June 26, 2002

MEMORANDUM TO: Christopher I. Grimes, Program Director
Policy and Rulemaking Program
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

FROM: Peter C. Wen, Project Manager ***/RA/***
Policy and Rulemaking Program
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Office of Nuclear Reactor Regulation

SUBJECT: SUMMARY OF JUNE 6, 2002, MEETING WITH THE NUCLEAR ENERGY INSTITUTE REGARDING HIGH BURNUP FUEL ISSUES

On June 6, 2002, the NRC staff held a public meeting with representatives of the Nuclear Energy Institute (NEI), the Electric Power Research Institute (EPRI), fuel vendors, and licensees to discuss EPRI topical report on Reactivity Initiated Accident (RIA), TR-1002865, "Basis for RIA Fuel Rod Failure and Core Coolability Criteria." Attachment 1 lists attendees at the meeting. Attachment 2 is a set of slides presented at the meeting by the industry representatives.

Since 1997, there have been extensive interactions between the staff and industry groups on the subject of extending fuel burnup beyond the currently licensed limit of 62 GWd/MTU. The industry has taken the lead in developing the criteria and in providing technical information about the behavior of the fuel at the higher burnup to support proposed burnup extensions. As part of this effort, the EPRI Robust Fuel Program has developed EPRI topical report, TR-1002865, for determining licensing criteria. On April 22, 2002, NEI requested the staff to review the EPRI topical report. (Refer to ADAMS Accession Numbers: ML021220250 and ML021220267.) The purpose of the June 6 meeting was to provide an opportunity for the industry groups to brief the staff on the EPRI topical report and to seek the staff's feedback on its initial acceptance review.

During the meeting, the industry representatives discussed the regulatory background associated with fuel failure limits, a database of RIA-simulation tests, and the proposed licensing criteria for fuel rod failure. The major points of their discussions are summarized as follows:

- As a result of a fuel failure during a test (RepNa-1) at the CABRI facility in France in 1993, concerns were raised by the staff and industry about fuel failure limits and fuel dispersal for high burnup fuel. The test result indicated that a fuel rod with a burnup of approximately 64 GWd/MTU failed at an enthalpy of 30 calories/gram, well below the current fuel enthalpy limit of 230 calories/gram for reactivity transients. Since then,

many RIA-simulation tests have been performed, including 11 CABRI tests in France and 36 NSRR tests in Japan; the RepNa-1 results were never duplicated. The industry representative indicated that the RepNa-1 results were unique because so many factors affected the test results, for example, the preexisting defects, the special test conditions, and the difficulty associated with short pulse signals. The representative indicated that the RepNa-1 results should not be used until the industry's RepNa-1 Task Force completes its investigation.

- The results of RIA-simulation tests indicate that the clad failure mechanism is dominated by the post-departure from nucleate boiling (DNB) operation for low burnup fuel and by the pellet-clad mechanical interaction combined with loss of clad ductility for high burnup fuel.

- The industry is proposing to use two separate limits for RIA acceptance criteria, one for fuel clad failure and one for core coolability; both are a function of fuel burnup. These limits are given in terms of enthalpy increase and are based on integral test results, mechanical property test data, and analytical evaluations.

- The fuel clad failure threshold proposed by the industry is 170 calories/gram for fuel burnup below 36 GWd/MTU and decreases asymptotically to 125 calories/gram as the fuel burnup increases. This proposed limit would preserve the current DNB-related acceptance criterion of 170 calories/gram for rod ejection accidents. The industry representative indicated that this threshold is based on non-spalled Zircaloy-4 material and could be applied to other advanced cladding materials such as ZIRLO and M5. However, the restriction on useing this threshold is that the fuel rod oxidation thickness should be less than 100 microns.

- The core coolability threshold proposed by the industry is 230 calories/gram for fuel burnup below 30 GWd/MTU and linearly decreases to 185 calories/gram when fuel burnup reaches 80 GWd/MTU. The proposed core coolability threshold is based on the fuel enthalpy needed to produce incipient fuel melting.

Following the industry representatives' presentations, the staff provided the following comments:

- The staff expressed its desire to independently go over industry's test data and analytical results. The staff indicated that the submitted EPRI topical report is acceptable for NRC review, and agreed to send a letter to NEI/EPRI to document this acceptance determination and provide an estimated review schedule.

- Because the importance of this topical report to the future development of high burnup fuel, the staff will keep its review of the topical report transparent and public. Thus, the staff will need a copy of the FALCON code, which was used by EPRI to establish the fuel rod failure threshold and core coolability limit. The staff will review this code as part of the topical review and use it to perform independent verifications. Whether this code would be put in the public domain will be discussed later.

- Regarding EPRI's proposal of using two separate limits for RIA acceptance criteria, one for fuel clad failure and one for core coolability, the staff questioned the industry's approach of having such two separate limits. A RES staff suggested that a single curve limit would serve better if the limit is set at the cladding failure threshold to prevent fuel dispersal rather than at some higher level that would permit fuel dispersal. The RES staff believes that this single limit should not result in any operating penalties because RIA pulse energies in light water reactors are expected to be well below the cladding failure threshold. The RES staff's comments are based on the following considerations:

  - The 280 calories/gram limit in Regulatory Guide 1.77 (equivalent to 230 calories/gram fuel enthalpy) was a value related to fuel dispersal, not to pressure pulses.

  - EPRI's position before July 2001 was that fuel dispersal was not possible for light water reactor fuel because pulse widths were expected to be greater than 20 milliseconds (ms) (see Attachment 3, Slide 1). There was a major change in the staff's understanding last July when Brookhaven National Laboratory presented analytical results that showed the relation between pulse width and pulse energy for a PWR rod ejection accident (see Attachment 3, Slide 2). Thus pulse widths for enthalpy above EPRI's proposed cladding failure threshold would be 10 ms or less and fuel dispersal could occur.

Having completed discussion of the agenda items, the group adjourned. Representatives of the NRC and the industry agreed that this meeting had been useful for the exchange of information on the discussion subject.

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*See previous concurrence

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NRC/NEI HIGH BURNUP FUEL MEETING
LIST OF ATTENDEES
June 6, 2002

NAME	ORGANIZATION
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Ralph Caruso	NRR/DSSA/SRXB
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Med El-Zeftawy	NRC/ACRS
Peter Wen	NRR/DRIP/RPRP
Carl Beyer	PNNL
John Butler	NEI
Rosa Yang	EPRI
Odelli Ozer	EPRI
Robert Montgomery	Anatech
Nicolas Waeckel	EDF
Joe Mihalcik	Constellation Energy
Owen Thomsen	SCE
Al Strasser	Aguarius Services
Gary Darden	Dominion
Pablo Garcia Sedana	Iberdrola
Rob Sisk	Westinghouse
David Mitchell	Westinghouse
David Diamond	BNL
Elaine Hiruo	Platts Nuclear
Adel Alapour	Southern Nuclear
Robert Tsai	Exelon
Gregg Swindlehurst	Duke Power
Whee Choe	TXU
Jerry Holm	Framatome
Bert Dumn	Framatome

Attachment 1