Department of Energy
Washington, DC 20585

July 13, 2016

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Rodney C. Ewing
Chair, United States Nuclear Waste Technical Review Board
2300 Clarendon Boulevard, Suite 1300
Arlington, VA 22201-3367

Dear Dr. Ewing,

Thank you for the May 23, 2016 NWTRB letter detailing the Board's review and associated recommendations resulting from the 2016 Board Winter Meeting in Knoxville, TN. In addition, the teleconference between the Board and DOE on May 26, 2016, to further discuss details of the Board letter was helpful.

This letter provides specific DOE responses to each of the three recommendations proposed by the Board in the May 23rd letter. We hope that this letter, coupled with the planned follow-on technical meeting in July, will provide the Board sufficient information to assess the status of the DOE R&D program associated with the degradation characteristics of commercial spent nuclear fuel in extended storage and transportation.

> *Recommendation 1 – The Board recommends that the research program be structured such that the focus is on the likelihood and consequences of cladding failure during interim storage, transportation, possible repackaging, and eventual disposal of HBF in a repository.*

We agree that the risk posed by cladding failure is important to understand, but we have chosen to evaluate this risk as a part of a more comprehensive systems engineering approach.

The DOE R&D program in this area began in earnest in 2009. The first task we focused on was the development of a technical gap analysis to identify data that was needed to sufficiently develop the right level of understanding of how various parameters affect the degradation mechanisms of spent fuel and the resultant ability of the spent fuel to withstand extended storage and transportation loading environments. Rather than use a risk based approach, the DOE has taken a systems engineering approach to identify and prioritize these gaps. The systems engineering approach includes risk based evaluation that includes likelihood and consequence factors. In one of our early reports, Gap Analysis to Support Extended Storage of Used Nuclear Fuel Rev. 0, FCRD-USED-2011-000136, PNNL-20509, January 2012, it states:

> *"Based upon the importance of the SSC to licensing a dry storage system or an independent spent fuel storage installation (ISFSI), the potential effects of extended storage or high burnup on the degradation mechanism, and a combination of the data needs, regulatory considerations, likelihood of occurrence, the consequence of degradation, the means to remediate the degradation, and the impact of degradation on*

cost, operations, and future waste management strategies, a research and development (R&D) priority (Low, Medium, or High) is assigned."

We believe that the systems engineering approach provides a more comprehensive evaluation of prioritization by including other factors into the evaluation than just risk. It is felt that this prioritization is crucial to properly manage the acquisition of data with the greatest resultant impact in light of a limited R&D budget. Prior to the issuance of this report, it was externally reviewed by a wide range of external groups, including the NWTRB, NRC, NEI, EPRI, as well as several cognizant international organizations. The DOE continues to work with NRC and NEI to get information to ensure that our research priorities are consistent with the concerns of others. Through this process, the issue of cladding behavior during extended storage and transportation has been a recognized top priority. Focused work over the past six years has resulted in major progress, to the point that the NRC has stated that long term storage and transportation of high burnup spent fuel is safe.

Recommendation 2 – The Board recommends that DOE develop a physical-chemical model that relates the behavior of unirradiated cladding to the behavior of irradiated cladding. This work should also include experimental work to test the model's predictions and evaluate the associated uncertainties.

The idea behind this recommendation has been discussed and several efforts in modeling and early experimental work have been conducted to develop the important parameter associations between irradiated cladding and unirradicated cladding. It is believed that correlating factors for this would be intensely subtle or non-existent, so a full development of this recommendation would be multi-year in scope and would need a sustained high level of funding. Modeling validation to the data, development of statistical confidence of important parameters, and understanding of how important parameter effects transfer from one cladding type to another and one duty cycle to another must be fully understood before modeling predictions can be done with any degree of confidence.

Further, a comprehensive journal article was published by leading U.S. scientists in this area; "Ductile-to-brittle transition temperature for high-burnup cladding alloys exposed to simulated drying-storage conditions", Billone, Burtseva, Einziger, Journal of Nuclear Materials, Vol 433, 2013. The last sentence in the abstract from this article is important to highlight.

"It was also observed that uniformly pre-hydrided, non-irradiated cladding was not a good surrogate for high-burnup cladding because of the high density of circumferential hydrides across the wall and the high metal-matrix ductility for pre-hydrided cladding."

Dr. Billone continues to believe that there are major issues regarding the cost-benefit of launching a significant effort to develop these correlations as recommended. For this reason, as well as a potential host of parameter interactions that have not been addressed regarding the behavior of irradiated cladding v. unirradiated hydrided cladding, the NRC has also expressed skepticism in pursuing this path.

While the DOE is still investigating this approach experimentally at a low level of funding, other high priority issues (e.g., stress corrosion cracking of SS canisters), the current experimental work on irradiated cladding focused on closing this technical gap, and the planned experimental work for the sister pins make this an area that does not rise to a priority level that would warrant the type of funding that is required.

> *Recommendation 3 – The Board recommends that DOE make transparent how it integrates the results from Nuclear Energy University Programs, and other relevant U.S. and foreign research activities into its overall research program on HBF degradation.*

We agree with the need to provide increased clarity regarding how NEUP work is integrated to achieve the desired results. As you have noted, DOE is funding a significant amount of work in this area through its NEUP programs. We are working to better integrate the work going on at these universities into the fabric of our internal R&D program. This is done mainly through assigning DOE Laboratory Technical Points of Contact to provide technical input to the university and communication back to the DOE program. In some cases, the integration is high and the work just hasn't been communicated in a way that has been apparent to the NWTRB. With regard to other relevant U.S. and foreign research programs, the DOE has worked closely with the U.S and international communities in this area. This work has been published and has been submitted to the NWTRB.

Please let me know if you have any questions regarding this letter. We look forward to further technical exchanges with the Board.

Sincerely,

John F. Kotek
Acting Assistant Secretary
for Nuclear Energy