April 20, 2004

Bill Eaton, BWRVIP Chairman
Entergy Operations, Inc.
Echelon One
1340 Echelon Parkway
Jackson, MS 39213-8202

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION - REVIEW OF BWR VESSEL AND INTERNALS PROJECT REPORTS, BWRVIP-114, BWRVIP-115, BWRVIP-117, AND BWRVIP-121, AND TRANSWARE ENTERPRISES INC. REPORT TWE-PSE-001-R-001, REVISION 0 (TAC NO. MB9765)

Dear Mr. Eaton:

By applications dated August 1, August 5, October 23, and October 29, 2003, respectively, you submitted for NRC staff review, four Electric Power Research Institute (EPRI) proprietary reports, BWRVIP-114, "RAMA Fluence Methodology Theory Manual," BWRVIP-115, "RAMA Fluence Methodology Benchmark Manual-Evaluation of Regulatory Guide 1.190 Benchmark Problems," BWRVIP-117, "RAMA Fluence Methodology Plant Application-Susquehanna Unit 2 Surveillance Capsule Fluence Evaluation for Cycles 1-5," and BWRVIP-121, "RAMA Fluence Methodology Procedures Manual." In addition, by application dated March 23, 2004, you submitted for NRC staff review, TransWare Enterprises, Inc. Report, TWE-PSE-001-R-001, Revision 0, "Hope Creek Flux Wire Dosimeter Activation Evaluation for Cycle 1 Using the RAMA Fluence Methodology." These reports were submitted 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 NRC staff has completed its initial review of the BWRVIP-114, BWRVIP-115, BWRVIP-117, and BWRVIP-121 reports, and the TransWare Enterprises, Inc. Report, TWE-PSE-001-R-001, Revision 0. As indicated in the attached request for additional

information (RAI), the NRC staff has determined that additional information is needed to complete the review. If you have any questions, please contact Meena Khanna at (301) 415-2150.

Sincerely,

/RA/

Stephanie M. Coffin, Chief
Vessels & Internals Integrity and Welding Section
Materials and Chemical Engineering Branch
Division of Engineering
Office of Nuclear Reactor Regulation

Project No. 704

Enclosure: As stated

cc: BWRVIP Service List

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REQUEST FOR ADDITIONAL INFORMATION
FOR THE REVIEW OF THE ELECTRIC POWER RESEARCH INSTITUTE (EPRI) RAMA METHODOLOGY FOR REACTOR PRESSURE VESSEL FLUENCE EVALUATION

BWRVIP-114: "BWR Vessel and Internals Project, RAMA Fluence Methodology Theory Manual"

RAI 114-1 In the plant-specific applications, what specific tests and criteria are used to assure the adequacy of the number of rays and the number of volumes used in the RAMA fluence calculations?

RAI 114-2 It is not evident that the RAMA geometry model described in Ref. 1 provides a correct representation of the true geometry (i.e., preserves the location, orientation and shape of all surfaces defining the physical geometry). For example, the modeling of the reflector region, surrounding the core, involves geometry elements that have both planar and cylindrical side boundaries. Since the geometry elements described in Ref. 1, Section 3.2, do not include bodies of this type, does RAMA introduce any distortion of the physical geometry in modeling the reflector and, if so, how is this distortion controlled to ensure acceptable accuracy?

RAI 114-3 The equation provided in Ref. 1, (Equation 7-38) for determining the M/C bias for the benchmark database requires an additional 1/M multiplicative normalization factor.

RAI 114-4 Equation 7-40 of Ref. 1 combines the analytical bias (B_a) and the benchmark bias (B_{bi}) to determine the overall calculational bias. The analytical bias (B_a), defined in Equation 7-34, provides the effect of not using the optimum asymptotic calculational input in the RAMA fluence calculation. Since the benchmark biases include the effect of the approximate calculational input used in the benchmark calculations (i.e., use of the standard input parameters rather than the asymptotic parameters), the analytical bias is only required when there is an inconsistency between the input used in the vessel fluence calculations and the benchmark calculations; e.g., when the calculations of the benchmark measurements are made with the asymptotic input values and the vessel fluence calculations are made with the standard input values. The staff requests that the BWRVIP clearly address the determination of the bias.

RAI 114-5 The weights defined in Equation 7-41 are not normalized (i.e., sum to unity), as required. Also, the weights should reflect the reliability of the bias estimates. If, for example, a weight of $1/\sigma^2$ is used, the σ should represent the standard deviation of the bias estimate, not the standard deviation of the M/C data about the mean.

ATTACHMENT

RAI 114-6 The values of σ_a, σ_{b1} and σ_{b2} of Equation (7-43) represent the (one standard deviation) uncertainty in the RAMA calculated fluence, based on the analytical estimate of the uncertainties, comparisons with simulator benchmarks, and comparisons with operating plant data, respectively. These three uncertainty values represent independent estimates of the RAMA calculational uncertainty.

Therefore, the staff requests that the BWRVIP, in calculating the final estimate of the RAMA calculational uncertainty, σ_c, use an appropriately weighted combination of these three values, where each weight reflects the reliability of the uncertainty estimate, and then normalize the weights. The staff requests that the BWRVIP address this issue and provide a justification.

BWRVIP-115, "BWR Vessel and Internals Project, RAMA Fluence Methodology Benchmark Manual - Evaluation of Regulatory Guide 1.190 Benchmark Problems"

RAI 115-1 Identify all differences between the methods used in performing the RAMA benchmark analyses of Reference 2 and the methods that will be used in performing the calculations of the vessel and shroud fluence. Also, address how the effects of these inconsistencies will be accounted for in determining the RAMA calculational bias and uncertainty.

RAI 115-2 (a) Regulatory Guide 1.190 requires that, as they become available, new measurements are to be incorporated into the M/C database and the fluence calculational bias and uncertainty estimates are to be updated, as necessary. The staff requests that the BWRVIP address how it will ensure that new measurements are incorporated in the M/C database and that the fluence bias and uncertainty will be updated in a timely manner.

(b) How many BWR samples (measurements) are currently available and when is it anticipated that a statistically significant set of measurements will be available to evaluate the overall bias?

RAI 115-3 In the calculation of the VENUS-3 benchmark, it is stated that the source is normalized to the experimental results. If the experimental results used for this normalization are the fluence measurements (which would erroneously reduce the M/C uncertainty), rather than the measurements of the core source distribution, discuss the effect that this simplification has on the calculational bias and uncertainty inferred from this benchmark comparison.

RAI 115-4 In Table 2-24, the sensitivity of the RAMA calculation of the NUREG-6115 benchmark problem to the axial distance between parallel rays has not been included (as in Table 2-16 for the HBR-2 calculation). Please discuss the sensitivity of the RAMA calculation to the axial distance between parallel rays. Please present your results on the same (or a similar) graph as Figures 5.4.6 or 5.4.8 of NUREG-6115.

BWRVIP-117, "BWR Vessel and Internals Project, RAMA Fluence Methodology Plant Application - Susquehanna Unit 2 Surveillance Capsule Fluence Evaluation for Cycles 1-5"

RAI 117-1 In Ref. 3, what criteria was used to select the sixty-three state points used to represent the Cycle 1-5 core operating history and what determination criteria was used in the weighing assignments of each state point calculation?

RAI 117-2 Was the Susquehanna Cycle 1-5 power, void and exposure distribution data based on calculational results or plant process computer data? If this data was the result of recent calculations, rather than the original historical calculations, discuss why new calculations were required and what differences were introduced in the calculations. Also, discuss the effect of any approximations used in representing the state-point dependence of the pin-wise source distribution of the peripheral fuel bundles.

RAI 117-3 Discuss the basis for the Table 5-3 parameter uncertainty for the following locations: (1) capsule and flux wire locations, (2) vessel inner radius, (3) core void fraction, (4) peripheral bundle power, and the (5) iron cross section.

RAI 117-4 Describe the spatial mesh used to represent the capsule and the capsule/vessel water gap.

RAI 117-5 What fluence uncertainty is introduced by the uncertainty in the Cu-63(n, α)Co-60, Fe-54(n, p)Mn-54 and Ni-58(n, p)Co-58 dosimetry cross sections?

RAI 117-6 Provide a discussion of the method used to determine the analytical modeling input bias and the associated uncertainty provided in Table 5-3.

RAI 117-7 In view of the fact that the uncertainty in the bias, inferred from the measurements of Table 5-4, is larger than the bias itself, provide justification for applying this bias to the RAMA calculated fluence.

RAI 117-8 In view of the fact that the RAMA calculation of the benchmark measurements used the "standard" fluence input parameters and the C/M comparisons (and the inferred C/M bias), address the effect of these parameters and provide justification for applying the analytical bias to the RAMA fluence calculation.

RAI 117-9 Discuss the methods used to measure the flux wire activations and conformance to ASTM E-263-93 (Ref. 4), ASTM E-263-93 (Ref. 5) and ASTM E-264-92 (Ref. 6). Also, discuss the basis for the 2.5% measurement accuracy.

BWRVIP-121, "BWR Vessel and Internals Project RAMA Fluence Methodology Procedures Manual"

RAI 121-1 Ref. 7 states that the BWR shroud is a "priority 1 component." However, no mention or attempt was made to demonstrate how RAMA performs in the evaluation of the shroud. Provide benchmarking data and calculations for the core shroud.

RAI 121-2 The staff requests that the BWRVIP provide a justification of the statement in the BWRVIP-121 report, "The nature of the guidelines is applicable to BWR plants without jet pumps..." In most BWRs, the dosimeters are placed behind the jet pump, which introduces spectral distortions, particularly for Fe and Ni dosimeters. If the BWRVIP report is indicating that the RAMA bias and uncertainties, based on jet pump plants, are applicable to plants without jet pumps, then the staff requests that the BWRVIP justify this statement.

TWE-PSE-001-R-001, "Hope Creek Flux Wire Dosimeter Activation Evaluation for Cycle 1"

1. The surveillance capsule is situated directly behind the jet pump. Given the "window" in the inelastic scattering of Fe in the 1.0 to 2.5 MeV range, what is the effect of the spectrum on the Fe, Ni, and Cu activation?

2. There is no mention of the estimation of the neutron spectrum in these calculations. The report states that there are 12 segments in the cycle, with different material compositions. It seems that the major differences in these segments are the decreasing concentration of U-235, the increasing concentration of Pu-239, and the increasing concentration of fission products. How do these changes affect the spectrum and how is it calculated?

3. What were the findings/results from the sensitivity study? Are the parameter default settings optimized?

4. Given the systematic underestimation of the Cu dosimeters, address whether an investigation shall be launched to determine if a dosimeter-specific bias exists?

5. The report states that the Cu discrepancy could be due to Co-59 impurity. The staff requests that the BWRVIP address that dosimeters supposed to be chemically and isotopically pure?

REFERENCES

1. BWRVIP-114, “BWR Vessel and Internals Project, RAMA Fluence Methodology Theory Manual,” EPRI, Palo Alto, CA 2003 1003660.

2. “BWRVIP-115, “BWR Vessel and Internals Project, RAMA Fluence Methodology Benchmark Manual - Evaluation of Regulatory Guide 1.190 Benchmark Problems,” EPRI, Palo Alto, CA 2003 1008063.

3. “BWRVIP-117, “BWR Vessel and Internals Project, RAMA Fluence Methodology Plant Application - Susquehanna Unit 2 Surveillance Capsule Fluence Evaluation for Cycles 1-5,” EPRI, Palo Alto, CA 2003 1008065.

4. ASTM E-263-93, “Standard Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Iron,” ASTM Standards, Section 12, American Society for Testing and Materials, Philadelphia, PA, 1995.

5. ASTM E-523-92, “Standard Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Copper,” ASTM Standards, Section 12, American Society for Testing and Materials, Philadelphia, PA, 1995.

6. ASTM E-264-92, “Standard Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Nickel,” ASTM Standards, Section 12, American Society for Testing and Materials, Philadelphia, PA, 1995.

7. BWRVIP-121, “BWR Vessel and Internals Project RAMA Fluence Methodology Procedures Manual,” EPRI, Palo Alto, CA 2003 1008062.