February 16, 2007

Mr. Randy C. Bunt
Chair, BWR Owners Group
Southern Nuclear Operating Company
40 Inverness Center Parkway/Bin B057
Birmingham, AL 35242

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION (RAI) REGARDING THE BOILING WATER REACTOR (BWR) OWNERS' GROUP (BWROG) TOPICAL REPORT (TR) NEDO-33163, "HIGH BURN UP BWR FUEL ROD GAP RELEASE FRACTIONS" (TAC NO. MD1764)

Dear Mr. Bunt:

By letter dated March 30, 2006, the BWROG submitted for U.S. Nuclear Regulatory Commission (NRC) staff review TR NEDO-33163, "High Burn Up BWR Fuel Rod Gap Release Fractions." The NRC staff has identified a number of items for which additional information is needed to continue its review. The NRC staff requires responses to the enclosed RAI questions in order to continue the review.

In a e-mail from Mr. Gregory Broadbent, it was agreed upon that the NRC staff will receive your response to the enclosed RAI questions by May 19, 2007. Please call me at 301-415-1774, if you have any questions on this issue.

Sincerely,

/RA/

Michelle C. Honcharik, Project Manager
Special Projects Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 691

Enclosure: RAI questions

cc w/encl: See next page

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Accession No.: ML070230581 **NRR-088**

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REQUEST FOR ADDITIONAL INFORMATION

BOILING WATER REACTOR (BWR) OWNERS' GROUP

TOPICAL REPORT (TR) NEDO-33163

"HIGH BURN UP BWR FUEL ROD GAP RELEASE FRACTIONS"

PROJECT NO. 691

All appendix, section, page, table, figure, or reference numbers in the questions below refer to items in TR NEDO-33163 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML060940469), unless specified otherwise.

1. The Pacific Northwest National Laboratory (PNNL) as a contractor for the U.S. Nuclear Regulatory Commission (NRC) has performed an audit calculation with FRAPCON-3.3 for the General Electric (GE)-10x10 full-length rod design using the rod average powers provided in Figure 2.1 and the peak local powers provided in Figure 2.3. The axial power profiles were selected to approximate the local peak powers in Figure 2.3. The FRAPCON-3.3 calculated gap release fraction for Kr-85 was approximately 0.116 at the end-of-life (EOL). This value is considerably larger than the 0.065 at the EOL calculated in Table A-6 for full-length GE-10x10 rods. The FRAPCON-3.3 calculated peak gap release fraction was 0.122 between 50 to 55 GWd/MTU (rod average) while the peak value in Table A-6 was 0.087 at 42 GWd/MTU. The PNNL audit calculation used the Massih model in FRAPCON-3.3. This demonstrates that there is a considerable difference in Kr-85 gap release fraction between the audit calculation and the values presented in Appendix A for a given rod and power history. The source of the differences (e.g., the input values used, the analysis models used, or the application of the analysis models) in gap release fraction values need to be determined. This will allow the NRC and PNNL reviewers to determine if the differences are acceptable. A more exact audit calculation can be made if the input used for Appendix A calculations is provided.

    a. It is requested that the BWROG provide the input values for those full-length and part-length designs that result in the peak gap release fraction, thereby, enabling PNNL to perform a direct comparison to the gap release fraction results given in Appendix A. It is requested that the input be provided for the GE12, GE14, and SVEA-96 Optima2 designs, because the large difference in gap release fraction can not be duplicated as shown in Figures 4.11 and 4.12. If the input used does not explain the differences then further examination will be needed on the analysis models and their application to the gap release fractions.

    b. Are there 8x8 fuel designs in reactor cores today? If so, when will these rods be discharged and are they considered to be in limiting positions that could result in large gap release fractions? If so, the 8x8 fuel designs should be considered for this review.

2. Please provide an example of how the rod average power versus burnup was determined for the curves in Figures 2.1 and 2.2 (e.g., provide a comparison of actual

power histories used to determine the limit along with the limiting curve). An example for one fuel design is sufficient, preferably a design that operates the closest to the linear heat generation rate limit curves in Figures 2.1 and 2.2.

3. The "Proposed BWR Non-LOCA Gap Fractions" provided in the table in BWROG-06009 letter, dated March 30, 2006 (ADAMS Accession No. ML060940464) are lower than the majority of gap release fractions provided in Tables 4.1 and 4.2 that are stated to be the basis for the "Proposed BWR Non-LOCA Gap Fractions." Please explain why the gap release fractions in BWROG-06009 do not agree (are lower) with those calculated in TR NEDO-33163.

4. Proprietary Enclosure 3 to BWROG-06009 (ADAMS Accession No. ML06940471) provided justification for not including fast transients due to reactivity insertions that are terminated by scram within a few seconds. The justification provided was that diffusion could not release any significant gas within the time frame of a few seconds.

   a. This justification does not agree with experimental evidence from reactivity insertion accident (RIA) experiments in Cabri (Reference 1 of this RAI set) and Nuclear Safety Research Reactor (References 2 and 3 of this RAI set) where gap release fractions up to 20 percent are observed. There is evidence that release due to RIA is not diffusion controlled but due to release from fracture of grain boundaries. The issue of gap release fractions during RIA events may take considerable more time for review than non-RIA events. Therefore, it is recommended that this review be broken into two parts: 1) review of gap release fractions for events that do not involve large thermal or power transients and 2) review of gap release fractions for RIA events. Assuming the BWROG agrees with this approach and to cover item 1 first, address RAI 4.b for normal operation including anticipated operational occurrences (AOOs) and RAI 4.c for RIA release.

   b. Are the gap release fractions proposed in the BWROG letter dated March 30, 2006, intended to replace those in Table 3 of Regulatory Guide (RG) 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors." The gap release fractions in Table 3 of RG 1.183 are for non-LOCA accidents, that do not involve large thermal or power transients (such as fuel handling accidents) but do include release due to normal operation and AOOs. Because AOOs are relatively mild in terms of thermal increase the release from these transients may be a combination of both diffusion and non-diffusion releases. To justify why the TR does not include release due to thermal transients from AOOs, please perform the following:

      - Provide a table of power increase and the time period at power for each AOO event. This information will be used to establish the range of rod powers and time at power during AOO events and address whether there are power ramp gap release fraction data from light-water reactor rods that span the range of AOO events for the burnup range of interest.

      - Provide additional power ramp gap release fraction data available to the BWROG that are not currently used in the FRAPCON-3 calibration and validation database (References 4 and 5 of this RAI set) particularly data at high burnup and short hold-time at power (i.e., minutes to a few hours). Please review the AOO events, the gap release fraction data, and the conservatisms in the calculation to demonstrate that the gap release fraction (stable or unstable isotopes) from these events can be ignored, bounded or accurately predicted by the proposed models.

- Based on the above, please provide a methodology and example analysis of gap release fraction for those AOO events where release is not negligible.

c. Please propose an approach to calculating the gap release fractions or a bounding estimate for RIA events. Identify if any non-LOCA events other than a control rod drop accident (e.g., a rod withdrawal event) would exhibit both diffusion and non-diffusion releases.

5. The analysis in Section 4.1 provides an upper bound for the EOL shutdown pressure. What was the assumed shutdown temperature?

6. Section 4.2 suggests that the gadolinia rods will be less limiting than non-gadolinia fuel rods based on current operation and gap release fraction measurements from Reference 8. Please provide a copy of Reference 8. The assumption that gadolinia rods are less limiting is based on current operational practices, but there is nothing to prevent future operational practices that would allow gadolinia rods to be more limiting than non-gadolinia rods. Please provide an approach/methodology that would allow confirmation that gadolinia rods will remain less limiting for future operation, or a commitment that the analysis methodology for gadolinia rods will be submitted to NRC for review.

<u>REFERENCES</u>

1. Lemoine, F., Papin, J., Frizonnet, J., Cazalis, B., Rigat, H., "The Role of Grain Boundary Fission Gases in High Burn-up Fuel Under Reactivity Initiated Accident Conditions," Organization for Economic Co-Operation and Development (OECD), Paris, France; 2002, Proceedings of the Fission Gas Behavior in Water Reactor Fuels Seminar, pages 175-187.

2. Fuketa, T., Sasajima, H., and Sugiyama, T., "Behavior of High-Burnup PWR with Low-Tin Zircaloy-4 Cladding Under Reactivity-Initiated-Accident Conditions," Nuclear Technology, Vol.133, pages 50-62, January 2001.

3. Nakamura, T., Kusagaya, K., and Fuketa, T., H. Uetsuka, "High Burnup BWR Fuel Behavior Under Simulated Reactivity-Initiated Accident Conditions," Nuclear Technology, Vol. 138, pages 246-259, June 2002.

4. Lanning, D., Beyer, C., and Berna, G., FRAPCON-3: Integral Assessment, NUREG/CR-6534, Vol. 3, December 1997.

5. Lanning, D., Beyer, C., and Geelhood, K., FRAPCON-3 Updates, Including Mixed-Oxide Fuel Properties, NUREG/CR-6534, Vol. 4, May 2005, ADAMS Accession No. ML051440720.