ArevaEPRDCPEm Resource

From: Pederson Ronda M (AREVA NP INC) [Ronda.Pederson@areva.com]
Sent: Thursday, April 30, 2009 8:20 PM
To: Getachew Tesfaye
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); HOLM Jerald S (EXT); GUCWA Len T (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 167, FSAR Ch. 15, Supplement 2 (Part 2 of 2)
Attachments: RAI 167 Supplement 2 Response US EPR DC (part 2 of 2).pdf

Getachew,

Response file, "RAI 167 Supplement 2 Response US EPR DC (part 2 of 2).pdf" attached.

Sincerely,

Ronda Pederson
ronda.pederson@areva.com
Licensing Manager, U.S. EPR Design Certification
AREVA NP Inc.
An AREVA and Siemens company
3315 Old Forest Road
Lynchburg, VA 24506-0935
Phone: 434-832-3694
Cell: 434-841-8788

From: Pederson Ronda M (AREVA NP INC)
Sent: Thursday, April 30, 2009 8:19 PM
To: Getachew Tesfaye (gxt2@nrc.gov)
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); HOLM Jerald S (EXT); GUCWA Len T (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 167, FSAR Ch. 15, Supplement 2 (Part 1 of 2)

Getachew,

AREVA NP Inc. (AREVA NP) provided responses to 4 of the 17 questions of RAI No. 167 on February 19, 2009. Supplement 1 to AREVA NP's response to RAI No. 167 was sent March 31, 2009 to address 5 of the remaining questions.

The response files, “RAI 167 Supplement 2 Response US EPR DC (part 1 of 2).pdf” and "RAI 167 Supplement 2 Response US EPR DC (part 2 of 2).pdf" provide technically correct and complete responses to 5 of the remaining 8 questions, as committed. Due to transmittal size limitations, the response file has been separated to e-mail the response in two parts.

Appended are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 167 Question 15.06.05-33.

The following table indicates the respective pages in the response document, “RAI 167 Supplement 2 Response US EPR DC.pdf,” that contain AREVA NP’s response to the subject questions.

Question #	Start Page	End Page
RAI 167 – 15.06.05-30	2	6

RAI 167 – 15.06.05-31	7	20
RAI 167 – 15.06.05-32	21	22
RAI 167 – 15.06.05-33	23	24
RAI 167 – 15.06.05-36	25	28

The schedule for a technically correct and complete response to the remaining three questions in RAI No. 167 remains unchanged and is provided below:

Question #	Response Date
RAI 167 – 15.06.05-29	May 29, 2009
RAI 167 – 15.06.05-34	May 29, 2009
RAI 167 – 15.06.05-37	May 29, 2009

Sincerely,

Ronda Pederson
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From: Pederson Ronda M (AREVA NP INC)
Sent: Tuesday, March 31, 2009 7:56 PM
To: 'Getachew Tesfaye'
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); GUCWA Len T (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 167, Supplement 1

Getachew,

On February 19, 2009, AREVA NP Inc. (AREVA NP) provided technically correct and complete responses to 4 of the 17 questions in RAI No. 167. The proprietary and non-proprietary versions of the response to RAI No. 167, Supplement 1 are submitted via AREVA NP Inc. letter, "Response to U.S. EPR Design Certification Application RAI No. 167" – NRC 09:030, dated March 31, 2009. The enclosure to that letter provides technically correct and complete responses to 5 of the remaining 13 questions in RAI No. 167. An affidavit to support withholding of information from public disclosure, per 10CFR2.390(b), is provided as an enclosure to the letter.

The following table indicates the RAI No. 167 questions that are answered in the subject AREVA NP Inc. letter.

Question #	Start Page	End Page
RAI 167—15.06.05-28	2	4
RAI 167—15.06.05-38	5	34
RAI 167—15.06.05-39	35	35
RAI 167—15.06.05-41	36	36
RAI 167—15.06.05-42	37	46

The schedule for a technically correct and complete response to the remaining eight questions remains unchanged and is provided below:

Question #	Response Date
RAI 167—15.06.05-29	May 29, 2009
RAI 167—15.06.05-30	May 1, 2009
RAI 167—15.06.05-31	May 1, 2009
RAI 167—15.06.05-32	May 1, 2009
RAI 167—15.06.05-33	May 1, 2009
RAI 167—15.06.05-34	May 29, 2009
RAI 167—15.06.05-36	May 1, 2009
RAI 167—15.06.05-37	May 29, 2009

Sincerely,

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From: Pederson Ronda M (AREVA NP INC)
Sent: Thursday, February 19, 2009 7:19 PM
To: 'Getachew Tesfaye'
Cc: DELANO Karen V (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); GUCWA Len T (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 167, FSAR Ch. 15

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 167 Response US EPR DC.pdf" provides technically correct and complete responses to 4 of the 17 questions.

RAI 167, Question 15.06.05-40 requested that AREVA NP provide S-RELAP5 code input files. Since the requested files contain information that AREVA NP considers proprietary, the information is provided on a proprietary compact disk (CD) as an enclosure to AREVA NP Inc. letter, "Response to U.S. EPR Design Certification Application RAI No. 167, Question 15.06.05-40– SRELAP5 Code Input Files," dated February 19, 2009. An affidavit to support withholding of information from public disclosure, per 10CFR2.390(b), is provided as an enclosure to that letter.

The following table indicates the respective pages in the response document, "RAI 167 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 167—15.03.03-15.03.04-9	2	3
RAI 167—15.06.05-27	4	5
RAI 167—15.06.05-28	6	6
RAI 167—15.06.05-29	7	7
RAI 167—15.06.05-30	8	8
RAI 167—15.06.05-31	9	9
RAI 167—15.06.05-32	10	10
RAI 167—15.06.05-33	11	11
RAI 167—15.06.05-34	12	12
RAI 167—15.06.05-35	13	15
RAI 167—15.06.05-36	16	16
RAI 167—15.06.05-37	17	17
RAI 167—15.06.05-38	18	18
RAI 167—15.06.05-39	19	19
RAI 167—15.06.05-40	20	22

RAI 167—15.06.05-41	23	23
RAI 167—15.06.05-42	24	24

A complete answer is not provided for 13 of the 17 questions. The schedule for a technically correct and complete response to these questions is provided below.

Question #	Response Date
RAI 167—15.06.05-28	April 1, 2009
RAI 167—15.06.05-29	May 29, 2009
RAI 167—15.06.05-30	May 1, 2009
RAI 167—15.06.05-31	May 1, 2009
RAI 167—15.06.05-32	May 1, 2009
RAI 167—15.06.05-33	May 1, 2009
RAI 167—15.06.05-34	May 29, 2009
RAI 167—15.06.05-36	May 1, 2009
RAI 167—15.06.05-37	May 29, 2009
RAI 167—15.06.05-38	April 1, 2009
RAI 167—15.06.05-39	April 1, 2009
RAI 167—15.06.05-41	April 1, 2009
RAI 167—15.06.05-42	April 1, 2009

Sincerely,

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From: Getachew Tesfaye [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Friday, January 23, 2009 10:22 AM
To: ZZ-DL-A-USEPR-DL
Cc: Fred Forsaty; Jaclyn Dorn; John Budzynski; Shanlai Lu; Joseph Donoghue; Jason Carneal; Prosanta Chowdhury; Joseph Colaccino; Meena Khanna; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 167 (1711, 1838,1832), FSAR Ch. 15

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on January 6, 2009, and discussed with your staff on January 16, 2009. Draft RAI Question 15.03.01-15.03.02-1 was deleted and Draft RAI Questions 15.06.05-39 and 15.06.05-42 were modified as a result of that discussion. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAIs that cannot be answered within 30 days, it is expected that a date for receipt of this information will be provided to the staff within the 30 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: 446

Mail Envelope Properties (5CEC4184E98FFE49A383961FAD402D31DFFBD0)

Subject: Response to U.S. EPR Design Certification Application RAI No. 167, FSAR Ch. 15, Supplement 2 (Part 2 of 2)
Sent Date: 4/30/2009 8:20:26 PM
Received Date: 4/30/2009 8:20:44 PM
From: Pederson Ronda M (AREVA NP INC)

Created By: Ronda.Pederson@areva.com

Recipients:
"BENNETT Kathy A (OFR) (AREVA NP INC)" <Kathy.Bennett@areva.com>
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Tracking Status: None
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Tracking Status: None

Post Office: AUSLYNCMX02.adom.ad.corp

Files	**Size**	**Date & Time**
MESSAGE	8916	4/30/2009 8:20:44 PM
RAI 167 Supplement 2 Response US EPR DC (part 2 of 2).pdf	4621728	

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

U.S. EPR Final Safety Analysis Report Markups

by the long-lived radioactive isotopes remaining in the core. The core remains subcritical.

Several issues are addressed to demonstrate adequate long term cooling following a LOCA:

- Boron precipitation. Boron in the coolant can concentrate and precipitate in the upper region of the core when there is protracted boiling following a LOCA.
- Boron dilution during SBLOCA. GSI-185 raises a concern regarding the potential for recriticality during an SBLOCA if unborated water accumulates in the SGs and cold leg piping due to condensation and moves to the core as a slug.
- Containment debris. GSI-191 raises concerns regarding the potential damage to ECCS equipment and blockage of core channels due to debris in the water re-circulated from the IRWST.

15.6.5.4.1 Prevention of Boric Acid Precipitation

15.06.05-33

The U.S. EPR provides the operator the capability to redirect LHSI so that some or all of it is injected through the hot leg letdown line of the residual heat removal system (RHRS). Analyses show that switching the LHSI to hot leg injection, thereby redirecting a majority of the LHSI to the hot leg, ~~an equal split of flow between the cold legs and hot legs~~ is effective at ~~preventing~~limiting the boron ~~precipitation~~ concentration in the core region regardless of the break location. When started ~~early~~within 8000 seconds, precipitation is prevented in the core and other regions of the reactor vessel and RCS. The small break analyses show that more water is retained in the core region than for the large break LOCA. Therefore, the large break LOCA bounds all small break LOCAs relative to boron precipitation.

The mitigating effect of combined hot- and cold-leg injection is confirmed by extending the S-RELAP5 calculations for a representative range of breaks analyzed in Sections 15.6.5.1 and Section 15.6.5.2.

15.6.5.4.1.1 Small-Break LOCA Flow Behavior

15.06.05-33

Five SBLOCA cases are analyzed between 1.5 inches and 6.5 inches in diameter. For breaks up to 4 inches in diameter, the RCS refills in less than four hours with two trains of MHSI and LHSI and returns to natural circulation. ~~The pool boiling period ranged up to about three hours for the 4-inch diameter break.~~

~~The 6-inch diameter break did not refill during the 20,000 seconds analyzed, but two-phase natural circulation is established.~~ In the 6.5 inch break, f~~F~~ollowing completion of the automatic partial cooldown, operator action is assumed at 1800 seconds to continue ~~the~~ depressurization of the SGs at a rate corresponding to 90°F/h. At the same time, the operator is assumed to re~~-~~align the two operating trains of LHSI to

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inject ~~half~~ approximately 75 percent of their flow into the respective hot legs. The exact value of the hotleg/cold leg flow split depends on the RCS pressure. As seen in Figure 15.6-84—SBLOCA - 6.5 Inch Break - Integral of Upper Plenum Flow to the Hot Legs, the redirected flow reverses the flow in loops 1 and 4 into the upper plenum, making additional coolant available to the core region. These are the loops with the operating SI trains and are the same loops receiving EFW. Figure 15.6-85—SBLOCA - 6.5 inch Break - Integral of Core Region Exit Flows shows that the hot leg injected flows further reverse the fuel assembly flow in the peripheral region of the core. Some of the downflow continues out through the lower plenum to the lower head region (Figure 15.6-86—SBLOCA - 6.5 inch Break - Integral of Lower Plenum Flow to Lower Head). At 7000 seconds into the event, the continued cooldown of the steam generators has not caused the secondary side pressure to reach the point where the steam generators will remove decay heat, as illustrated by the RCS pressure and the steam generator 1 pressure (Figure 15.6-87—SBLOCA - 6.5 Inch Break - Pressurizer and Steam Generator 1 Pressure).~~These are the same loops receiving EFW. Two-phase natural circulation begins in these active loops when the SGs are depressurized below RCS pressure and begin condensing primary system steam. Figure 15.6-84—SBLOCA - 6 inch Break - Steam Generator Upside Collapsed Liquid Level and Figure 15.6-85—SBLOCA - 6 inch Break - Steam Generator Downside Collapsed Liquid Level respectively show the collapsed liquid levels on the hot and cold side of the SGs. Figure 15.6-86—SBLOCA - 6 inch Break - Reactor Coolant Loop Mass shows the increase in coolant mass in the loops. Figure 15.6-87—SBLOCA - 6 inch Break - Pressurizer and Steam Generator Pressure shows the RCS pressure and pressure in one of the SGs receiving EFW.~~

The hot leg injection reduces the boron concentration in the core region and prevents precipitation of boron in the core and RCS. Additionally, as can be seen in Figure 15.6-92, the small breaks are bounded by the LBLOCA analysis that is described in the next section.~~The return to single- or two-phase natural circulation prevents the concentration and precipitation of boron in the core and establishes long term cooling via the SGs and SIS flow through the core to the break. Larger small breaks that do not refill and re-establish natural circulation are bounded by the LBLOCA analysis that is described in the next section.~~

15.6.5.4.1.2 Large-Break LOCA Flow Behavior

A 4.1 ft^2 LBLOCA case analyzed in Section 15.6.5.1 is extended to about 6000 seconds to evaluate the effectiveness of hot leg injection for break sizes too large for the MHSI and LHSI to refill the loops. This is assumed to occur at 2000 seconds. Although boiling continues in the core, LHSI water injected into the two hot legs flows into the reactor outlet plenum. This can be seen in Figure 15.6-88—Upper Plenum Flow into the Hot Leg of a Loop Receiving Hot Leg Injection, a plot of integrated flow out the hot leg nozzle. Flow reversal is indicated when the slope becomes negative soon after the initiation of hot leg injection.

Figure 15.6-89—Peripheral Core Region Flow into Upper Plenum shows integrated flow out of the peripheral fuel assemblies of core. It indicates flow reversal at about 2200 seconds. Flow remains positive in the other regions of the core due to higher power density and heating. This analysis demonstrates effective mixing of the coolant in the core. Figure 15.6-90—Lower Plenum Flow into the Peripheral Core Region shows integrated flow from the lower plenum into the peripheral fuel assemblies, also demonstrating flow reversal. Figure 15.6-91—Lower Head Flow into the Lower Plenum integrated flow from the reactor vessel (RV) lower head to the lower plenum, shows reversal at about 2250 seconds, thereby demonstrating overall flow reversal in the RV. The average reverse flow from the lower plenum to the lower head for the last 3000 seconds is about 250 lb_m/s. It is shown in the next section that this is adequate to flush excess boron from the core and vessel to the cold-leg break.

If the LOCA is a large hot leg break, the ECCS injection into the cold leg exceeds the core boil off rate and the excess ECCS has sufficient flow through the core to prevent the formation of a boron concentration that approaches the precipitation limit even with redirection of half of the LHSI flow to the hot legs.

15.6.5.4.1.3 Boron Precipitation Assessment

The maximum initial boron concentration is determined by mixing the conservatively biased solutions in the IRWST, accumulators and the manually actuated EBS is 1925 ppm. This value is used as the starting point for the calculation of concentration over time using the methodology described in U.S. EPR Boron Precipitation and Boron Dilution (Reference 9).

The calculation conservatively neglects the following mitigating processes:

- Increased boron solubility due to other solutes.
- Increased boiling temperature due to boric acid concentration.
- Carryout of dissolved boric acid by steam generated in the core.
- Carryout of boric acid due to droplet entrainment.
- Addition of nonborated water from sources such as the CVCS.

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Figure 15.6-92—Time Dependent Boron Concentration During the Pool Boiling Period shows the predicted boron concentration over time for the ~~2.0~~4.1 ft^2 LBLOCA case and bounding 6.5-inch diameter SBLOCA. The curves for these representative cases demonstrate that for the complete spectrum of breaks, boric acid does not concentrate to the degree that boron precipitates out of solution. Moreover, there is adequate time for the operator to initiate hot leg injection to limit the buildup of boron in the core region and~~, if started early,~~ prevent precipitation in other regions of the RCS.

15.06.05-33

15.6.5.4.2 SBLOCA Boron Dilution

GSI-185, "Control of Recriticality Following Small-Break LOCAS in PWRs," raises the concern for SBLOCA events that de-borated water could accumulate in cold leg pump suction piping due to the condensation of steam. When natural circulation is restored, this de-borated water gets flushed as a slug to the RV and core, potentially causing recriticality and fuel damage.

The conditions necessary for this condition to occur develop for a narrow range of break sizes. Breaks smaller than this range do not interrupt natural circulation and therefore do not accumulate de-borated water. Those larger than this range depressurize quickly to low pressure, during which time the secondary sides of the SGs are a heat source to the primary system. Even if heat transfer is re-established to the SGs after they are depressurized, the break is too large for the LHSI to refill the loops. Because natural circulation does not restart, de-borated water is not flushed to the core as a slug.

AREVA performed tests at the PKL integral-loop test facility to investigate boron dilution during SBLOCA, as described in Final Report of the PKL Experimental Program Within the OECD/SETH Project (Reference 10). Some of the tests simulate the controlled cooldown of the SGs representative of the U.S. EPR plant design. The tests demonstrate that natural circulation does not restart abruptly. It is preceded by a period of intermittent circulation. Moreover, the circulation starts first in one active loop and is followed independently by circulation in other active loops. This thermal-hydraulic behavior provides a basis for evaluating boron concentrations in the cold legs and core.

Bounding calculations of boron concentration in the cold legs, RV, and core are performed assuming different natural circulation restart scenarios. These calculations are described in Reference 9. The calculations demonstrate that the concentration in coolant entering the core does not fall to the minimum core average concentration for recriticality of ~~1005~~ 1519ppm.

15.06.05-33

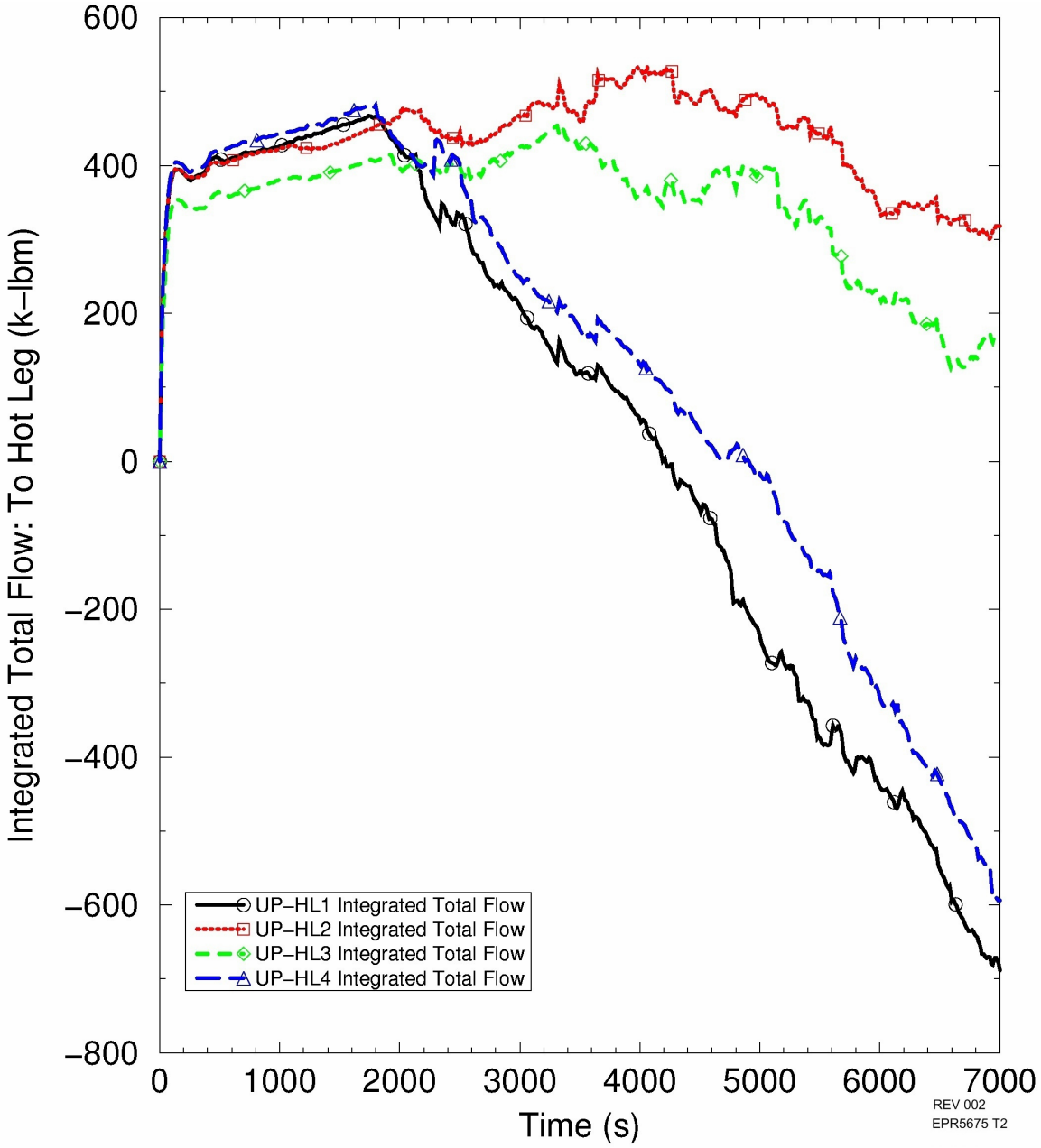
15.6.5.4.3 IRWST Recirculation Cooling

GSI-191, "Assessment of Debris Accumulation on PWR Sump Performance," raises the concern that the high-energy jet from a LOCA may rip away insulation, pulverize concrete, and create other miscellaneous debris particles. Debris generated and transported to the IRWST may potentially penetrate the strainers and screens, degrade the performance of plant mitigating systems, and block coolant channels in the core.

ANP-10293 (Reference 11) describes the design features that address the GSI-191 concerns. The U.S. EPR design reduces the potential for debris generation by using reflective metal insulation to insulate RCS components. This insulation does not produce particulate or fibrous debris that is easily transported to the SIS inlet and

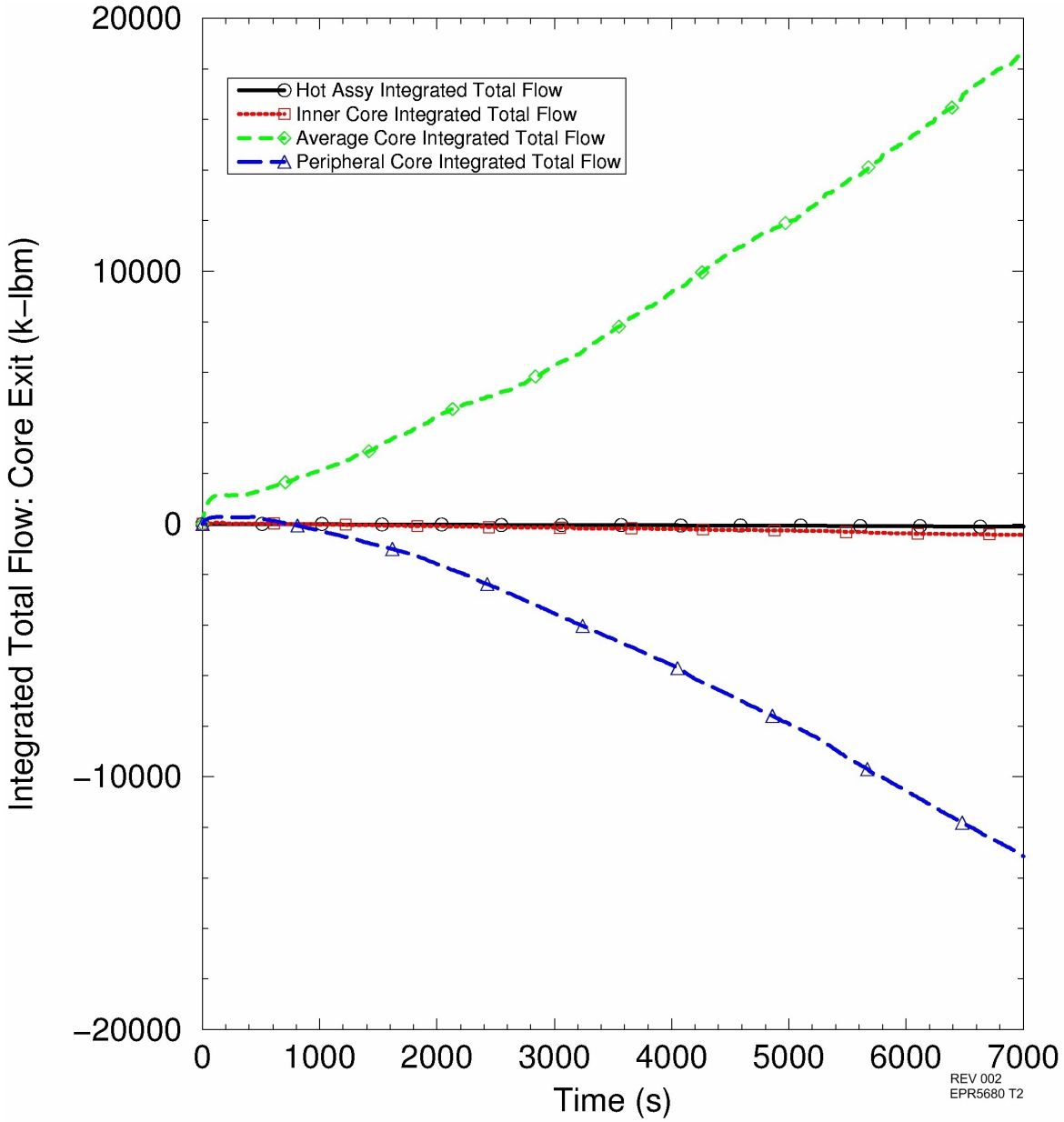
15.06.05-33

Figure 15.6-84—SBLOCA - 6.5 Inch Break - Integral of Upper Plenum Flow to the Hot Legs~~Steam Generator Upside Collapsed Liquid Level~~



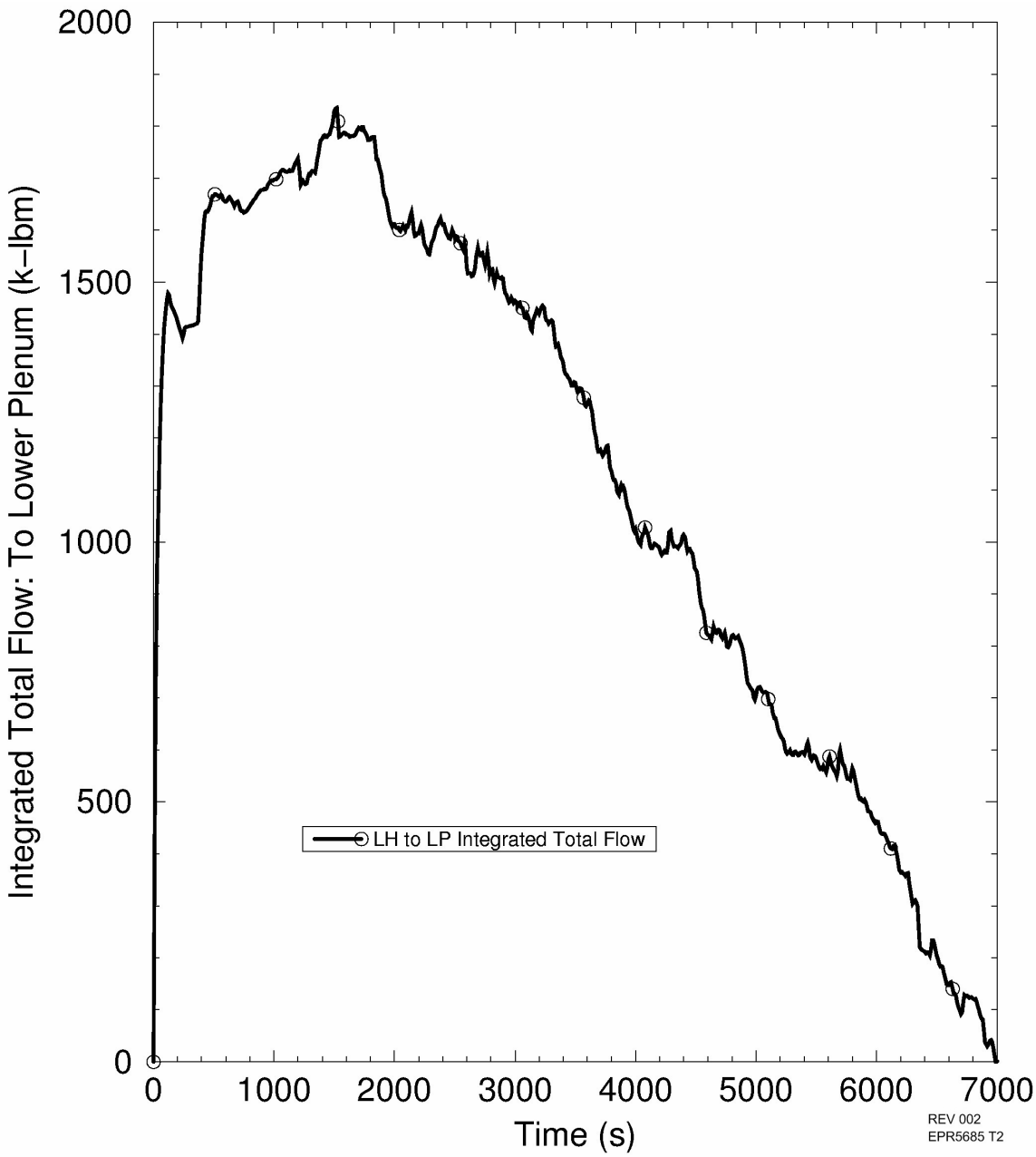
15.06.05-33

Figure 15.6-85—SBLOCA - 6.5 Inch Break - Integral of Core Region Exit Flows~~Steam Generator Downside Collapsed Liquid Level~~



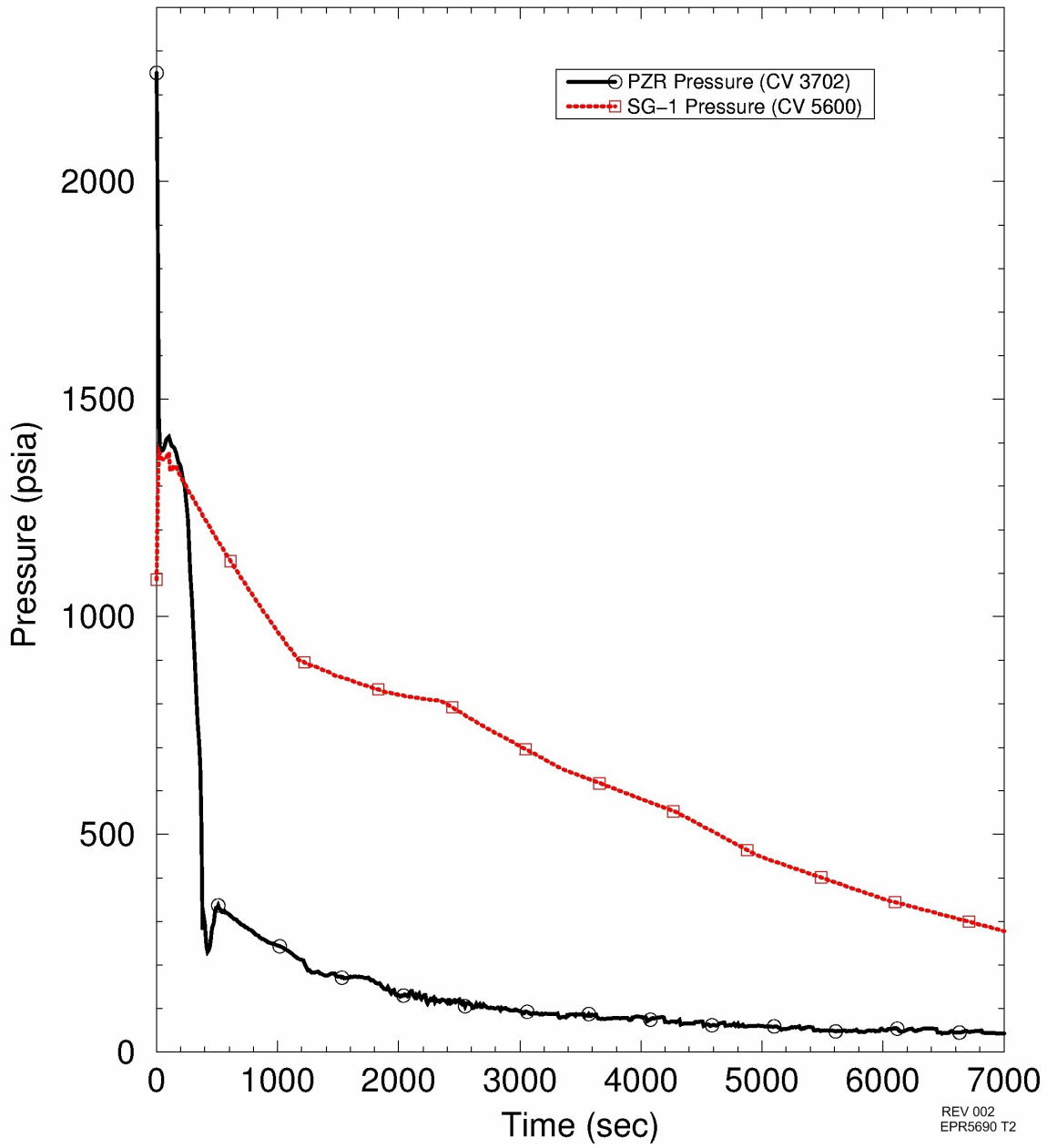
15.06.05-33

Figure 15.6-86—SBLOCA - 6.5 Inch Break - Integral of Lower Plenum Flow to Lower Head~~Reactor Coolant Loop Mass~~



15.06.05-33

Figure 15.6-87—SBLOCA - 6.5 Inch Break - Pressurizer and Steam Generator 1 Pressure



15.06.05-33

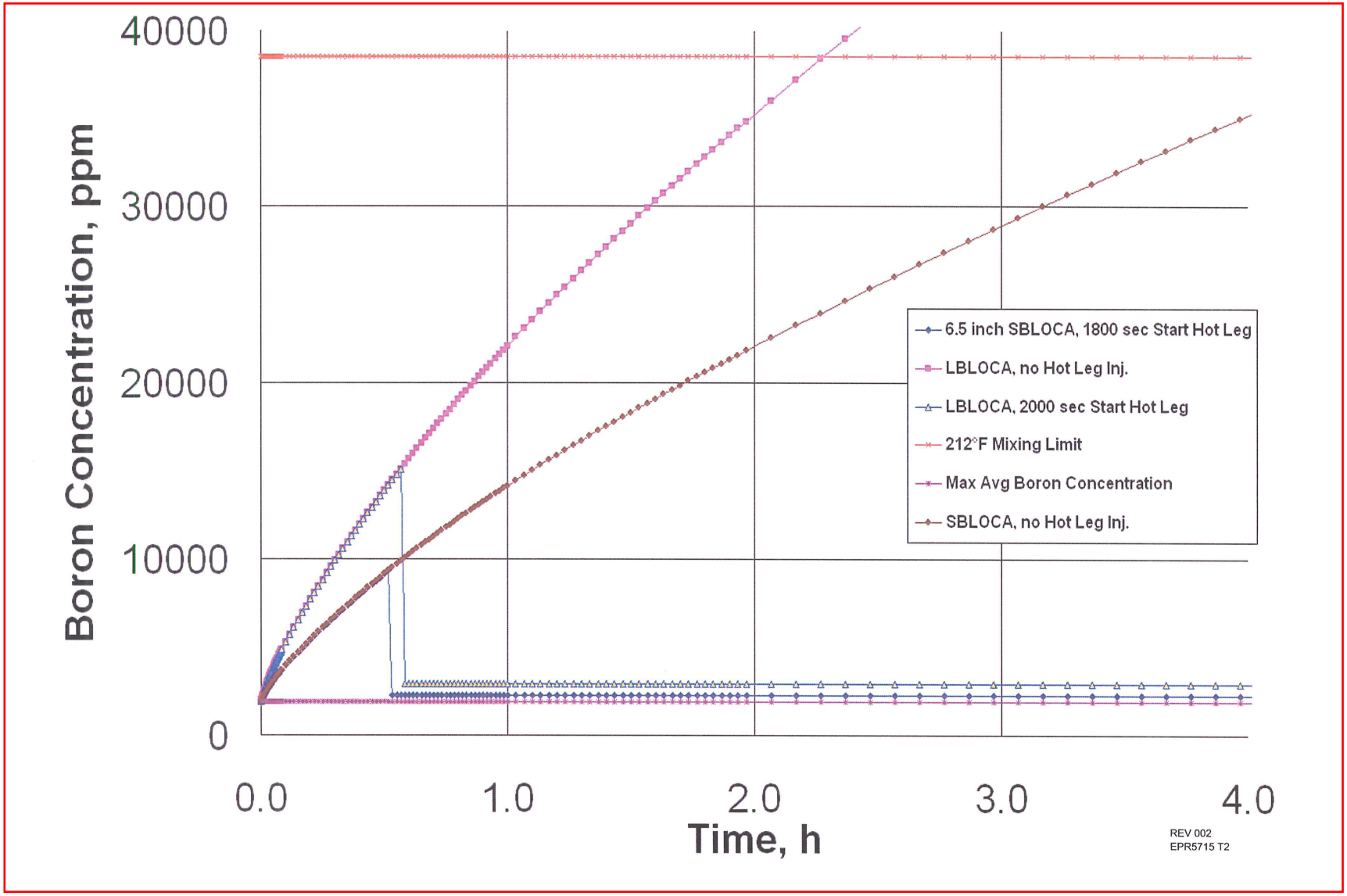



Figure 15.6-92—Time Dependent Boron Concentration During the Pool Boiling Period