UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 17, 1999

Mr. John E. Anderson
Acting Assistant Manager for Material
and Facility Stabilization
Savannah River Operations Office
U.S. Department of Energy
P.O. Box A
Aiken, SC 29802

SUBJECT: REVIEW OF THE U.S. DEPARTMENT OF ENERGY EVALUATION OF ALUMINUM-BASED RESEARCH REACTOR SPENT NUCLEAR FUEL DISPOSITION PROGRAM

Dear Mr. Anderson:

The U.S. Nuclear Regulatory Commission (NRC) has been providing technical assistance to the U.S. Department of Energy (DOE) on issues relating to the disposal of aluminum-based spent nuclear fuel (SNF) in a geologic repository. This work has been guided by the Memorandum of Understanding and Interagency Agreement signed by DOE and the NRC in August 1997. Your letter dated July 31,1998, to Dr. Weller (NRC) changed the focus of our reviews from evaluating direct co-disposal technology to evaluating the melt and dilute technology for disposition of the Al-based SNF. This review of the Alternate Technology Program (ATP) focused on preclosure and postclosure issues related to melt and dilute waste form and waste package.

The NRC staff's comments, recommendations, and conclusions regarding DOE's evaluation of the ATP melt and dilute waste form are summarized below. The NRC staff has identified issues for DOE to address; however, the current DOE analyses are deemed conservative. Based on impact to repository performance, the NRC staff believes that the melt and dilute waste form would be an acceptable concept for the disposal of the Al-based SNF in the repository.

Previously, the NRC issued two reports, on June 5, 1998 and August 9, 1999, based on NRC and the Center for Nuclear Waste Regulatory Analyses (CNWRA) reviews of DOE program documents evaluating the disposability of Al-based SNF in a geologic repository. The former report evaluated 11 program reports submitted by DOE in September 1997, and provided a topical review of the two disposal technologies (direct co-disposal and melt-dilute). The latter report evaluated two program reports submitted by DOE on criticality analyses for the melt-dilute and direct co-disposal Al-based SNF waste forms.

This transmittal documents our review of six additional program reports on the SNF waste forms in the ATP that were not previously covered. In July and August of 1998, DOE submitted two reports titled, "Thermal Analysis of Repository Co-disposal Waste Packages Containing Aluminum Spent Nuclear Fuel (U)" and "Analysis of Creep Deformation of Aluminum-Based Spent Nuclear Fuel (U)", respectively. In September 1998, the "Bases for Functional Performance Requirements for a Spent Nuclear Fuel Treatment and Storage Facility" document

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was submitted and in November 1998, the two additional documents, "Disposability Assessment: Aluminum-Based Spent Nuclear Fuel Forms" and "Preliminary Report on the Dissolution Rate and Degradation of Aluminum Spent Nuclear Fuels in Repository Environments (U)", were submitted. Finally, the draft ASTM C26.13 Standard Guide for Corrosion Testing of Al-Based SNF in Support of Repository Disposal was also submitted by email for NRC review in March 1999.

NRC and CNWRA staffs reviewed the DOE program reports to identify technical and regulatory issues on DOE's disposability analyses related to the final disposition of Al-based SNF. A detailed evaluation of DOE's analyses pertaining to the geologic disposal of Al-based SNF is enclosed with this letter (Enclosure 1). This evaluation was guided by the proposed regulatory requirements of draft 10 Code of Federal Regulations (CFR) Part 63. In this regard, the underlying technical issues pertaining to the aluminum-based fuel are anticipated to remain consistent between the the final version of the new regulations and the draft version.

Comments on issues related to interim storage of the melt and dilute waste form are only addressed in regard to meeting acceptance criteria for the waste form at the repository. Interim storage regulatory requirements are specified in 10 CFR Part 72. Evaluation of issues related to 10 CFR Part 71 requirements was outside the scope of this review. As such, issues pertaining to transportation safety are not included in this letter.

Background

The SNF from both domestic and foreign research reactors is significantly different from commercial SNF in design, structure, materials of construction, and enrichment. It is expected that approximately 62.4 metric tons of heavy metal of aluminum-based fuel will be received and stored at the Savannah River Site (SRS) over the next 40 years and will ultimately require geologic disposal in the repository. While the aluminum-based SNF constitutes only a small fraction (less than 1 percent by volume) of the total inventory of SNF anticipated for repository disposal, it warrants special consideration because of its unique metallurgical characteristics and high enrichment levels. In particular, preclosure issues pertaining to the integrity of both the "road-ready" canister and the waste form and postclosure issues related to criticality control and waste form performance are principal concerns for these types of SNF.

This letter and the accompanying report address issues that could impact preclosure operations and those that could affect post closure performance for the melt and dilute waste form. As mentioned above, additional NRC staff's comments and recommendations regarding DOE's evaluation of criticality of the melt and dilute waste form were previously addressed in my letter to you dated August 9, 1999.

Preclosure Performance

NRC concerns for DOE to investigate regarding pre-closure performance include evaluation of the integrity of the DOE canister during interim storage at SRS, which may extend to 100 years, as projected by DOE. Evidence to support the actual corrosion rate of the "road-ready" canisters under extended times in storage needs to be supported by using monitored canisters to measure corrosion of internal surfaces as well as external surfaces. In addition, the long term thermal exposure effects on canister and waste form need to be evaluated further. DOE's

basis for establishing the temperature limit for the canister and waste form is not clear. The potential for accelerated degradation of the canister and waste form during long-term storage at this temperature also needs to be evaluated further. Importantly, DOE should develop a plan for managing canisters which have degraded during interim storage. The impact of the Al-based SNF waste form and waste package on preclosure performance will be directly dependent on the final condition of the "road-ready" package and waste form during interim storage.

Postclosure Performance

NRC and CNWRA staff's reviews of the methodology, assumptions, and conclusions of DOE's evaluation of the disposability of Al-based SNF in a geologic repository have identified four key issues that need to be addressed to determine their impact on the repository performance. These issues are as follows. First, DOE should demonstrate adequate distribution of poisons for criticality control of the melt and dilute waste form. DOE has to demonstrate that the consequence of a criticality event would not impact the repository performance and alter the expected dose to a receptor group. Therefore the probability of a criticality event must be demonstrated to be unlikely to occur.

Second, DOE needs to clarify the basis for determining the maximum level of water that could be trapped in the DOE canister. Water trapped in the DOE canister is projected to lead to corrosion of the aluminum in the waste form with subsequent generation of hydrogen. The concern is with the production of the pyrophoric material UH_3 from the reaction of the hydrogen gas with U present and the resulting impact on radionuclide release.

Third, DOE should examine variations in dissolution rates and mechanisms of the inhomogeneous melt and dilute ingots in the environment anticipated to contact the waste form. An inhomogeneous waste form ingot could lead to spatial variations in the dissolution mechanisms (e.g., localized versus uniform corrosion) and rates with added uncertainty in the rate of radionuclide release.

Finally, the effects of long term thermal exposure on the material performance and eventual radionuclide release need to be examined. The impact of Al-based SNF melt and dilute waste form on repository performance cannot be determined if the potential detrimental effects of long-term thermal exposure on eventual radionuclide release have not been adequately examined. It is important to understand the rate of radionuclide release to assess the impact Al-based SNF will have on repository performance.

Conclusions

As noted above and described in detail in the enclosed report, as well as in the previous two reports (June 1998 and August 1999), the NRC staff has identified a number of technical issues in need of resolution to determine the impact of the Al-based SNF on performance of the proposed geologic repository and has made recommendations for additional work in DOE's further implementation of the ATP. However, the staff has identified no issues that by virtue of being unresolvable would exclude the Al-based SNF melt and dilute waste form from acceptance in the proposed repository based on impact to repository performance.

If you have any questions, or if you would like to schedule a meeting to discuss the content of this letter and the enclosed report, please contact King Stablein of my staff at (301) 415-7445.

Sincerely,

[Original signed by:]

C. William Reamer, Chief
High-Level Waste and Performance
Assessment Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated

cc: R. Ponik, DOE-SRS
N. Lyer, WSRC
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