Framatome ANP
An Areva and Siemens Company

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Response to a Request for Additional Information Regarding Addendum 3 to BAW-10199(P) "The BWU Critical Heat Flux Correlations"

Ref. 1: Letter, James F. Mallay (Framatome ANP) to Document Control Desk (NRC), "Request for Review and Approval of Addendum 3 to BAW-10199(P), 'The BWU Critical Heat Flux Correlation'," NRC:04:028, August 17, 2004.

Framatome ANP requested the NRC's review and approval of Addendum 3 to the topical report BAW-10199(P), "The BWU Critical Heat Flux Correlations" in Reference 1. A request for additional information was provided by the NRC in an e-mail on February 2, 2005. The questions and responses to this request are provided in Attachment A to this letter.

Sincerely,

Jerald S. Holm, Director
Regulatory Affairs

Enclosure

cc: M. C. Honcharik
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Attachment A

REQUEST FOR ADDITIONAL INFORMATION
BAW-10199P, ADDENDUM 3
The BWU Critical Heat Flux Correlations

The BWU-B11R CHF Correlation for the Mark-B11 Spacer Grid

Question 1: *Clarify whether or not Addendum 3 to BAW-10199(P) is an independent document (similar to Addendum 2) or a part of Appendix I in BAW-10199(P).*

Response 1: Addendum 3 contains Appendix I. It is, indeed, an independent document similar to Addendum 2. Note that Addendum 2 contains Appendices G and H. Appendix G is the application of the BWU-Z correlation to the Mark-BW17 MSM design and Appendix H contains the response to the NRC RAI on Appendix G. The final issue of Addendum 3 will be a stand alone report containing Appendix I.

Question 2: *As indicated in Section 2.0, the bundle condition CHF data for the Mark-B11 design was reported in Table E-6 of Addendum 1, which has 251 data. However, the new correlation presented in Addendum 3 is based solely on the 222 data from 5 different Mark-B11 CHF tests. Please provide the following information:*

a) a description of the databases used to develop the BWU-B11R CHF Correlation and why test 27.0 plays no role in this correlation development;
b) identification of 3 outliers and 3 out of range conditions data; and
c) justification and criteria to exclude only one outlier and to include the 3 out of range conditions.

Response 2:

a) The CHF test grids used in test 27.0 were intentionally designed with a vane angle smaller than the remaining Mark-B11 tests to determine the CHF performance impact of the vane angle reduction. The CHF test grids in all of the other Mark-B11 tests (26.0, 27.1, 28.0, 29.0, and 30.0) were designed with a vane angle consistent with the angle used in the Mark-B11 production fuel. Note 4 of Table E-1 on page E-6 of Addendum 1 states that test 27.0 was performed on a non-standard Mark-B11 design and was not analyzed in that application.

b) The three outliers were data points 29051, 29059 and 29064 (see Table E-7 page E-16 of Addendum 1). The M/P CHF ratios of each of these data were in excess of four standard deviations from the mean. (It is common practice in CHF correlation development to exclude data whose M/P CHF ratio deviates more than 3.5 standard deviations from the mean M/P CHF ratio of the correlation database. (3.5 standard deviations from the mean implies a probability of approximately 0.1 percent that this data point is actually in the database without error.) The three out of range conditions were data points 28061, 28062, 28063 (see Table E-7 page E-16 of Addendum 1). Each of these data was taken at a pressure of 315 psia. Since the BWU-Z correlation was being applied to the Mark-B11 data and since the lower limit of the BWU-Z correlation was 400 psia, these low pressure data were considered out of range (for any BWU-Z correlation application).

c) Since a new correlation was being developed specifically for the Mark-B11 spacer grid, it was appropriate to see if the entire eligible data base of 222 points could be successfully fit. Therefore, the excluded data in Addendum 1, three low pressure data at 315 psia and three outliers, were included in the data base for the new correlation. As expected, optimization of the uniform CHF coefficients on this homogeneous data base resulted in a much improved fit as compared to the forced fit to the original BWU-Z correlation. This can be seen in the improved standard deviation (reduced to 0.0679 from 0.0865 in Addendum 1) and the unbiased M/P CHF performance in the independent variable scatter plots (Figures I-1 through I-4). The improved correlation fit resulted in only one outlier, noted in Section 2.0, based on the criterion discussed above in Response 2b.

Question 3: *Describe in detail the approach and technical basis to obtain the uniform coefficients for the BWU-B11R CHF correlation in Table I-5. Additionally, provide clarification for the note under Table I-5 as to why the resulting uniform CHF must be exponentiated with the coefficients.*

Response 3: The technical basis used to obtain the uniform coefficients of the BWU-B11R CHF correlation is described in Reference 7, page 6-1of BAW-10199P-A ("Linearization and Sequential Optimization of Nonlinear Empirical Equations"). Only the coefficients of the uniform part of the correlation were reoptimized (the FLS geometry term and non-uniform heat addition F factor were not modified) the technique was simple linearization without sequential optimization. As such, the coefficients are determined with a standard least squares fitting routine.

The exponentiation of the uniform CHF is the result of a log transformation being applied to the dependent variable before optimization of the coefficients. Transformation of variables is a standard technique used in an attempt to obtain an improved correlation of the data. An improved correlation is evidenced by a decrease in the coefficient of variation or an improvement in some other figure of merit of the correlation.

Question 4: *Provide justification that the statistical method to develop the design limit (DNBR(L)) is conservative within the BWU-B11R range of application in Table I-6.*

Response 4: The technical development of the design limit is described in Section 4.0 (page 4-2) of the original topical. The technique is applied to the Mark-B11 grid in Section 4.0 of Addendum 3 (page I-2) where the standard deviation is adjusted (increased) for the number of degrees of freedom. Normality of the data was verified (Figure I-5) and uniformity of results over the entire range of independent variables was confirmed (Tables I-2 through I-4). These demonstrations of the quality of the M/P CHF results of the new correlation confirm the applicability of the 1.145 design limit for 95 percent protection with 95 percent confidence.