February 22, 2005

Document Control Desk
U. S. Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852

Attention: Meena Khanna

Subject: Project No. 704 – BWRVIP RAMA Fluence Methodology

References:
1. Letter from Carl Terry (BWRVIP Chairman) to Document Control Desk (NRC), "Project 704 – BWRVIP-114: BWR Vessel and Internals Project, RAMA Fluence Methodology Theory Manual," dated June 11, 2003.
2. "Letter from Carl Terry (BWRVIP Chairman) to Document Control Desk (NRC), Project No. 704 – BWRVIP-115: BWR Vessel and Internals Project, RAMA Fluence Methodology Benchmark Manual – Evaluation of Regulatory Guide 1.190 Benchmark Problems," dated June 26, 2003.
3. "Letter from Carl Terry (BWRVIP Chairman) to Document Control Desk (NRC), Project No. 704 – BWRVIP-117: BWR Vessel and Internals Project, RAMA Fluence Methodology Plant Application – Susquehanna Unit 2 Surveillance Capsule Fluence Evaluation for Cycles 1-5," dated August 5, 2003.
4. "Letter from Carl Terry (BWRVIP Chairman) to Document Control Desk (NRC), Project No. 704 – BWRVIP-121: BWR Vessel and Internals Project, RAMA Fluence Methodology Procedures Manual," dated October 29, 2003.
5. "Letter from William A. Eaton (BWRVIP Chairman) to Document Control Desk (NRC), "Hope Creek Flux Wire Dosimeter Activation Evaluation for Cycle 1 Using the RAMA Fluence Methodology," dated March 23, 2004.
6. "Letter from William A. Eaton (BWRVIP Chairman) to Document Control Desk (NRC), Project No. 704 – BWRVIP-128: BWR Vessel and Internals Project, Updated Fluence Calculations for Supplemental Surveillance Capsules D, G, and H Using RAMA Fluence Methodology," dated September 24, 2004.
7. "Letter from to William A. Eaton (BWRVIP Chairman) to Meena Khanna (NRC), "Project No. 704 – BWRVIP Response to NRC Request for Additional Information on BWRVIP-114, -115, -117 and -121," dated September 29, 2004.

On June 11, 2003 the BWRVIP submitted to the NRC the RAMA Theory Manual (Reference 1) which provided a description of the fluence methodology under development for application to BWRs. Since that time, the BWRVIP has submitted five additional reports (References 2-6) and responded to a NRC Request for Additional Information (Reference 7).

D058

These BWRVIP reports and responses to the RAI were transmitted to the NRC as a means of exchanging information with the NRC for the purpose of supporting generic regulatory improvements related to methodologies to determine neutron fluence in BWR internal components.

The BWRVIP believes that all activities to establish that the RAMA Fluence Methodology conforms to the requirements set forth in Regulatory Guide 1.190 have been completed. Therefore, the BWRVIP intends to implement the RAMA Fluence Methodology for calculating the fluence of surveillance capsules, the reactor pressure vessel, and the core shroud within the active fuel height.

The following summarizes the submittals regarding the RAMA Fluence Methodology, presents overall conclusions, and describes ongoing and planned activities related to RAMA.

BWRVIP-114: RAMA Fluence Methodology Theory Manual

BWRVIP-114 provides a description of the RAMA code and associated theory. The methodology includes an advanced three-dimensional nuclear particle transport theory code that performs neutron and gamma flux calculations. It couples a three-dimensional, multi-group deterministic nuclear transport theory method with a combinatorial geometry modeling capability to provide a flexible and accurate tool for determining fluxes for any light water reactor design. The code supports the method of characteristics transport theory solution technique, a three-dimensional ray-tracing method, combinatorial geometry, a fixed source iterative solution, anisotropic scattering, thermal-group upscattering treatments, and a nuclear cross-section data library based upon the ENDF/B-VI data. The methodology adheres to the requirements set forth in NRC Regulatory Guide 1.190 for pressure vessel neutron fluence determinations.

BWRVIP-115: RAMA Fluence Methodology Benchmark Manual – Evaluation of Regulatory Guide 1.190 Benchmark Problems

This report documents the results of the numerical and experimental benchmark cases prescribed by Reg. Guide 1.190. The following benchmark problems were evaluated; Pool Critical Assembly, Venus-3, H.B. Robinson and BWR Numerical Benchmark. The RAMA calculated results for all benchmarks are in good agreement with the measurements. Sensitivity analyses demonstrate that the results from the evaluations of the benchmark problems are stable with respect to the important mesh and solution parameters used in the neutron transport calculations.

BWRVIP-117: RAMA Fluence Methodology Plant Application – Susquehanna Unit 2 Surveillance Capsule Fluence Evaluation for Cycles 1-5

This report describes the results of a plant-specific demonstration of RAMA to calculate the capsule flux wire activities and fluence at the end of cycle 5 for the Susquehanna Unit 2 reactor.

The analyses showed that the total average calculated-to-measured (C/M) results of specific activities for all flux wires was determined to be 0.98 with a standard deviation of ±8%. These C/M ratios are in very good agreement indicating the RAMA Fluence Methodology is accurately predicting fluence and flux. The total capsule neutron fluence analytic uncertainty is 15.0% for energy >1.0 MeV and 15.0% for energy >0.1 MeV. The largest source of the capsule neutron fluence analytic uncertainty is attributable to the geometry parameters, with the reactor pressure vessel inner radius dimension having the single highest uncertainty of 10.0% for energy >1.0 MeV. By combining the measurement uncertainty and analytic uncertainty, the combined capsule fluence uncertainty is determined to be 17.2% for energy >1.0 MeV and 17.2% for energy >0.1 MeV.

Therefore, the RAMA Fluence Methodology produces accurate results that compare very well with measured data.

<u>Hope Creek Flux Wire Dosimeter Activation Evaluation for Cycle 1 Using the RAMA Fluence Methodology</u>

This report documents the results of a surveillance capsule flux wire dosimeter activation evaluation performed for the Hope Creek reactor at the end of cycle 1. A total average calculated-to-measured (C/M) result of specific activities for all flux wires was determined to be 0.93 with a standard deviation of ±4.1%. This result provides additional evidence that the RAMA Fluence Methodology is accurately predicting fluence and flux in BWR operating environments.

<u>BWRVIP-128: Updated Fluence Calculations for Supplemental Surveillance Capsules D, G, and H Using RAMA Fluence Methodology</u>

This report describes an evaluation of three surveillance capsules designated D, G and H which were irradiated at Oyster Creek and were analyzed using the RAMA computer code.

The report presents results for the predicted fluence at the capsule location as well as comparisons of predicted to measured activities of the copper and iron flux wires. The average predicted fluence (E >1.0 MeV) for the three capsules is approximately 1.5×10^{18} neutrons/cm^2. The neutron transport calculation and capsule dosimetry measurements are in very good agreement. The ratio of the calculated-to-measured (C/M) activities for the combined iron and copper flux wires in capsule D was determined to be 0.93 with a standard deviation of ±4%, for capsule G was 0.98 with a standard deviation of ±6%, and for capsule H was 0.98 with a standard deviation of ±5%. Overall, the C/M ratios are in good agreement indicating that the RAMA Fluence Methodology is accurately predicting fluence and flux.

<u>BWRVIP-121: RAMA Fluence Methodology Procedures Manual</u>

This report contains modeling guidelines and procedures for application of the RAMA Fluence Methodology software package in performing a fluence evaluation for a typical boiling water reactor (BWR). This manual describes the entire fluence evaluation process. It begins with determining the problem to be analyzed, describing computer resource requirements, and collecting the required data. Detailed information covers building geometry models for the reactor and components of interest, processing material data, evaluating flux and fluence results generated by the methodology, and performing an uncertainty analysis of the results. Guidelines are provided for determining and applying the bias and uncertainty parameters to the fluence evaluation in accordance with Regulatory Guide 1.190.

Responses to RAIs on BWRVIP-114, -115, -117 and -121

The BWRVIP provided responses to numerous RAIs. As a result, the BWRVIP believes that all questions have been adequately addressed.

Uncertainty and Bias Determinations

The combined reactor pressure vessel uncertainty is the weighted sum of the analytic, plant-specific comparison, and benchmark comparison uncertainties as described in the RAMA Theory Manual (Reference 1) and the Response to NRC Request for Additional Information on RAMA Fluence Methodology (Reference 7). The analytic uncertainty (1σ) has been determined to be on the order of 12% to 15%, depending upon key plant-specific considerations, such as the presence of as-built dimensional information and detailed plant operating data. RAMA Fluence Methodology predictions have been compared to a total of 302 BWR reactor surveillance capsule measurements from both jet pump and non-jet pump plants. The measurement samples consisted primarily of iron and copper flux wires, with some limited titanium and nickel samples. The measurement-to-calculation ratio (M/C) for these comparisons is 1.02, leading to a plant-specific comparison bias of +2%, with an overall uncertainty (1σ) of 7%. Simulator benchmark comparisons have been performed for a total of 413 measurement values from the Pool Critical Assembly (PCA) and VENUS-3 benchmark studies. The measurement-to-calculation ratio for all simulator benchmark comparisons is 0.97, leading to a benchmark comparison bias of -3%, with an overall uncertainty of 7%. The resulting combined uncertainty is determined to be on the order of 8% to 9%. The observed bias from the plant-specific and simulator benchmark comparisons is well below the combined uncertainty so that no statistically significant combined bias exists in the RAMA Fluence Methodology.

Conclusions

Analyses performed to date demonstrate that the RAMA Fluence Methodology is accurately predicting fluence and flux in BWR operating environments and consequently, the methodology is suitable for calculating the fluence of surveillance capsules, the reactor pressure vessel and the core shroud within the active fuel height.

The BWRVIP believes that all activities to establish that the RAMA Fluence Methodology conforms to the requirements set forth in Regulatory Guide 1.190 have been completed and is acceptable for generic application for calculating BWR fluence.

If you have any questions on this subject, please contact George Inch (Constellation Generation Group, BWRVIP Assessment Committee Chairman) by telephone at 315.349.2441.

Sincerely,

William A Eaton

William A. Eaton
Entergy Operations
Chairman, BWR Vessel and Internals Project