AREVA

March 31, 2009
NRC:09:030

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Supplemental Response to Third Request for Additional Information Regarding ANP-10278P, "U.S. EPR Realistic Large Break Loss of Coolant Accident Topical Report" (TAC No. MD4978)

Ref. 1: Letter, Ronnie L. Gardner (AREVA NP Inc.) to Document Control Desk (NRC), "Request for Review and Approval of ANP-10278P Revision 0, 'U.S. EPR Realistic Large Break Loss of Coolant Accident Topical Report'," NRC:07:010, March 26, 2007.

Ref. 2: Letter, Ronnie L. Gardner (AREVA NP Inc.) to Document Control Desk (NRC), "Response to an RAI on the Topical Report ANP-10278P 'U.S. EPR Realistic Large Break Loss of Coolant Accident Topical Report'," NRC:07:035, August 17, 2007.

Ref. 3: Letter, Ronnie L. Gardner (AREVA NP Inc.) to Document Control Desk (NRC), "Response to Second Request For Additional Information Regarding ANP-10278P, 'U.S. EPR Realistic Large Break Loss of Coolant Accident Topical Report' (TAC No. MD4978)," NRC:08:039, June 13, 2008.

Ref. 4: Letter, Getachew Tesfaye (NRC) to Ronnie L. Gardner (AREVA NP Inc.), "Third Request for Additional Information Regarding ANP-10278P, 'U.S. EPR Realistic Large Break Loss of Coolant Accident Topical Report,' (TAC No. MD4978)," September 5, 2008.

Ref. 5: Letter, Ronnie L. Gardner (AREVA NP Inc.) to Document Control Desk (NRC), "Response to Third Request For Additional Information Regarding ANP-10278P, 'U.S. EPR Realistic Large Break Loss of Coolant Accident Topical Report' (TAC No. MD4978)," NRC:08:105, December 19, 2008.

AREVA NP Inc. (AREVA NP) requested the NRC's review and approval of topical report ANP-10278P Revision 0, "U.S. EPR Realistic Large Break Loss of Coolant Accident Topical Report" in Reference 1. In this regard, AREVA NP Inc. provided additional information to the NRC in References 2 and 3. The NRC made a third request for additional information in Reference 4. A response to eleven of the fourteen questions posed in Reference 4 was provided in Reference 5. This letter provides a response to the remaining three questions.

AREVA NP considers some of the material contained in the attachments to this letter to be proprietary. As required by 10 CFR 2.390(b), an affidavit is enclosed to support the withholding of the information from public disclosure. Proprietary and non-proprietary versions of the enclosure to this letter are provided.

D077
NRO

If you have any questions related to this submittal, please contact Ms. Sandra M. Sloan, Regulatory Affairs Manager for New Plants, by telephone at 434-832-2369 or by e-mail to sandra.sloan@areva.com.

Sincerely,

Ronnie L. Gardner

Ronnie L. Gardner, Manager
Corporate Regulatory Affairs
AREVA NP Inc.

Enclosures

cc: G. Tesfaye
Docket No. 52-020

AFFIDAVIT

COMMONWEALTH OF VIRGINIA)
) ss.
COUNTY OF CAMPBELL)

1. My name is Ronda M. Pederson. I am Licensing Manager, Regulatory Affairs for New Plants, for AREVA NP Inc. and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA NP to determine whether certain AREVA NP information is proprietary. I am familiar with the policies established by AREVA NP to ensure the proper application of these criteria.

3. I am familiar with the AREVA NP information contained in letter NRC:09:030, the enclosed *Supplemental Response to Third Request for Additional Information Regarding ANP-10278P, "U.S. EPR Realistic Large Break Loss of Coolant Accident Topical Report" (TAC No. MD4978)*, and referred to herein as "Document." Information contained in this Document has been classified by AREVA NP as proprietary in accordance with the policies established by AREVA NP for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA NP and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of proprietary information is made in accordance with 10 CFR 2.390. The information for which withholding from disclosure is

requested qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information".

6. The following criteria are customarily applied by AREVA NP to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA NP's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA NP.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA NP in product optimization or marketability.

(e) The information is vital to a competitive advantage held by AREVA NP, would be helpful to competitors to AREVA NP, and would likely cause substantial harm to the competitive position of AREVA NP.

The information in the Document is considered proprietary for the reasons set forth in paragraphs 6(b) and 6(c) above.

7. In accordance with AREVA NP's policies governing the protection and control of information, proprietary information contained in this Document has been made available, on a limited basis, to others outside AREVA NP only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA NP policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

SUBSCRIBED before me this 31st
day of March, 2009.

Kathleen A. Bennett
NOTARY PUBLIC, COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES: 8/31/2011

KATHLEEN ANN BENNETT
Notary Public
Commonwealth of Virginia
110864
My Commission Expires Aug 31, 2011

Response to Third Request for Additional Information—ANP-10278P "U.S. EPR Realistic Large Break Loss of Coolant Accident Topical Report" (TAC No. MD4978)

***RAI 23**: AREVA has not provided sufficient documentation to support the containment model used to calculate the containment back pressure during a LBLOCA.*

a. provide justification that ICECON properly predicts appropriate containment pressure in the EPR's RLBLOCA analysis.

b. Explain how total heat transfer area is obtained and how heat transfer to the IRWST water surface is treated.

c. Explain how the "best estimate containment pressure curve" obtained as shown in Figure 3-1 is confirmed to be a best-estimate curve for RLBLOCA analysis.

Response to RAI 23:

a. Justification that ICECON properly predicts appropriate containment pressure in the U.S. EPR's RLBLOCA analysis.

The goal for the containment modeling in the realistic large break loss-of-coolant accident (RLBLOCA) evaluation is to produce a containment pressure that is reasonable yet conservatively biased to an under-prediction. This is accomplished through biasing of the building heat sinks toward larger heat transfer area and mass (see the response to part b) and by bounding the condensing heat transfer coefficient on the high side. Furthermore, the containment free volume is sampled from a realistic estimate to an over-estimate based on the volume inside the external containment walls with no subtraction for interior structures. These measures will result in an accurate or under-prediction of containment pressure, which is appropriate for a conservative ECCS evaluation.

To provide further evidence of appropriateness of the ICECON prediction method, a benchmark of ICECON to an equivalent GOTHIC model of the U.S. EPR containment was performed for the period of interest. The benchmark compared ICECON and GOTHIC containment pressure predictions within the first few minutes following the large break loss-of-coolant accident (LBLOCA). The comparison provides justification that ICECON properly predicts the appropriate containment pressure for the RLBLOCA analysis of the U.S. EPR. The benchmark uses an updated ICECON model. The major differences between this ICECON model and the model used in Reference 1 are discussed in the response to part (b) of this RAI question. The benchmark is summarized below.

A GOTHIC model with a break in a cold leg is used in the benchmark. This is consistent with the RLBLOCA analysis. The GOTHIC model is adequate for purposes of this benchmark calculation for the following reasons:

1) The physical characteristics of the containment and associated thermal conductors in the GOTHIC model match those used in the ICECON model; and

2) All modifying features (such as boundary conditions, forcing functions, heaters, etc) other than those associated with the mass and energy release (MER) are turned off in the GOTHIC model. That is, only those boundary conditions necessary to mimic

the mass and energy release in the ICECON model are activated in the GOTHIC model.

The integrated mass and energy release from S-RELAP5 were used to create the average mass flow rate and enthalpy input to both GOTHIC and ICECON.

Figure 23-1 provides the calculated U.S. EPR containment pressure response using the benchmark GOTHIC model based on input consistent with the ICECON model. Comparison of the GOTHIC and ICECON calculated U.S. EPR containment pressure profiles presented in Figure 23-1 shows good agreement between the two codes. ICECON conservatively predicts a lower containment pressure.

With the combination of conservative heat sink determinations, the sampling of containment volume higher than expected values and the verification of the basic ICECON modeling, it is concluded that ICECON predicts an appropriate containment pressure for the U.S. EPR RLBLOCA analysis.

b. Total Heat Transfer Surface Area and Heat Transfer to IRWST

Total Heat Transfer Surface Area

Developing the heat sinks in the ICECON model begins with the heat structure groups in the U.S. EPR GOTHIC containment model. Assumptions in the GOTHIC model are then assessed for applicability to a conservative minimum back-pressure calculation. This assessment confirms that the ICECON model includes heat sinks that may be conservatively neglected in the GOTHIC model.

In terms of surface area, the updated ICECON model includes the following changes:

1. The ICECON model treats the containment walls and the in-containment refueling water storage tank (IRWST) walls as two-sided heat structures. The IRWST walls are in contact with water on one side and the containment atmosphere on the other. The containment walls are in contact with the containment annulus on one side and the containment atmosphere on the other.

2. The ICECON model considers an increase in the surface area of un-insulated systems and components. The surface area of this additional heat sink is determined so that the total exposed internal steel heat sink area in ICECON is consistent with the total internal steel heat sink area recommended in Figure 1 of Reference 3. The combined containment volume (nominal containment gas volume plus nominal IRWST water volume) is 81,777 m^3. In accordance with Figure 1 of Reference 3, the total internal steel heat sink area is 3.5×10^4 m^2 (376,737 ft^2). It is assumed that the containment free volume in Figure 1 of Reference 3 ranges from 0.0 m^3 to 1.2×10^5 m^3.

3. All of the nominal heat transfer surface areas in the updated ICECON model are increased by 10% to increase the energy removed from the containment atmosphere.

The material properties of steel and concrete are consistent with Table 2 of Reference 3. The paint layer is assumed to have the material properties of steel. The air gap between the liner and concrete is neglected. These assumptions eliminate any insulating effects on the exposed surfaces of the heat structures.

Heat Transfer to IRWST

The ICECON model assumes the IRWST liquid is well mixed so the liquid temperature at the containment vapor space and the IRWST water interface is the bulk liquid temperature. The heat transfer from the pool surface consists of:

- The sensible heat transferred by the temperature gradient
- The latent heat of the mass transferred by the molar concentration gradient in the vapor.

In Reference 1, the only liquid mass transferred to the pool is the calculated condensate. That is, other than the liquid transferred to the pool through condensation, all the liquid is retained in the atmosphere (ICECON option ALWAYS = 0.0).

A sensitivity study performed when the ICECON model was updated evaluated the effect of modeling liquid dropout from the atmosphere. This study models water drop-out from the atmosphere region at each time step in the post-blowdown period. Choosing this particular ICECON option deactivates the evaporation-condensation model. That is, liquid mass transfer to the pool by condensation is not calculated, but the liquid dropout to the pool is modeled in the post-blowdown period (ICECON option ALWAYS = 1.0).

The results of the sensitivity study showed that modeling liquid dropout produces a slight decrease in containment back-pressure, which is conservative for the peak cladding temperature (PCT) calculation (see Figure 23-2). An examination of Figure 23-3 shows that the difference in the pressure response begins when the liquid drops-out at the end of the blowdown. Modeling liquid dropout increases the pool temperature, as shown in Figure 23-3. In contrast, the pool temperature when the liquid is completely entrained in the atmosphere shows no discernable change in temperature. Therefore, modeling liquid dropout is conservative and appropriate for the U.S. EPR RLBLOCA analysis. The legends in Figure 23-2 and Figure 23-3 below indicate that the updated ICECON model incorporates liquid dropout (ALWAYS = 1.0).

The response to RAI-16 in ANP-10278Q2P provides the results of a sensitivity study using 59 cases where the containment pressure is decreased by approximately 10 psi in each case. The results show a small sensitivity of the PCT calculation to a significant drop in containment back-pressure of less than 30°F in the highest PCT case.

c. Best-Estimate Containment Pressure Curve

The value of the Tagami coefficient is 72.5 Btu/hr-ft^2-°F for the best-estimate Tagami correlation. As shown in Figure 2 of Reference 3, the conservative evaluation model (EM) form of this coefficient uses an additional multiplier of 4.0, yielding an EM value of 290.0 Btu/hr-ft^2-°F.

The best estimate value of the Uchida multiplier is 1.0 and the EM value is 1.2.

Section 3.4.2 of Reference 4 states that ICECON was originally approved for calculating a conservative containment back-pressure under 10CFR50, Appendix K rules, but that it can also be used with realistic input to give a realistic back-pressure calculation. The specific changes made to ICECON for a realistic calculation include [

]

Figure 23-4 represents one of the two cases used to confirm the Uchida multiplier of [ ] in the Reference 1 ICECON containment model. The figure shows the containment pressure histories for the following five scenarios:

[

]

References

1. ANP-10278P, Revision 0, "U.S. EPR Realistic Large Break Loss-of-Coolant Accident Topical Report," AREVA NP Inc., March 2007.

2. ANP-10299P, Revision 0, "Applicability of AREVA NP Containment Response Evaluation Methodology to the U.S. EPR™ for Large Break LOCA Analysis," AREVA NP Inc., January 2009.

3. NRC Standard Review Plan Branch Technical Position 6-2, "Minimum Containment Pressure Model for PWR ECCS Performance Evaluation," Revision 3, NUREG-0800, March 2007.

4. EMF-2103(P)(A), Revision 0, "Realistic Large Break LOCA Methodology for Pressurized Water Reactors," FANP Richland, Inc., April 2003.

Figure 23-1: Comparison of Containment Pressure Histories – GOTHIC to ICECON Benchmark

Figure 23-2: Containment Pressure

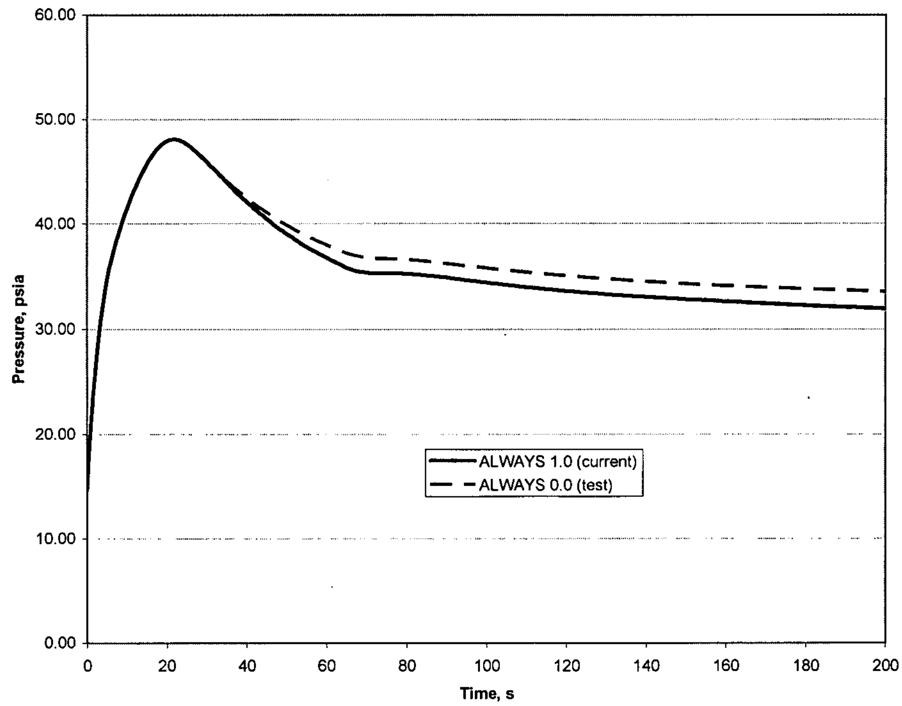

Figure 23-3: Atmosphere and Pool Temperature

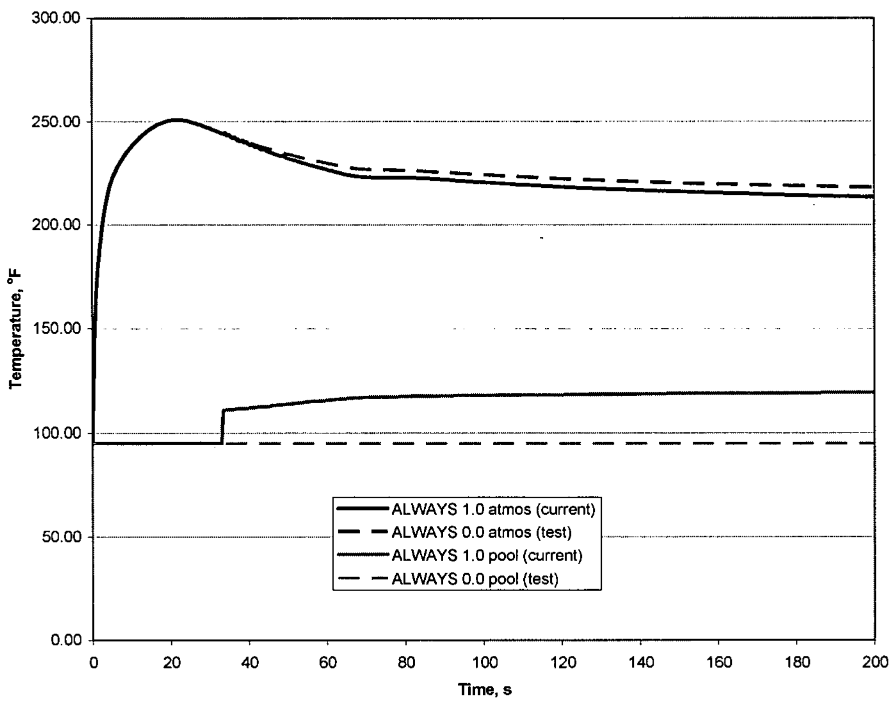

Figure 23-4: Comparison of Containment Pressure Histories

RAI 29:

The NRC staff has determined that (Reference 2) ["Realistic Large Break LOCA Methodology for Pressurized Water Reactors," EMF-2103(P)(A) Revision 0, FANP Richland, Inc., April 2003] *use of probability sampling theory to satisfy the acceptance criteria for peak cladding temperature, maximum local oxidation, and core wide oxidation should be limited to break sizes falling within the appropriate phenomenologically-driven region. Provide justification of break size spectrum used in the RLBLOCA analysis for US EPR.*

Response to RAI 29:

This RAI questions whether the range of applicability of the RLBLOCA methodology extends to 10% of the cross-sectional area of the reactor coolant system (RCS) cold leg pipe (0.1 A_{pipe}). The realistic large break loss-of-coolant accident (RLBLOCA) methodology applies to the spectrum of break sizes, ranging from the full double-ended guillotine large break to the largest small break (i.e., 10% of the cross-sectional area of the cold leg pump discharge piping to the reactor pressure vessel). This range was approved by the NRC in EMF-2103(P)(A) Revision 0, "Realistic Large Break LOCA Methodology for Pressurized Water Reactors."

To provide assurance that the RLBLOCA methodology is applicable to the smaller break sizes, AREVA reviewed the application of the original RLBLOCA methods approved in EMF-2103(P)(A) with a focus on the phenomena relevant to smaller break sizes. This work included:

1. A phenomena identification and ranking table (PIRT) review and the re-ranking of phenomena for break areas between approximately 0.1 A_{pipe} and 0.3 A_{pipe}
2. A validation of the RLBLOCA methodology approach for each of the highly ranked PIRT parameters
3. A comparison between the results of the U.S. EPR RLBLOCA methodology (ANP-10278P) and the U.S. EPR small break loss-of-coolant (SBLOCA) methodology (ANP-10263P) for near transition-size breaks. This evaluation was performed to confirm that, for the transition-size breaks, the models produce comparable results that differ because of the boundary conditions imposed by the deterministic and best-estimate methodologies.

PIRT Review - Breaks Between Approximately 0.1 A_{pipe} and 0.3 A_{pipe}

Five experts and a moderator (with an average of 30 years of LOCA methods development and analyses experience each) conducted the PIRT review. The PIRT panel's ranking decisions were unanimous.

The results of the PIRT review are provided in Table 29-1 and are contrasted to the original PIRT in EMF-2103(P)(A). The original PIRT used a numeric ranking of 1 to 9. The symbol "-" in the table implies that the phenomena are not present and are not ranked in the indicated accident phase. This review categorized the importance as high (9, 8, 7), medium (6, 5, 4), or low (3, 2, 1, -). For most phenomena, the revised ranking was either the same as the original ranking in EMF-2103(P)(A) or was ranked lower; primarily because the smaller breaks proceed more slowly and with less intensity. For a few phenomena, such as those relating to void distributions, the ranking shifted to higher importance. New phenomena that had not been considered by the original PIRT (for example, cold leg condensation efficiency) were added because of their importance. Where a ranking difference occurred between the original PIRT and the more recent PIRT review concentrating on smaller breaks, Table 29-1 provides the rationale for the new ranking.

Methodology Validation for Increases in Importance

Following the updated PIRT review, the RLBLOCA phenomena were divided into two categories: those that increased in importance, and those that had the same or decreased importance. For the latter category the methodology verification of the original PIRT (EMF-2103) was accepted. For those phenomena that increased in importance, AREVA NP reviewed the applicability of the methodology.

Only a few phenomena increased in importance (see Table 29-1), and the review confirmed the adequacy of S-RELAP5 modeling. Moreover, the review found no need for re-benchmarking or revalidating S-RELAP5 or the RLBLOCA methodology. The phenomena that increased in importance for smaller breaks included:

1. Fuel rod gap conductance during refill went from low importance to medium importance for all RLBLOCA break sizes. The PIRT panel disagreed with the original EMF-2103 PIRT that gap conductance was of low importance during refill for any RLBLOCA break. Gap conductance importance is related to the initial fuel pellet stored energy, and the initial stored energy is determined by a fuel performance code that is benchmarked directly to experimental data. The gap conductance is well-predicted by the methodology.
2. Nucleate boiling within the core was found to be of moderate importance during both refill and reflood. The importance is based on the observation that nucleate boiling is one of the major sources of steam supporting the mixture volumes within the RCS. However, nucleate boiling is a strong heat transfer regime, and changes in its prediction only alter the system metal temperatures by a few degrees. Thus, almost any level of nucleate boiling is sufficient and the methodology employed by S-RELAP5 is adequate.

[ ]

Examination of RLBLOCA and SBLOCA Interface Break

The results of the smaller breaks calculated with the RLBLOCA model were compared to the results for the larger breaks calculated with the SBLOCA model. The differences in the models stem from the need, in SBLOCA evaluations, to model quasi-steady-state boil-down and refill phenomena at higher pressures and for longer times. Such modeling is not required for breaks larger than 0.1 x A_{pipe}; therefore, the models are different for large and small breaks, and modeling studies are verified to different experiments. Thus, the comparison of a similar break size area for the two methodologies provides an independent verification that both methodologies produce essentially the same results at the application interface.

The most significant difference between the U.S. EPR RLBLOCA and SBLOCA models is the deterministic (Appendix K) requirement on decay heat. For an SBLOCA the decay heat is modeled with the ANSI/ANS-5.1-1973 standard increased by 20%. For the U.S. EPR RLBLOCA methodology the decay heat is modeled using the ANSI/ANS-5.1-1979 ANS standard. Because the peak cladding temperature (PCT) from an SBLOCA calculation is essentially determined by the amount of super heat absorbed in steam rising through the core up to the elevation of the hot spot, it is reasonable to estimate the temperature sensitivity of the SBLOCA model to a change in decay heat by multiplying the amount that the cladding temperature is above saturation temperature by the decay heat difference.

The calculated PCT for the U.S. EPR larger break size SBLOCAs is about 1450°F, and the saturation temperature is approximately 250°F. Adjusting for the decay heat difference gives a difference above saturation of 1000°F (0.83 x 1200°F). Adding the saturation temperature back in provides an estimate of 1250°F for the SBLOCA PCT, had it been calculated with the lower RLBLOCA decay heat model. The RLBLOCA results for breaks near the transition break size lie between 1100°F and 1200°F. Thus, the two models are in good agreement and both models provide a reasonable estimate of the LOCA peak cladding temperature given the boundary condition differences.

Conclusions

Applying the RLBLOCA methodology to break sizes as low as the originally approved EMF-2103(P)(A) cross-sectional break size of 0.1 x A_{pipe}, was reviewed to identify important phenomena and to verify the phenomena were modeled properly. Some differences were identified between the larger breaks and those near the smallest applied break area. However, in all cases the modeling approach incorporated within S-RELAP5 and the RLBLOCA methodology was verified as sufficient to evaluate pipe breaks near the lowest applied break area (0.1 x A_{pipe}).

A comparison between the RLBLOCA methodology and the SBLOCA modeling shows good agreement, indicating that at the transition either model is adequate to evaluate the LOCA. Thus, the RLBLOCA methodology can be applied to breaks as small as 0.1 x A_{pipe}, and the results correctly evaluate the LOCA consequences.

Table 29-1: PIRT Review for Smaller Break Areas (~ 0.3 to 0.1 A_{pipe})

[ ]

Table nomenclature:

Importance ranking scale:

- H (High) = 7, 8, 9
- M (Medium) = 4, 5, 6
- L (Low) = 1, 2, 3
- "-" – indicates the phenomenon is not present and not ranked

LOCA Phase

- BD = Blowdown
- RFL = Refill
- RFD = Reflood

***RAI 31**: The staff had expressed concerns regarding the insensitivity of downcomer nodalization on downcomer boiling following large break LOCAs (Reference 2)* ["Realistic Large Break LOCA Methodology for Pressurized Water Reactors," EMF-2103(P)(A) Revision 0, FANP Richland, Inc., April 2003]. *Staff requests that AREVA quantify the downcomer boiling impact on the EPR RLBLOCA results. It is noted that the staff had also agreed (Reference 2) that with the high containment pressures and PCTs of the order of less than 1800 °F, sufficient margin exists relative to the 10CFR50.46 criteria to not warrant further investigations. However, should PCTs increase above 1800°F and/or the containment design result in pressures below the containment design pressure in the order of 30 psia, the staff plans to establish the limitation of this RLBLOCA method regarding downcomer boiling modeling.*

Response to RAI 31:

The downcomer model for the realistic large break loss-of-coolant accident (RLBLOCA) analyses is adequate for computing downcomer phenomena, including predicting local boiling effects. The model was benchmarked against the Upper Plenum Test Facility (UPTF) tests and the Loss of Fluid Test (LOFT) facility in Reference 1. In Reference 2 (which was subsequently incorporated into Reference 1), AREVA NP addressed the effects of boiling in the downcomer. [

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These studies are documented below.

In contrast to the sensitivity studies in Reference 3, Section 6.5, this RAI question is primarily concerned with the phenomenon of U.S. EPR downcomer boiling when containment pressures approach or fall below 30 psia during the reflood phase. Boiling, wherever it occurs, is a phenomenon that codes like S-RELAP5 have been developed to predict. Downcomer boiling is the result of the release of energy stored in the vessel metal mass. [

] This modeling has been validated through the prediction of several assessments on boiling phenomena provided in the S-RELAP5 code verification and validation document (Reference 4).

Sensitivity analyses have been performed based on RLBLOCA Case 43 for Cycle-01 of the U.S. EPR. This is the highest PCT case presented in the U.S. EPR FSAR and provides a sufficiently high PCT to provide for meaningful results. [

] This effect is shown in Figure 31-1 and Figure 31-2 below.

[

] Figure 31-1 through Figure 31-12 show the downcomer wall heat flux, PCT independent of elevation, downcomer liquid level, and the average core liquid level, respectively, for the base case and the modified case.

[

] Thus, this

model is sufficient to predict the downcomer driving head and the resolution of downcomer boiling effects.

Conclusions

To further justify the ability of the RLBLOCA methodology to predict the potential for, and impact of, U.S. EPR downcomer boiling at minimum containment pressure, studies were performed [

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These studies demonstrate that S-RELAP5 delivers energy to the downcomer liquid volumes at an appropriate rate and that the downcomer noding detail is sufficient to track the distribution of any steam formed. Thus, the RLBLOCA model used for the design certification of the U.S. EPR is demonstrated to be adequate for predicting downcomer boiling at the minimum expected system pressures.

References

1. EMF-2103(P)(A), Revision 0, "Realistic Large Break LOCA Methodology for Pressurized Water Reactors," April 2003.
2. Letter, James F. Mallay (Framatome ANP Inc.) to Document Control Desk (NRC), "Responses to a Request for Additional Information on EMF-2103(P) Revision 0, 'Realistic Large Break LOCA Methodology for Pressurized Water Reactors,'" December 20, 2002.
3. ANP-2695P, Revision 0, "Sequoyah Nuclear Plant Unit 1 Realistic Large Break LOCA Analysis," February 2008.
4. EMF-2102(P)(A), Revision 0, "S-RELAP5: Code Verification and Validation," August 2001.
5. ANP-10278P, Revision 0, "U.S. EPR Realistic Large Break Loss-of-Coolant Accident Topical Report," AREVA NP Inc., March 2007.

Figure 31-1: Design Certification Containment Pressure Comparison

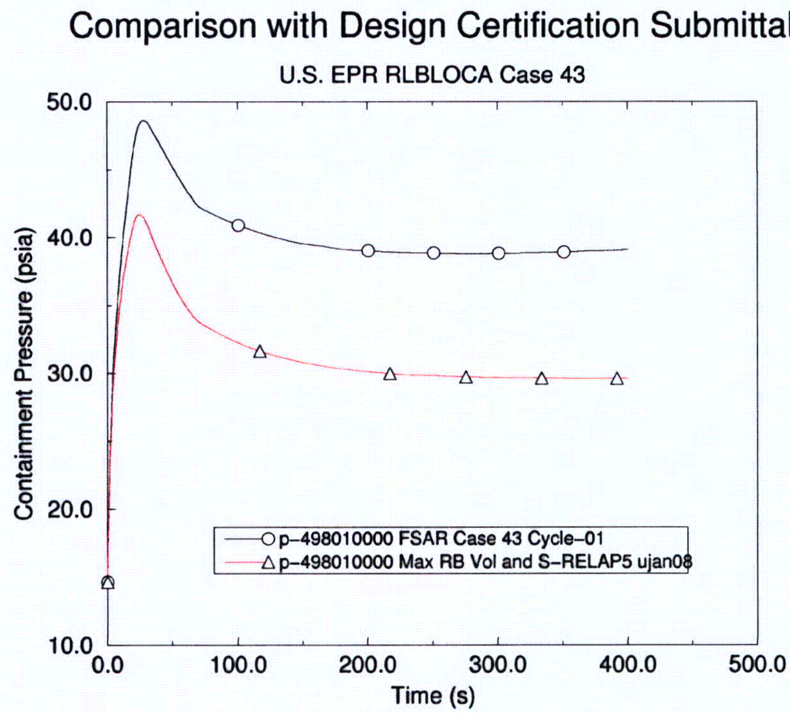

Figure 31-2: Design Certification PCT Comparison

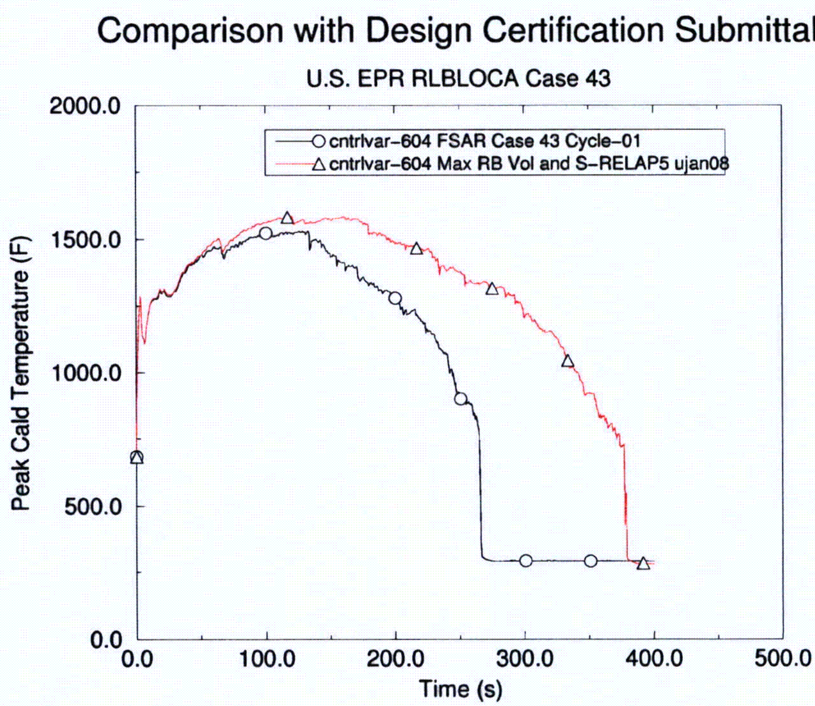

Figure 31-3: Containment Dynamic Pressure – Wall Mesh Point Sensitivity

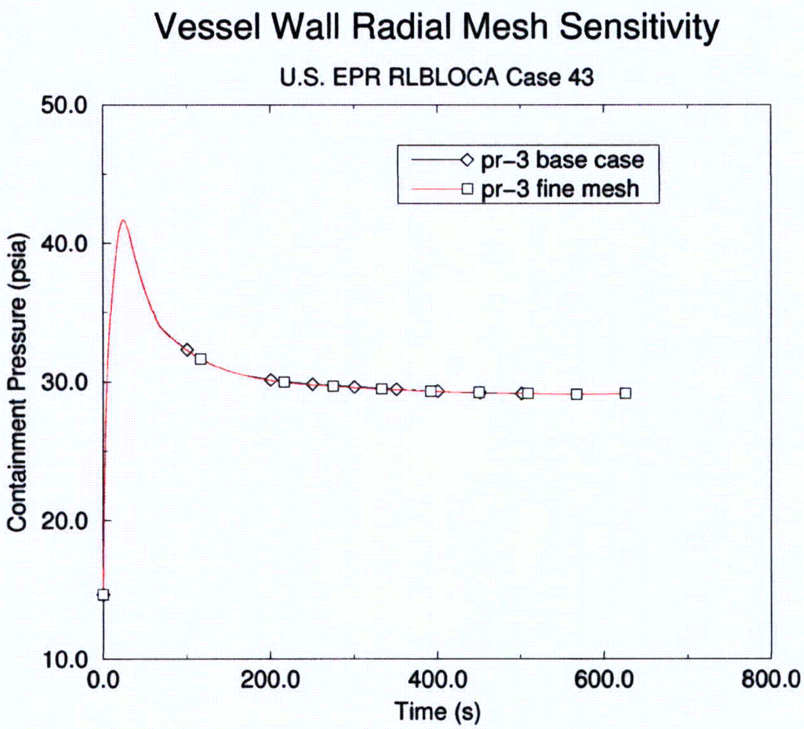

Figure 31-4: Downcomer Wall Heat Flux – Wall Mesh Point Sensitivity

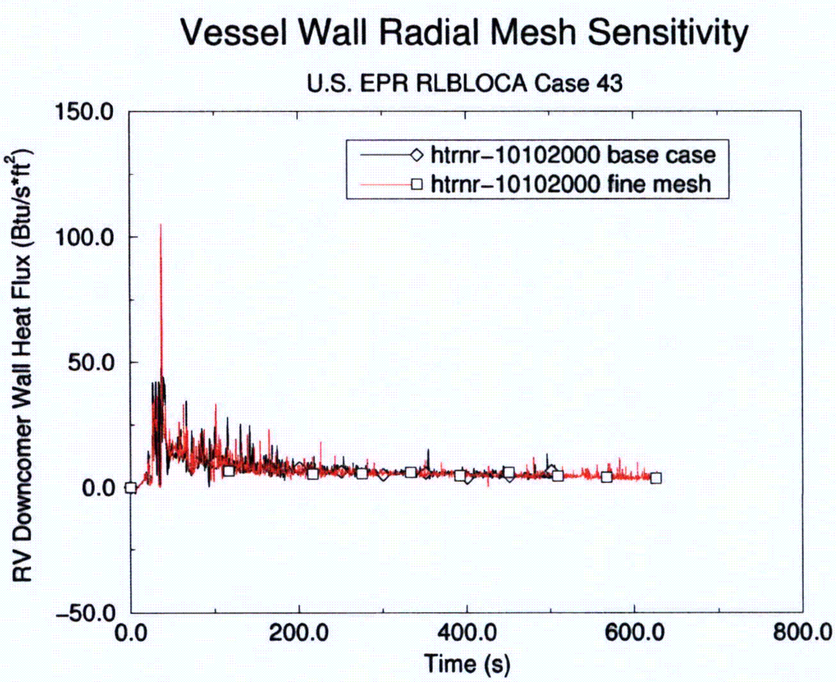

Figure 31-5: PCT Independent of Elevation – Wall Mesh Point Sensitivity

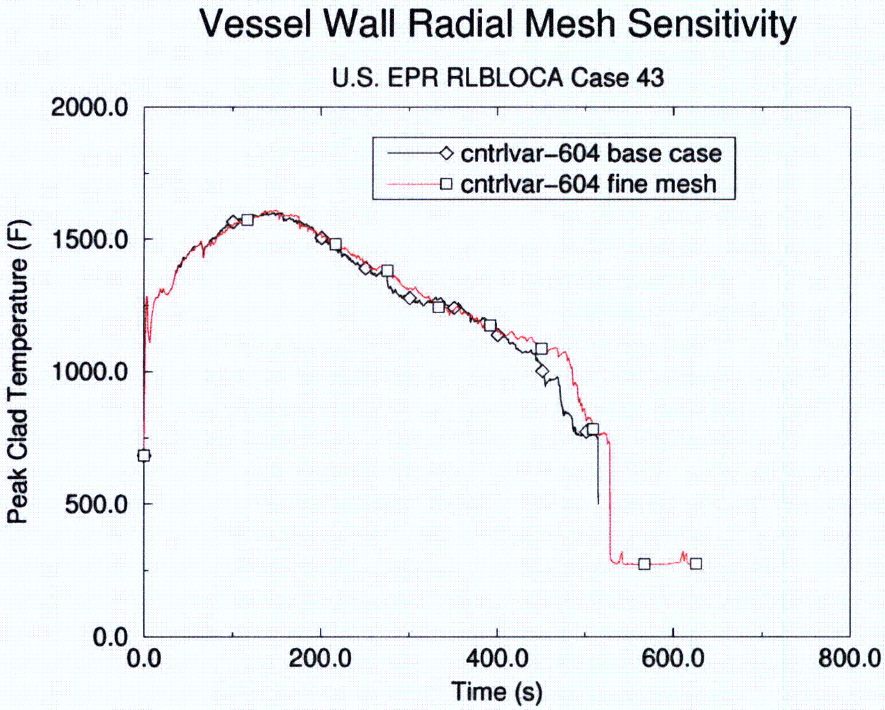

Figure 31-6: Downcomer Liquid Level – Wall Mesh Point Sensitivity

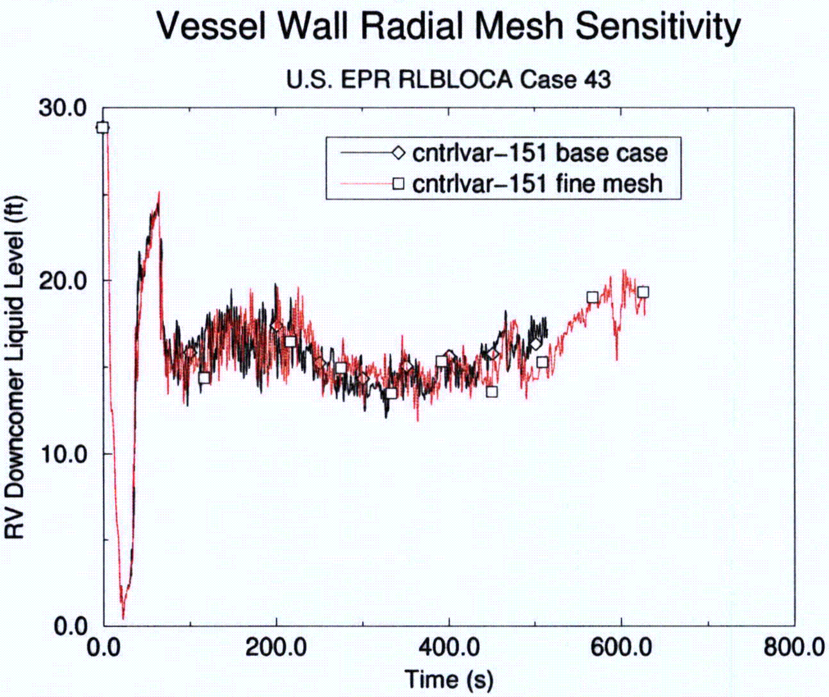

Figure 31-7: Core Liquid Level – Wall Mesh Point Sensitivity

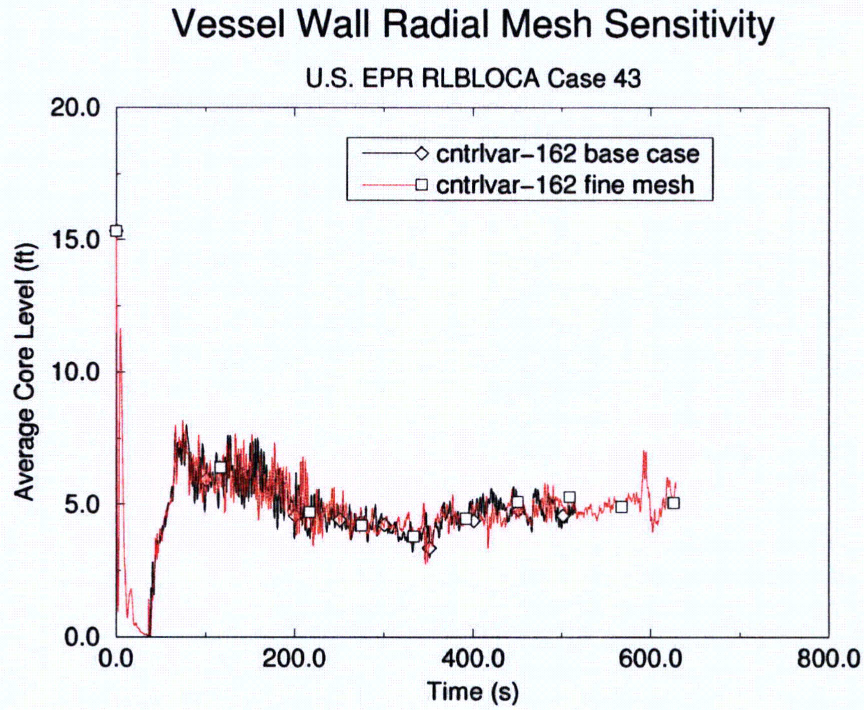

Figure 31-8: Containment Dynamic Pressure – Axial Noding Sensitivity Study

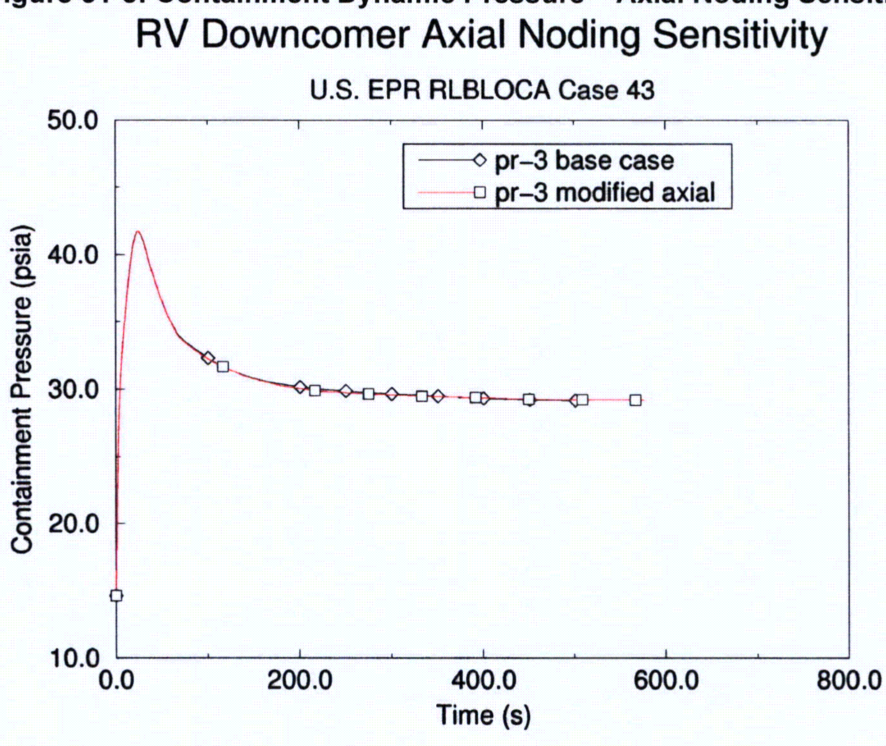

Figure 31-9: Downcomer Wall Heat Flux – Axial Noding Sensitivity Study

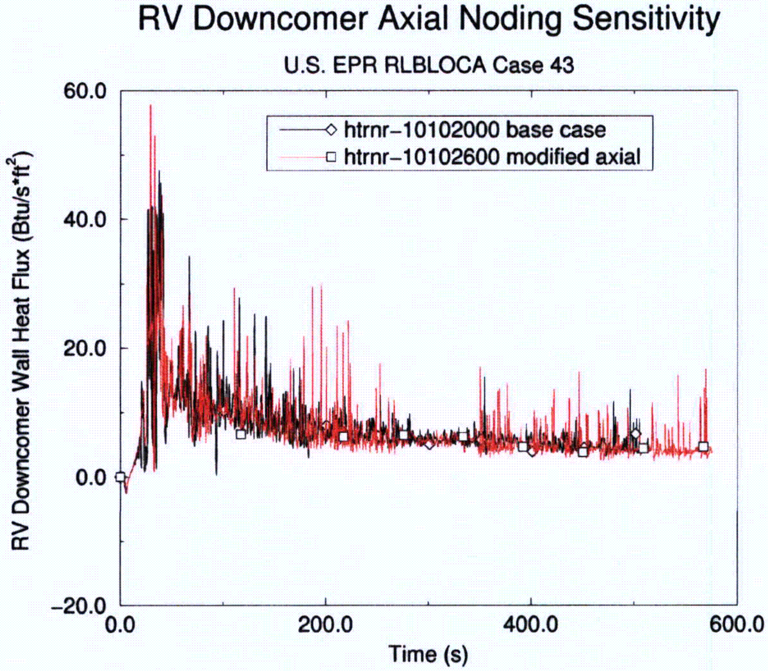

Figure 31-10: PCT Independent of Elevation – Axial Noding Sensitivity Study

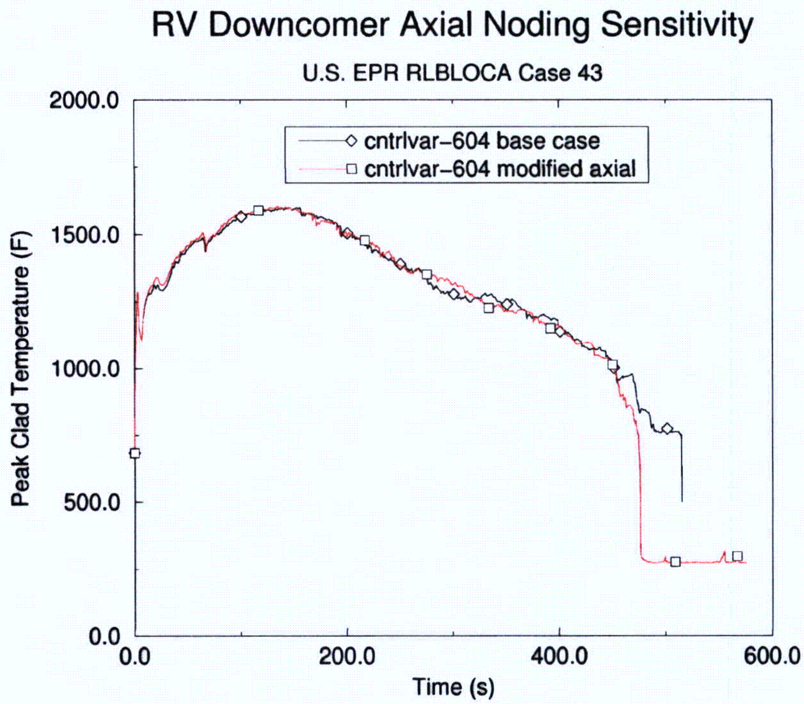

Figure 31-11: Downcomer Liquid Level – Axial Noding Sensitivity Study

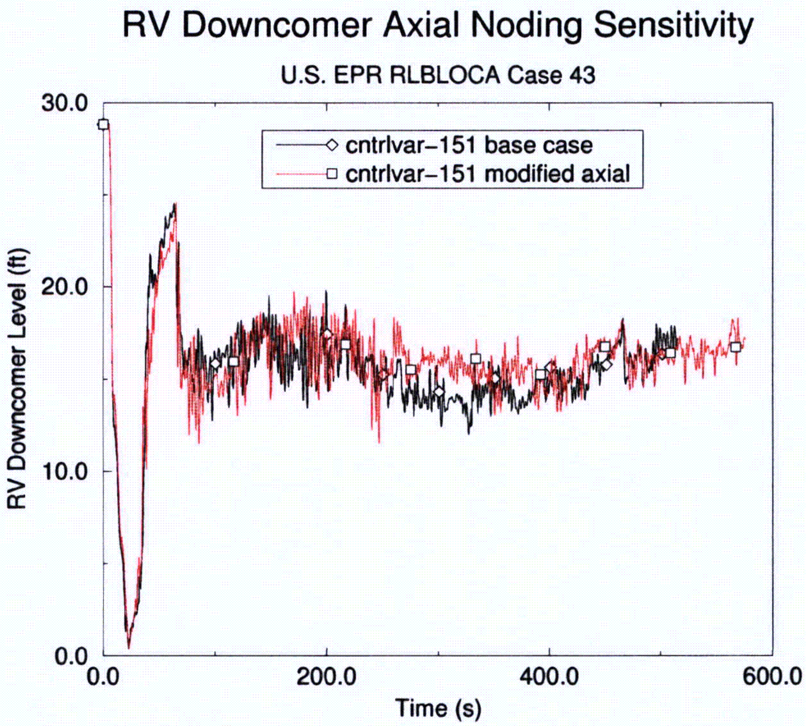

Figure 31-12: Core Liquid Level – Axial Noding Sensitivity Study