March 5, 2004

MEMORANDUM TO: Ashok C. Thadani, Director
Office of Nuclear Regulatory Research

FROM: Martin J. Virgilio, Director /RA/
Office of Nuclear Material Safety
and Safeguards

SUBJECT: USER NEED MEMORANDUM – ASSESSMENT OF HIGH BURNUP FUEL CLADDING INTEGRITY PERFORMANCE UNDER ACCIDENT CONDITIONS

The Office of Nuclear Material Safety and Safeguards (NMSS) requests assistance from the Office of Nuclear Regulatory Research (RES) regarding testing of high burnup spent fuel cladding. This user need is related to a prior (July 25, 2000) user need concerning a demonstration program for mechanical properties of high burnup fuel to support dry storage certifications. However, the July 2000 user need did not address the need for impact and fracture toughness data on high burnup spent fuel cladding to support transportation certifications. Hence, this user need expands the previous user need to include fracture toughness/impact data and establish a technical basis to support transport of high burnup fuel (in excess of 45 GWd/MTU).

BACKGROUND

In accordance with the transportation regulations in 10 CFR Part 71, the geometric form of the spent fuel should not become substantially altered under normal conditions of transport as analyzed and specified in the Safety Analysis Report (SAR). Studies have shown that the fuel rods of intact spent fuel assemblies with burnups up to 45 GWd/MTU are capable of resisting the normally expected impact loads of hypothetical Part 71 design accident conditions. However, the effective cladding thickness for intact fuel assemblies with burnup greater than 45 GWd/MTU is reduced due to increased oxide growth and hydride formation. The capability of the fuel rod to withstand the expected loads encountered under normal and accident conditions of transport may be decreased by any embrittled regions containing very high hydrogen (over ~500 ppm of hydrogen) content, increased oxide growth, and increased rod internal pressures. Furthermore, with increasing fuel burnup, the cladding material's ductility decreases and the cladding stress increases. Consequently, the NRC staff desires additional data for spent fuel cladding properties, especially as related to impact resistance. We also consider such data useful for Probabilistic Risk Assessment (PRA) and vulnerability studies.

CONTACT: Christopher L. Brown, NMSS/SFPO
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AREAS OF NEEDED ASSISTANCE

To support the licensing reviews for transportation of high burnup fuel, the Spent Fuel Project Office (SFPO) proposes that suitable test programs be developed to accurately and fully assess cladding properties. Tests should be conducted to assess the impact resistance of high burnup cladding. In particular, fracture toughness tests (or other tests as appropriate) should be conducted to measure the cladding resistance to impact loads that result in bending and lateral crushing (separately). Hydride levels for each sample tested should be determined. The data should include test temperatures of 150°C, 350°C, and 400°C to bound anticipated temperatures in spent fuel casks. Specimens should be examined to determine presence, size, and orientation of pre-existing flaws (beyond hydride layer) using transmission electron microscopy, eddy-current, or ultrasonic testing. The hydrides should also be characterized including orientation, distribution, and hydride rim thickness (measurement technique needs to be defined). Irradiated zirconium-based alloys (i.e., Zircaloy, ZIRLO™, and M5 cladding) should be used in the testing program. Samples may include partial or full-sized or cladding sections.

Following the testing program, the staff hopes to incorporate the results of this high burnup testing program into its technical bases and strategy for approval of transportation of high burnup fuel and revise ISG-11, Rev.3. This information will be used to expand NRC's technical knowledge for transport of high burnup fuel and to support cask certification. Until such information becomes available, the staff will continue to handle transportation certifications on a case-by-case basis.

We request that SFPO be included in all discussions and decision making that may impact the RES program. Once the program has been completed and a technical basis has been established to allow transport of high burnup fuel, we request that a technical position paper or NUREG/CR document be developed to include a summary of all tests and data developed during the program. This request is of high priority in preparation for anticipated licensing applications and amendments for transportation of high burnup fuel. Although SFPO does not foresee being able to contribute to the cost of this testing program, we understand that RES is requesting $300K of mid-year funds to get this effort started.

This request was coordinated with Ralph Meyer of your staff.

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