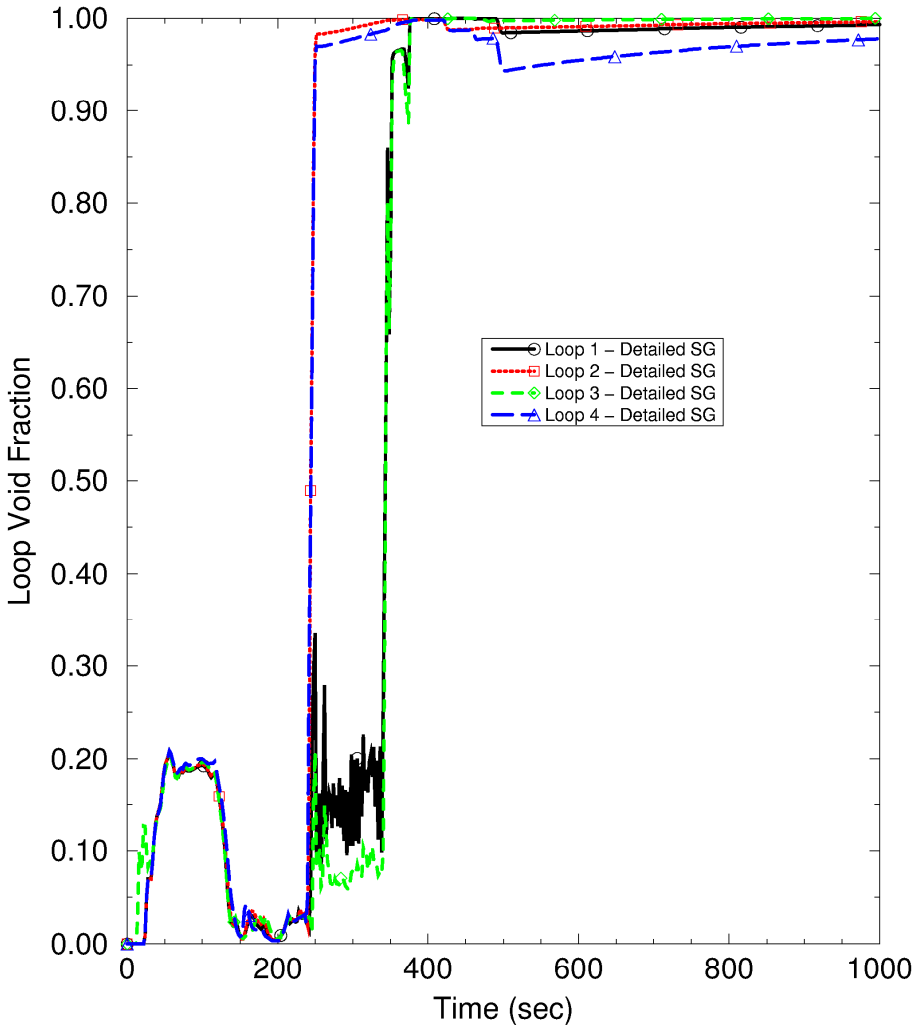

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Figure 15.06.05-26-13—6.0 inch SBLOCA without LOOP – Hot Rod Cladding Temperature

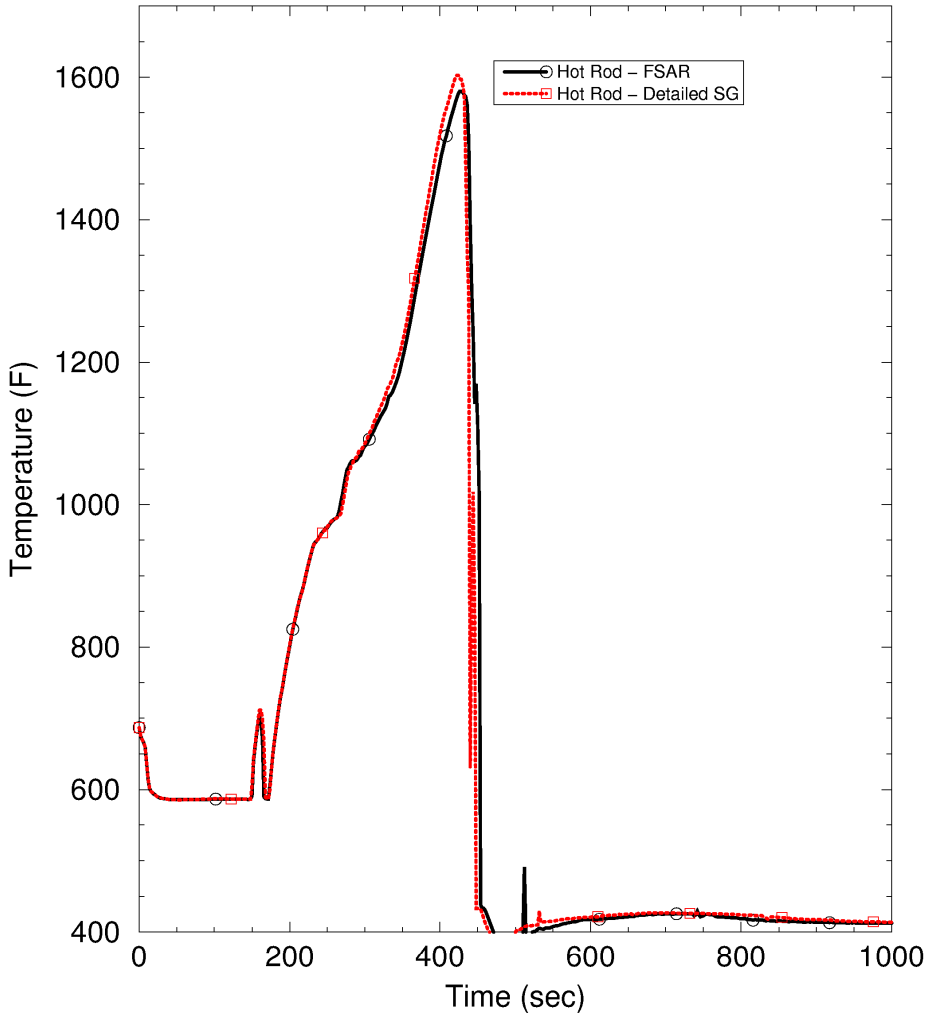

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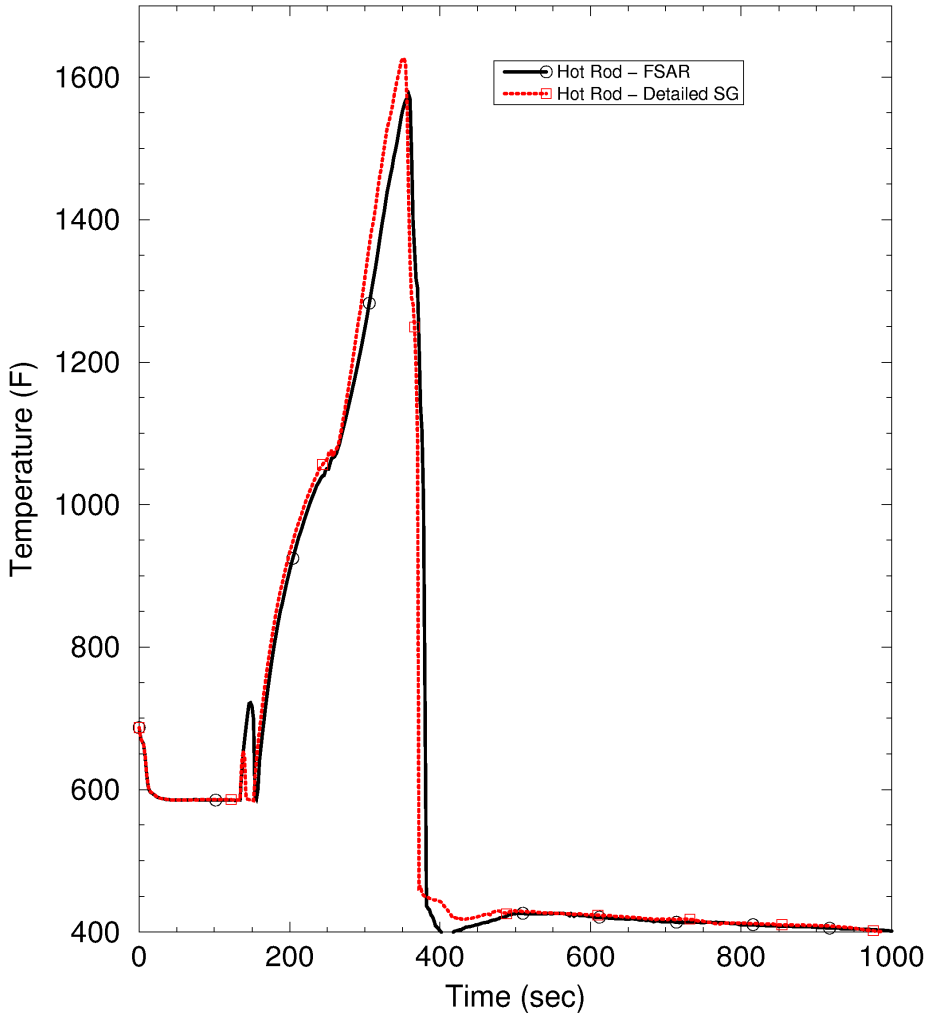
Figure 15.06.05-26-14—6.5 inch SBLOCA without LOOP – Hot Rod Cladding Temperature



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FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of Part a) of this question.

Part b)

U.S. EPR FSAR Tier 2, Figure 15.6-55—SBLOCA - 6.5 Inch Break - Break Flow presents the break flow for the limiting SBLOCA case, the 6.5 inch break at the reactor coolant pump (RCP) discharge. The calculation shows a change in the magnitude of the break flow of approximately 380 lbm/hr, between 100 seconds and 110, seconds into the transient (see Figure 15.06.05-26-15). The jump in the break flow occurred when the critical flow computation switched from single-phase S-RELAP5 subcooled to Moody two-phase choking flow formulations.

The formulations for the single-phase subcooled S-RELAP5 choked flow and the Moody two-phase choked flow are distinctly different. In accordance with 10 CFR 50 Appendix K, the Moody critical flow is applied once the flow at the break becomes two-phase. Therefore the time of the transition from single-phase to two-phase choking cannot be extended past the detection of two-phase flow.

Because the S-RELAP5 single-phase subcooled model calculates realistic values for the choked flow and the Moody critical flow model produces conservative, higher flows and, because there is not a smooth transition between the critical flow models, a flow jump occurs when the two-phase flow begins. Figure 15.06.05-26-15 shows the jump in break flow when the two-phase (as indicated by void fraction) begins at approximately 110 seconds.

A calculation was performed to validate the break flow increase at the time it transitioned from subcooled to two-phase. The system conditions at this time are extracted from the S-RELAP5 output of the analysis of the 6.5 inch break case presented in the U.S. EPR Tier 2 FSAR. The Homogeneous Equilibrium Model (HEM) and the Moody Critical Flow Tables are then used to determine the choked flow at these conditions. The HEM is used for the subcooled critical flow instead of the S-RELAP5 model due to the availability of HEM flow tables and simplicity of use.

Interpolation of the conditions at the break in the subcooled region produced an HEM choked flow rate of 6767.54 lbm/ft^2 sec. Interpolation of the conditions at the break at the time of the transition to two-phase produced a Moody choked flow rate of 9128.4 lbm/ft^2 sec. The resulting flow increase is 2360.86 lbm/ft^2 sec, or 543.94 lbm/sec for the 6.5 inch break area.

This calculation supports the flow increase predicted by the S-RELAP5 calculation at the time of transition to two-phase choked flow. The greater magnitude of the flow increase obtained using the critical flow tables is attributed to the differences between the HEM and the S-RELAP5 subcooled choked flow formulations.

In contrast to the Moody critical flow model, the S-RELAP5 critical flow model contains an empirical procedure to smooth the transition from S-RELAP5 single-phase choked flow formulations into S-RELAP5 two-phase choked flow formulations and therefore prevents a sudden change in the magnitude of the flow. When this model is invoked, the transition into the two-phase produces a lower flow than the single-phase subcooled choked flow.

Figure 15.06.05-26-16 shows the break flow and the break void fraction for the limiting SBLOCA case (the 6.5 inch break) with the S-RELAP5 choking model applied at the break junction. As shown, the S-RELAP5 two-phase choked flow model calculates realistic flow values and, therefore, the two-phase choked flow decreases as the transition from single-phase to two-phase flow takes place. The transition into the two-phase choked flow is extended past the time

when the two-phase flow is detected at the break, resulting in a more gradual flow decrease which lasts from approximately 100 seconds to 140 seconds.

Figure 15.06.05-26-15—6.5 inch ID SBLOCA - Moody Choke Flow Model

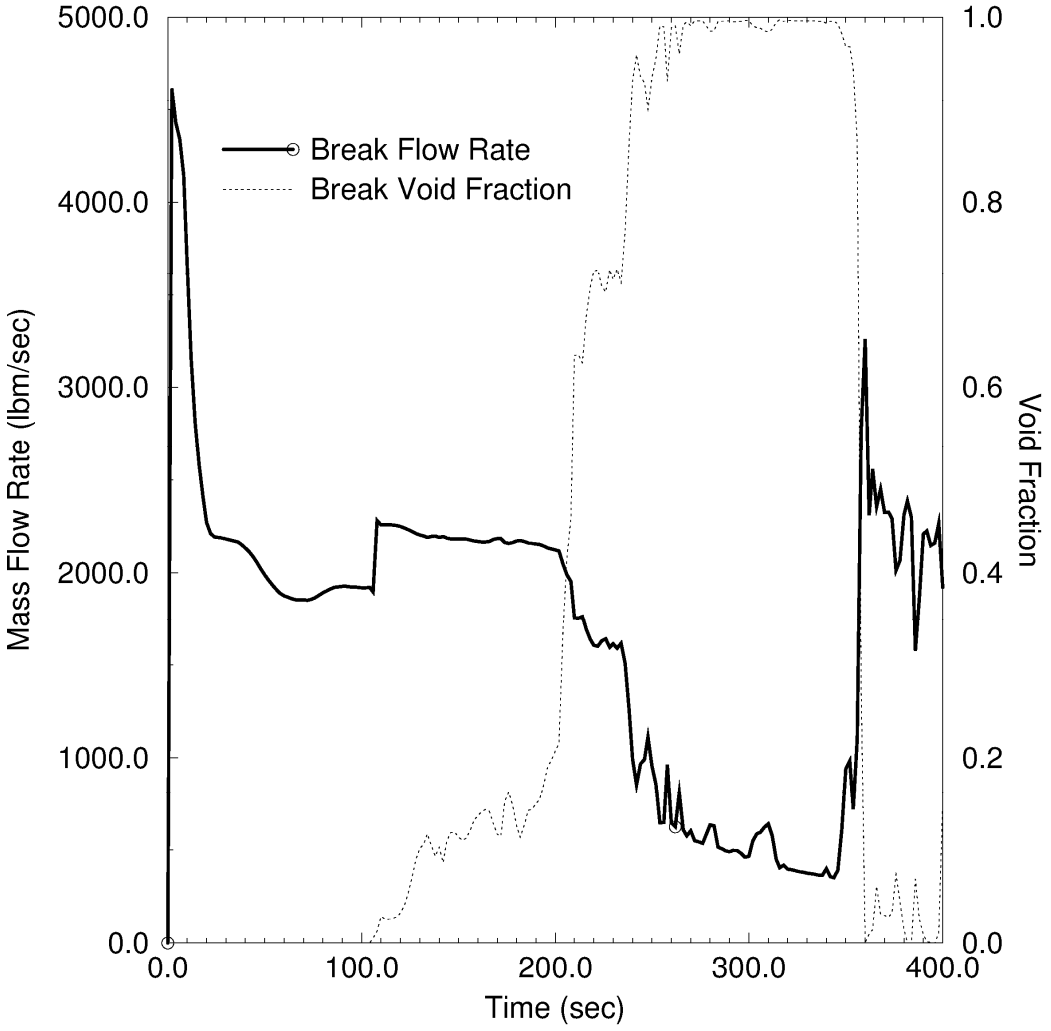

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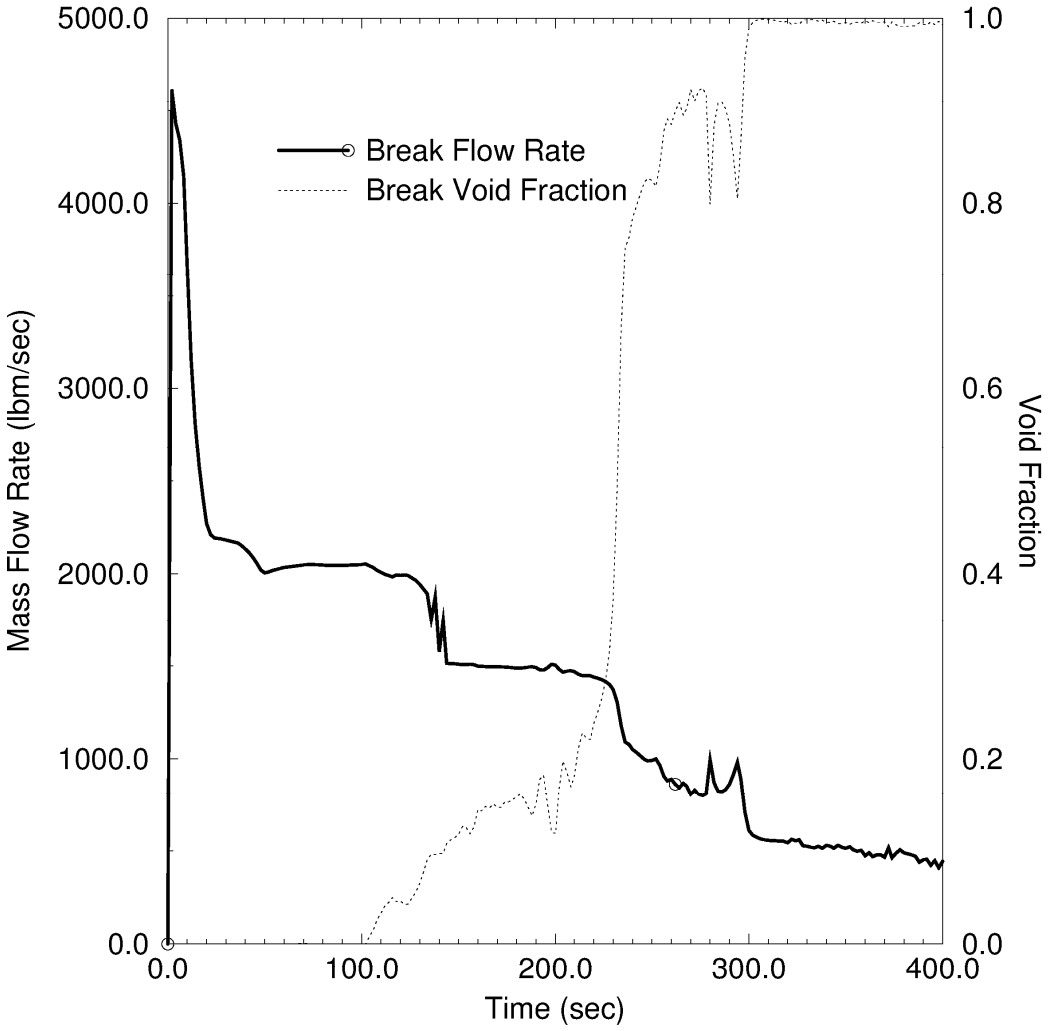
Figure 15.06.05-26-16—6.5 inch ID SBLOCA - S-RELAP5 Choke Flow Model



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FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of Part b) of this question.

Part c)

A response to Part c) of this question will be provided by April 14, 2009.