September 14, 2012

MEMORANDUM TO: Patrick L. Hiland, Director
Division of Engineering
Office of Nuclear Reactor Regulation

FROM: Michael J. Case, Director ***/RA/***
Division of Engineering
Office of Nuclear Regulatory Research

SUBJECT: PUBLIC RELEASE OF TECHNICAL LETTER REPORT: "INITIAL ASSESSMENT OF UNCERTAINTIES ASSOCIATED WITH THE BADGER METHODOLOGY"

REFERENCE: Office of Nuclear Reactor Regulation User Need 2010-015: "User Need Request to develop the Technical Bases for the Evaluation of Neutron Absorbing Materials in Spent Fuel Pools"

The Office of Nuclear Regulatory Research (RES) plans to make publicly available in the Agencywide Document Access Management Systems the attached technical letter report, entitled "Initial Assessment of Uncertainties Associated with the BADGER Methodology," in two weeks. If you object to making this report public, or if you propose this document be made publicly available before the end of the two-week period, please let us know.

Note that this report was send for your review as draft NUREG/CR 7130 "Assessment of Uncertainties Associated with the BADGER Methodology," which was subject to the NRC Non-Concurrence Process as documented in NCP-2012-004 (ML12255A350), enclosed. At your staff's request, the report was changed from a draft NUREG/CR to a technical letter report.

This report documents research performed under the Office of Nuclear Reactor Regulation (NRR) "User Need Request to Develop the Technical Bases for the Evaluation of Neutron Absorbing Materials in Spent Fuel Pools," per the memorandum from Eric J. Leeds to Brian W. Sheron, dated June 24, 2010 (NRR-2010-015, ML101720572). In Tasks 2 and 3 of the user need request, NRR requested that RES review the accuracy of in-situ surveillance testing of ^{10}B based neutron absorber materials in spent fuel pools. Two commonly used methods of surveillance are the RACKLIFE software program, which calculates the degradation of the neutron absorber Boraflex, and the Boron Areal Density Gauge for Evaluating Racks (BADGER), an in-situ instrument which measures the neutron-absorption capabilities, in the form of ^{10}B areal density, of the panels encased in spent fuel racks. A companion technical letter report, "Boraflex, RACKLIFE, and BADGER: Description and Uncertainties," prepared by consultant Thomas C. Haley, describes RACKLIFE in detail and is being submitted concurrently with the attached report.

CONTACT: April Pulvirenti, RES/DE
301-251-7976

The attached technical letter report was prepared by John Scaglione and Jeff Chapman, senior technical staff at Oak Ridge National Laboratory (ORNL). The report focuses exclusively on BADGER and comprises four major parts:

- a short description of the BADGER instrument and measurement methodology (Section 4)
- a discussion assessing the contributors to uncertainty in the BADGER results (Section 5)
- a table summarizing individual contributors to uncertainty in the BADGER results (Section 6)
- an appendix detailing the calculation of uncertainty associated with head misalignment (Appendix A).

The analysis and assessment of the BADGER instrument and the associated measurement methodology yielded three principal findings. First, detailed documentation is required in order to conduct a rigorous quantitative uncertainty analysis. This includes technical specifications and/or quality control test reports. For BADGER, such documentation is not publicly available nor was it available to the authors of this report. Therefore, a Type B analysis, as defined by National Institute for Standards and Testing for use in cases where supporting measurement data is not available, was conducted. Estimates of uncertainty that appear in this report are a combination of data, analytical estimates and expert opinions.

Secondly, although the Type B analysis did not provide quantitative estimates for each contributor to overall uncertainty, several contributors to uncertainty were identified that can potentially invalidate measurement results. Examples of such errors are use of the instrument in a very high gamma field, the improper adjustment of low-level pulse discrimination, inconsistency in operator interpretation of data, and material mismatch between calibration and test panel. Flux-trap racks, a configuration where two neutron absorber panels are interposed between spent fuel assemblies, are especially susceptible to high error because neutrons must travel through two panels in order to reach the detector.

Lastly, head misalignment may contribute an estimated uncertainty of ±40 percent to the overall BADGER results. The uncertainty resulting when the source and detector head are not properly aligned was estimated using the MAVRIC neutron radiation transport sequence in the SCALE criticality package. This 40 percent error may be significantly higher if the rack cell walls are warped or deformed.

RES staff wishes to acknowledge Ms. Emma Wong, Mr. Matt Yoder, and Ms. Gloria Kulesa from NRR/Division of Engineering, who provided assistance throughout the development of this report. Substantial support was also received from Mr. Kent Wood of NRR/Division of Safety Systems and Mr. Charles Harris of RES/Division of Engineering. RES staff has also received input from Dr. Allen Hiser of NRR/Division of License Renewal. Dr. Mourad Aissa of RES/Division of Safety Analysis provided technical oversight. Staff from NRO and NMSS has been kept informed primarily through discussions in the context of the neutron absorber technical advisory group, and their comments have been addressed.

Please feel free to contact me or Dr. April Pulvirenti of my staff if you have additional questions.

Enclosure:
As stated

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DATE	9/10/12	9/13/12 Non-Concurrence	9/13/12	9/13/12	9/13/12	9/14/12

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Memo to P. Hiland from M. Case Last Dated September 14, 2012

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