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10 CFR 50.46(a)(3)

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT:
Davis-Besse Nuclear Power Station, Unit No. 1
Docket No. 50-346, License No. NPF-3
Response to Request for Additional Information Regarding 10 CFR 50.46 30-Day Report (TAC No. ME4780)

By letter dated September 2, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML102530281), the FirstEnergy Nuclear Operating Company (FENOC) submitted a notification of a significant change to the small-break loss-of-coolant accident emergency core cooling model in accordance with Title 10 of the *Code of Federal Regulations*, Section 50.46(a)(3) for the Davis-Besse Nuclear Power Station, Unit No. 1. By letter dated October 19, 2010 (ADAMS Accession No. ML102810285), the Nuclear Regulatory Commission (NRC) requested additional information to complete its review. The AREVA evaluation of the impact of the peak cladding temperature modeling error is summarized in the Attachment. Also included in the Attachment are FENOC's planned corrective actions.

There are no regulatory commitments contained in this letter. If there are any questions or if additional information is required, please contact Mr. Thomas A. Lentz, Manager – Fleet Licensing, at (330) 761-6071.

Sincerely,

Barry S. Allen

A002
NRR

Attachment:
Response to Request for Additional Information Regarding 10 CFR 50.46 30-Day Report

cc: NRC Region III Administrator
NRR Project Manager
NRC Resident Inspector
Utility Radiological Safety Board

By letter dated September 2, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML102530281), the FirstEnergy Nuclear Operating Company (FENOC) submitted a notification of a significant change to the small-break loss-of-coolant accident emergency core cooling model in accordance with Title 10 of the *Code of Federal Regulations*, Section 50.46(a)(3) for the Davis-Besse Nuclear Power Station, Unit No. 1 (DBNPS). By letter dated October 19, 2010 (ADAMS Accession No. ML102810285), the Nuclear Regulatory Commission (NRC) requested additional information to complete its review. The NRC staff request is provided below in bold type followed by the FENOC response for DBNPS.

1. Please provide additional information regarding FENOC's evaluation of the impact of this peak cladding temperature modeling error. This evaluation should include a discussion of the causes of the error and evidence to support a conclusion that the model as a whole remains adequate to predict PCT. Please include a discussion of the impact of this model error on the full spectrum of postulated break sizes as well as FENOC's planned corrective actions and actions to prevent reoccurrence.

Response

The apparent cause of the error can be traced to an oversight during the Babcock & Wilcox Nuclear Technologies (BWNT) loss-of-coolant accident (LOCA) evaluation model (EM) development. At that time, the focus was on reporting the limiting peak cladding temperature (PCT), which was set by the large break LOCA (LBLOCA). While the EM consists of calculational frameworks for both LBLOCA and SBLOCA, the much lower SBLOCA PCTs and the availability of significant margin between the generated peaks and the linear heat rate limit at the core exit did not result in the same methodological rigor as the LBLOCA EM. Since that time, changes in plant parameters (power uprates, emergency feedwater (EFW) flows, high pressure injection flows, core flood tank initial conditions, steam generator tube plugging, EFW wetting for replacement steam generators, etc.) and fuel cycle designs (gadolinia rods, extended cycle lengths, etc.) have increased the calculated SBLOCA PCTs and reduced the peaking margins at the top of the core. Further, the 10 CFR 50.46 reporting requirements were expanded to include the SBLOCA PCT separately.

Subsequent reviews of the core power distribution analyses (or maneuvering analyses) for all 177-fuel assembly (FA) plants concluded that all achievable end-of-cycle (EOC) axial power shapes were not bounded in elevation by the axial peak used in the SBLOCA analyses of record. An axial shape skewed higher in the core was needed to bound the axial peaks that could be achieved at the EOC for all Babcock & Wilcox (B&W) designed plants following certain maneuvers. Specifically, the maneuver consists of partial control rod insertion with a subsequent full withdrawal. The normalized axial power peak is also increased by timing the rod withdrawal to coincide with the peak xenon spatial power redistribution.

A spreadsheet, based on a first-principles approach, assisted in the initial estimation of the PCT changes. It used the quasi-steady-state steaming rate, minimum core mixture level, and representative surface heat transfer rates at the conditions and time of the PCT to develop the initial PCT estimates. The quasi-steady-state approximation predicts a conservative estimate for SBLOCA PCT changes with the axial power shape change. It is a reasonable yet conservative tool that is applicable provided the PCTs do not reach ranges with significant metal water reaction contribution changes (for example >1800°F). Several cursory cases were initially performed with the computer code RELAP5/MOD2-B&W to confirm the validity of the bounding spreadsheet approximations. The spreadsheet estimations, cursory RELAP5 cases, and recently completed RELAP5 analyses support the conclusion that the PCT could increase up to a maximum of 225°F for some cases. As a result, SBLOCA 10 CFR 50.46 30-day reports with this bounding, generic, 225°F PCT increase were prepared for each B&W-designed 177-FA plant that used the BWNT LOCA EM SBLOCA method (BAW-10192).

Evaluation of the SBLOCA Axial Peak Changes

There are two components associated with the SBLOCA PCT changes. They include: (1) the time-in-cycle axial power shapes, and (2) the PCT differences realized with an axial power shape change for the spectrum of break sizes. Additional information is provided for each of these in the following paragraphs.

Generally, core total peaks are the highest for fresh fuel at the limits of allowable operation. The key peaking component at the beginning-of-cycle (BOC) is the high radial peaks predicted at this time in life. When combined with the axial peaks, the highest total peaking predictions are produced. The radial peaks generally decrease with increasing burnup. As the cycle progresses, the total peaking decreases, and there are larger margins to the allowed LOCA linear heat rate (LHR) limits. When the total peaking is lower, the maximum PCT should also decrease.

The initial questions on the validity of the axial power shape originated with SBLOCA scoping analyses performed for a 177-FA plant considering an extended power uprate (EPU). The upper regions of the core were uncovered for a longer time period with the uprated core power. As a result, the maneuvering analyses were reviewed to determine if the radial and axial peaks used in the SBLOCA were bounding. The questions led to review of some preliminary EPU cycle designs. The conclusion was that the radial and the 1.7 axial were bounding, but the elevation of the axial peak could be higher than the current EM SBLOCA axial peak (9.5 feet). The increase in elevation had been considered and accounted for in the LBLOCA analyses and limits but had not been considered for the SBLOCA cases. Given that the large and small break spectrum PCTs are now reported separately, these new SBLOCA peaking considerations need to be incorporated into the BWNT SBLOCA EM analyses.

Review of the representative core power distributions showed that at BOC the top-skewed axial power profile was bounded by the 9.5-feet axial power shape used in the current SBLOCA analyses. Figure 1 provides this comparison. Also, shown in this figure is a middle-of-cycle (MOC) axial power shape at 375 effective full power days (EFPD). The peak locations coincide with the MOC case and the axial shape is also reasonably bounded by the SBLOCA analysis shape. With increasing core burnup, the margins between the maneuvering analysis peaks and the LOCA normalized axial peak increases, but the axial peak elevations are no longer bounded by the shape used in the previous SBLOCA analyses. In Figure 2 the 575 EFPD burnup axial peak is just barely bounded by the 9.5-feet SBLOCA axial shape, but the 715 EFPD elevation of the axial peak is not bounded.

Figure 3 combines all the power shapes and shows the increasing elevation of the axial peaks with increased burnup. To bound the EOC peak elevations, a new SBLOCA normalized axial power shape was created. The 11-feet axial peak selected for use in new SBLOCA analyses is shown in Figure 4 along with the BOC and EOC shapes. The 11-feet shape covers all times in cycle; however, it is very conservative for the BOC case. The EOC peaks were generated by core power distribution cases that typically produce imbalances larger than those allowed by Technical Specifications for plant operation. If the Technical Specification allowable axial power imbalance limits were used, the elevations of the axial peaks would not change, but the magnitude of the axial peak would decrease. Unless cycle-specific SBLOCA analyses were undertaken, the 1.7 normalized axial shape peaked at the 11-feet elevation should be used to bound all current and future cycles. The magnitude of the peak is bounding for EOC peaks and its use in the SBLOCA analyses with maximum allowed LHR limits (total peaks) will not impact the plant LOCA limits specified in the Core Operating Limits Report or add considerable efforts to the cycle-specific maneuvering analyses. The described selection imposes additional conservatism on the SBLOCA calculated PCTs by imposing higher axial peaks to avert LHR limit reductions and minimize the burden on the future cycle-specific core peaking design checks.

Each B&W-designed plant has different high pressure injection, EFW systems, and low pressure injection flows and piping arrangements as well as different core flood tank (CFT) initial conditions. Several plants have analyses performed at uprated core power levels to support future EPU transitions. These plant and analysis differences result in PCT variations over the spectrum of small break sizes. Generally, the SBLOCA PCT is produced by a smaller to intermediate break size (~0.07 – 0.15 feet^2). For most plants, the PCTs occur 10 to 20 minutes after break opening and slightly after the CFTs begin to inject. One plant has a limiting PCT case for a much smaller break size that does not have CFT injection, and the PCT occurs later in the transient. If the transient evolves slowly, then the fuel pin temperature distribution approaches a quasi-steady-state condition in which the temperature differences established near the time of PCT are sufficient for the superheated steam to remove the core decay heat generation rate. The integrated decay heat energy generated below the mixture level creates a steaming rate that can be used to determine the enthalpy rise of the steam surrounding the PCT location.

The core power at the time of the quasi-steady-state conditions determines the temperature difference between the cladding and steam. If the decay heat is lower, the

PCT is lower. The core power decreases above the original 9.5-feet axial peak in the core; therefore, the cladding temperature decreases with increasing elevation. Figure 5 shows a representative steam and cladding temperature approximation when the 9.5-feet axial peak is used with a 10-feet mixture level. In this case, the peak power location is below the mixture level and the PCT is predicted at approximately 10.3 feet with a steam temperature that is closer to the saturation value. The PCT occurs at a location in the rod with a power level that is considerably lower than the total peak. Since the power peak is lower, the PCT is lower.

When the 11-feet axial peak is used for a similar case, the PCT occurs near the peak power location. Figure 6 adds the cladding and steam temperatures for the 11-feet axial peak along with the 9.5-feet temperatures from Figure 5. The two key differences are that the steam temperature and power generation are higher. Consequently, the steam temperature plus the temperature difference between the cladding and steam, results in the maximum PCT value at the 11.3-feet core elevation. This resultant PCT is approximately 225°F higher than the 9.5-feet axial PCT based on the quasi-steady-state prediction.

Several cursory SBLOCA RELAP5 cases were performed with the axial power shape changed from 9.5-feet to 11-feet peak elevation. These EM-method based cases also confirmed that the 225°F increase was a bounding value for the PCT cases. Since the time when the issue was identified, one revised SBLOCA spectrum has been completed and documented for one 177-FA lowered-loop plant. These new SBLOCA analyses used the 11-feet axial power shape and other input changes to the actinide decay heat contribution and the steam generator tube plugging fractions. These changes do not significantly change the PCTs, but they would both tend to increase the PCTs slightly. Figure 7 shows the PCT differences for the two cold leg pump discharge (CLPD) spectrums.

The PCT differences observed for the spectrum of CLPD breaks in Figure 7 show that the 225°F value assigned to the PCT is reasonable, yet bounding. The smaller break sizes for this spectrum did not have core uncovering so there was no PCT increase. The intermediate to larger SBLOCAs had PCT increases less than the 225°F value assigned generically to all plants prior to completion of any formal reanalyses. The larger SBLOCA sizes evolve rapidly and do not have time to achieve the quasi-steady-state conditions used to develop the 225°F estimated increase. For these reasons, the PCT differences for larger SBLOCAs will be smaller than the 225°F value assigned to the limiting PCT case. The smaller break sizes have more potential to evolve to the quasi-steady-state conditions that were assumed. These break sizes, however, achieve those conditions at a later time, with a lower decay heat level and generally higher mixture level. When the decay heat is lower, the cladding to steam temperature difference is less and the PCT increase will be less than the 225°F assigned to all breaks with core uncovering at an earlier time period in the CR evaluation. The overall conclusion is that the PCT increase for all plants is expected to be less than the 225°F estimate created to provide a reasonable bounding value for the limiting SBLOCA.

In conclusion, the information provided above includes a discussion of the history of the SBLOCA axial power shape and the factors contributing to the error in determining a bounding axial power shape for use in SBLOCA analyses. Evidence is provided to show that the 11-feet axial power shape is a conservative Appendix K compliant model that is bounding for any time in the cycle and predicts bounding PCTs. The impact of this error on the full spectrum of postulated break sizes was discussed and was shown that the 225°F increase is a bounding generic value. While the current approach used a bounding axial peak of 1.7 at 11 feet, this axial peak or elevation is not explicitly fixed by the SBLOCA EM and could be adjusted if necessary to bound future cycle-specific axial peaks.

The SBLOCA EM is a deterministic method with considerable conservatisms imposed by the regulations and added by the inputs selected and method of analyses. It is conservative for the purpose of maximizing SBLOCA PCTs. The additional conservatism of imposing the 11-feet axial power shape is applied to minimize the additional burden on the time-in-cycle analyses or reload peaking evaluations.

FENOC's planned corrective actions and actions to prevent reoccurrence

FENOC maintains an engineering calculation that summarizes the analyses performed for, and results of, both LBLOCAs and SBLOCAs. An action has been entered into the FENOC Corrective Action Program to update this calculation to include the increased PCT (that is 225°F) for SBLOCAs associated with the increased axial flux shape as estimated by AREVA's simplified model. As required by plant procedures, applicable outputs from the engineering calculation will be incorporated into the DBNPS Updated Final Safety Analysis Report.

AREVA is contracted by FENOC to perform LOCA analyses. AREVA indicated that they will prevent reoccurrence by establishing a reload analysis check to confirm that the axial peaking elevation and the magnitude of the peak utilized by the SBLOCA analysis is bounding. FENOC will prevent reoccurrence by using the Corrective Action Program to monitor and verify that AREVA has taken actions to prevent reoccurrence.

2. If a plant-specific assessment regarding the modeling errors was not performed, justify the use of any generic evaluation.

Response

The estimated PCT increase of 225°F was assigned to the DBNPS limiting SBLOCA case PCT of 1,555°F resulting in an estimated PCT of 1,780°F for MOC to EOC conditions. The SBLOCA analyses were performed at an EPU power level that is roughly 7 percent higher than the licensed power level. The previous PCT value of 1,555°F is expected to be a conservative estimate at the current analyzed power level of 2,827 megawatts thermal with an 11-feet axial peak. This engineering judgment was supported with a DBNPS specific RELAP5/MOD2-B&W scoping analysis. Given the conservatisms in the generic analysis and the scoping analysis conclusions, there are no plans for revising SBLOCA RELAP5/MOD2-B&W analyses to update the axial power shape.

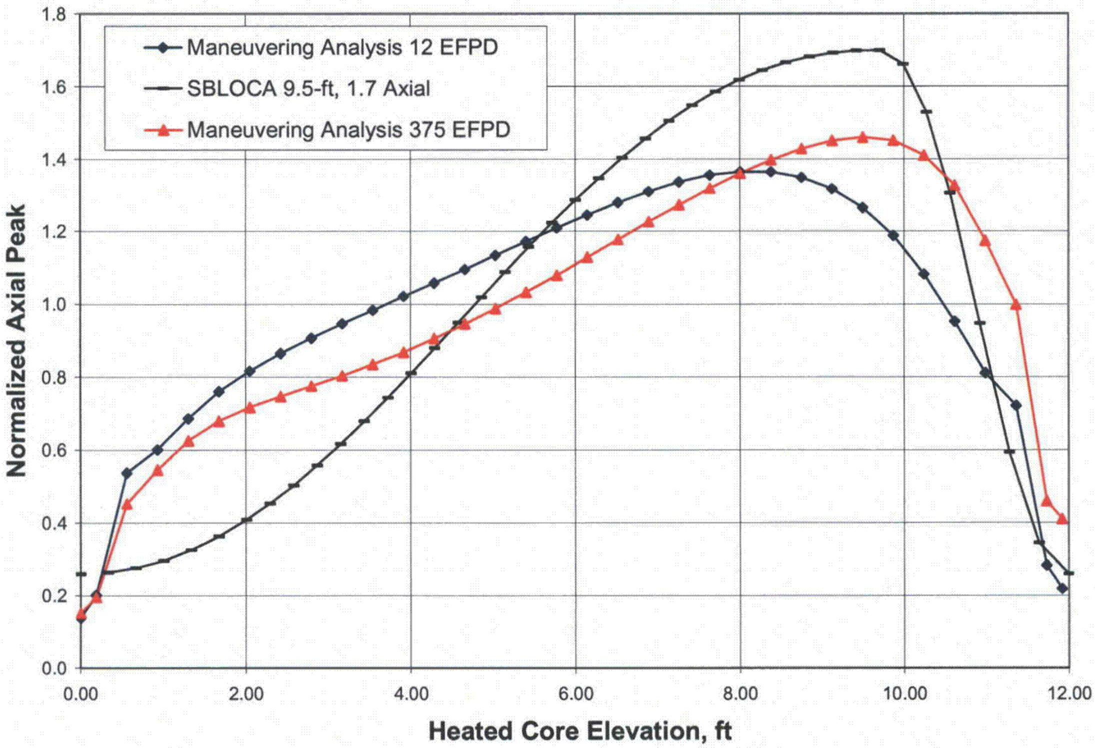

Figure 1. SBLOCA 9.5-ft Axial Shape with Characteristic BOC and MOC Limiting Axial Shapes

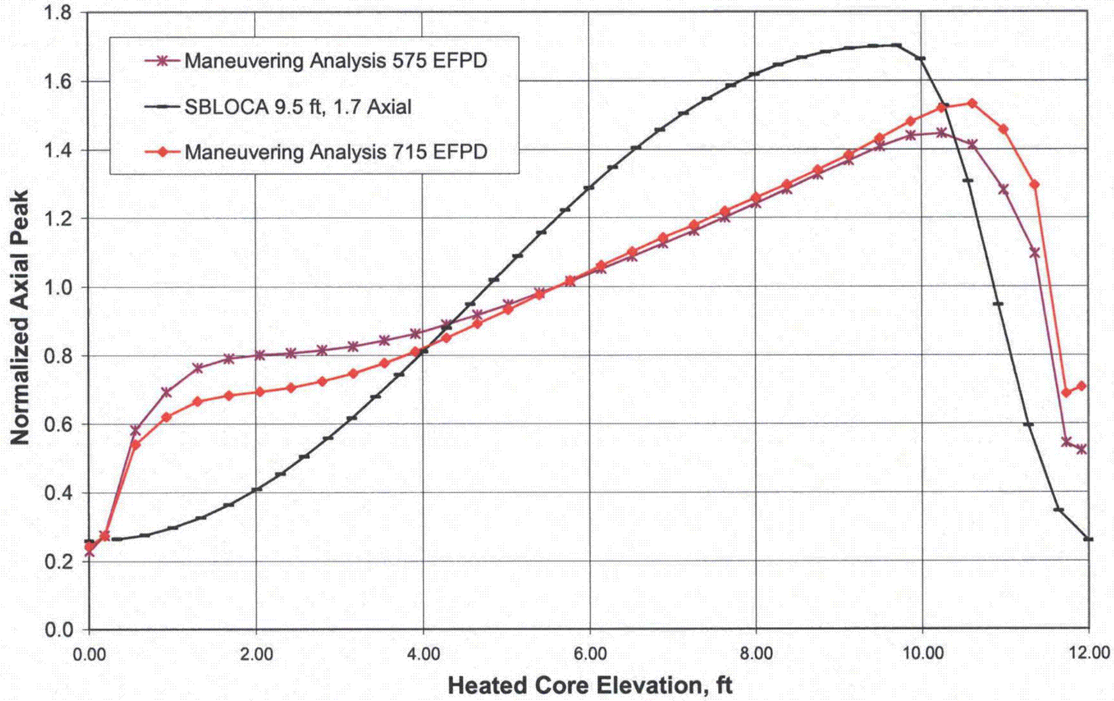

Figure 2. SBLOCA 9.5-ft Axial Shape with Characteristic EOC Limiting Axial Shapes

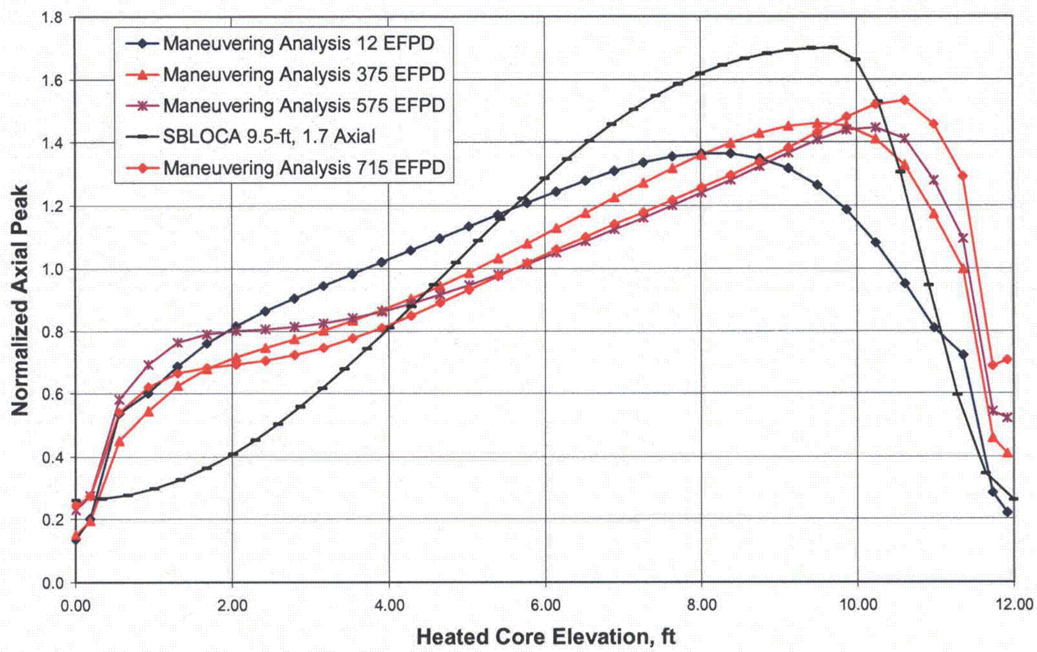

Figure 3. SBLOCA 9.5-ft Axial Shape with Characteristic Limiting Axial Shapes for all Times in Cycle

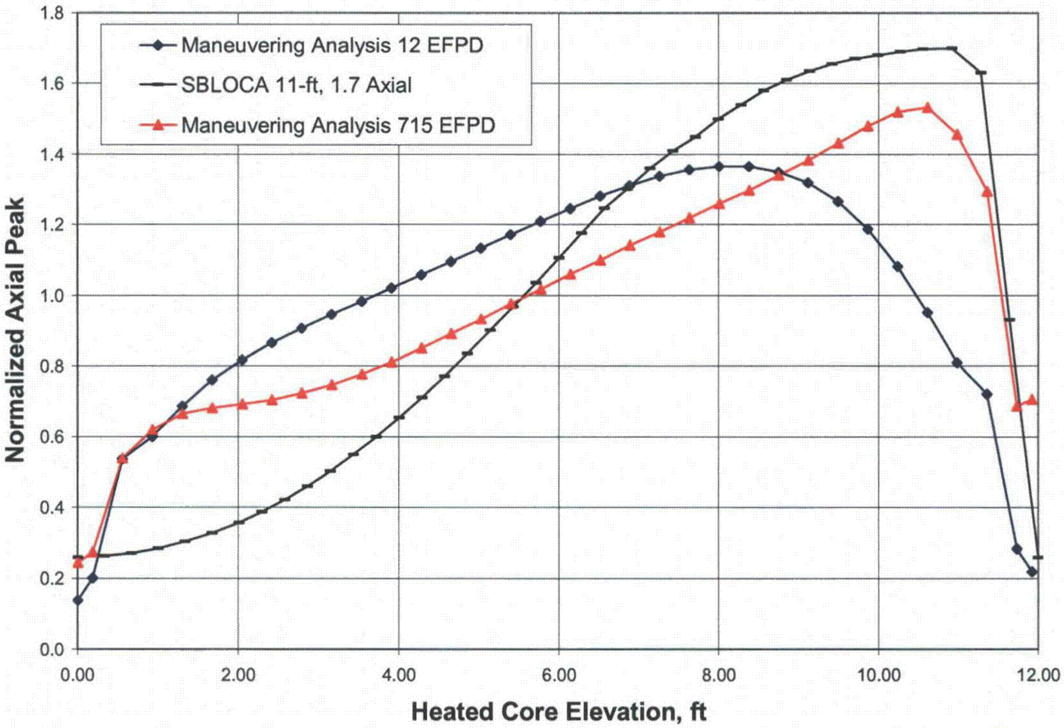

Figure 4. SBLOCA 11-ft Axial Shape with Characteristic BOC and EOC Limiting Axial Shapes

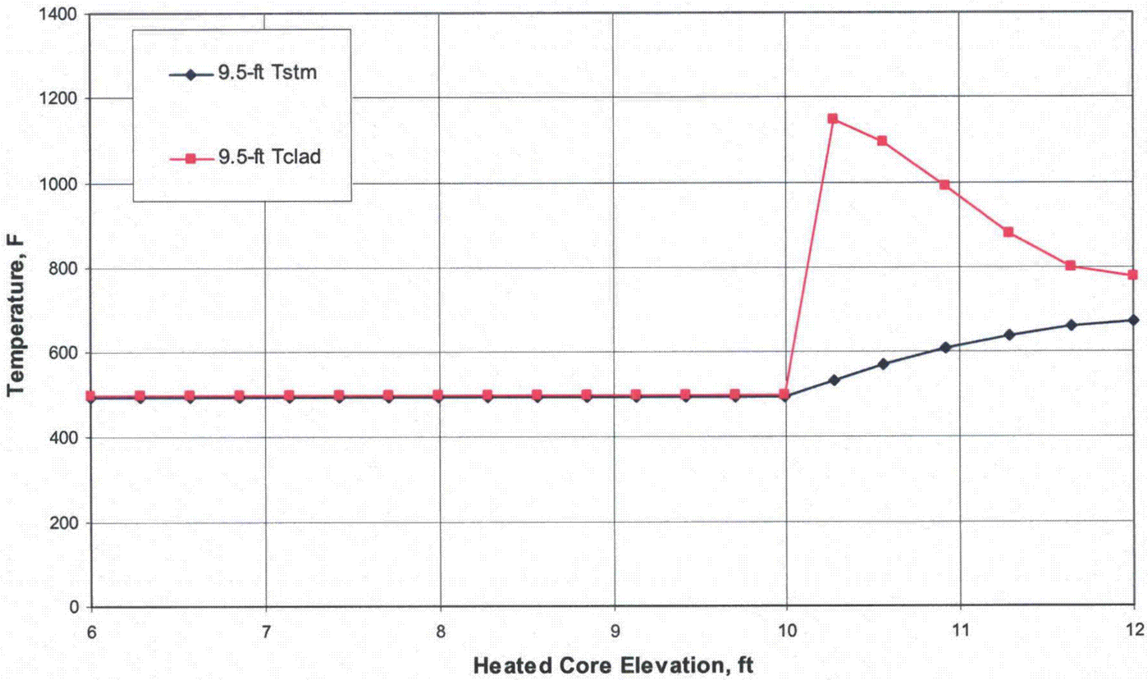

Figure 5. Quasi-SS SBLOCA Steam and Clad Temperatures with a 10 ft Mixture Level at 20 Minutes

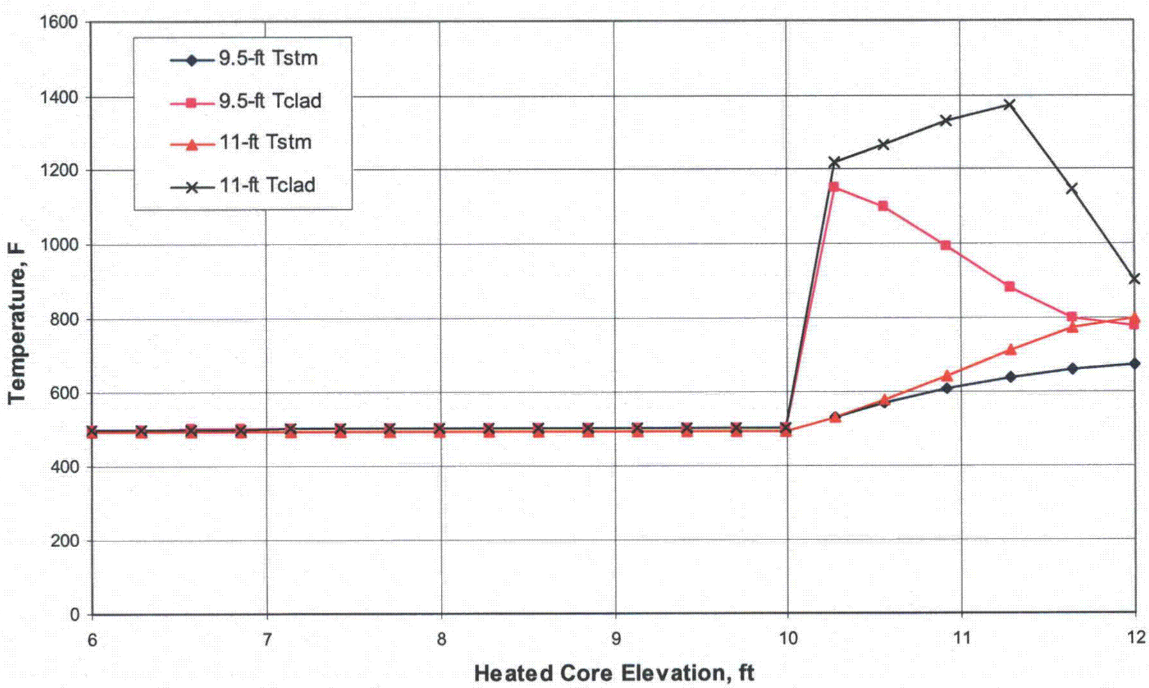

Figure 6. Quasi-SS SBLOCA Steam and Clad Temperatures with a 10 ft Mixture Level at 20 Minutes

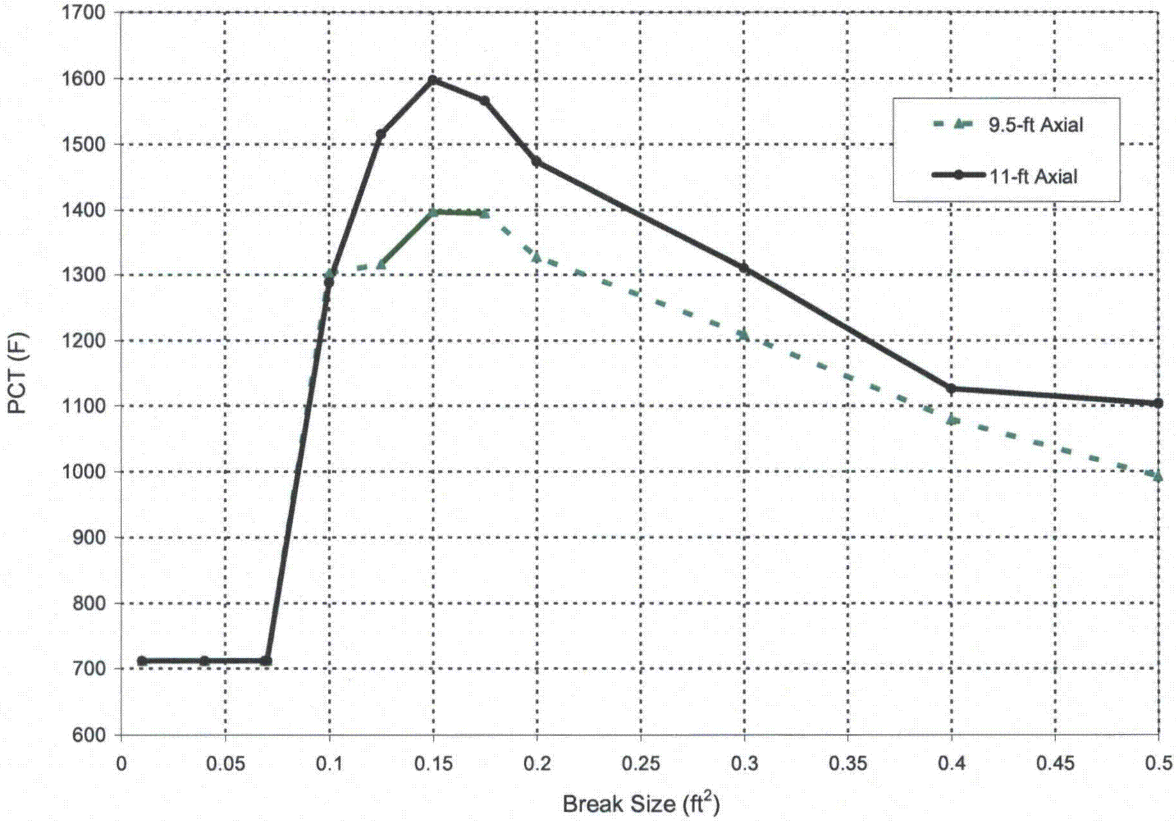

Figure 7. Plant-Specific Mark-B-HTP SBLOCA PCT Comparison versus Break Size

Note: There are several minor input differences other than the axial power shape included in these spectrum results. In the 11-feet SBLOCA spectrum analyses, the steam generator tube plugging is higher by 2 percent, there was a full-core Mark-B-HTP fuel, and higher actinide decay heat contribution. It is estimated that the increase in PCT from the other changes is 20 to 40°F. In addition, the PCTs for the 9.5-feet cases other than at 0.125, 0.15, and 0.175 feet^2 were estimated based on analyses with a different fuel design. The Mark-B-HTP 9.5-feet axial analyzed cases are shown as a solid line and the estimated cases based on the Mark-B11 fuel design is shown as a dashed line.