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Acceptance Criteria for Interim Dry Storage of Aluminum-Clad Fuels (U)

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Introduction

Direct repository disposal of foreign and domestic research reactor fuels owned by the United States Department of Energy is an alternative to reprocessing (together with vitrification of the high level waste and storage in an engineered barrier) for ultimate disposition. Neither the storage systems nor the requirements and specifications for acceptable forms for direct repository disposal have been developed; therefore, an interim storage strategy is needed to safely store these fuels. Dry storage (within identified limits) of the fuels received from wet-basin storage would avoid excessive degradation to assure post-storage handleability, a full range of ultimate disposal options, criticality safety, and provide for maintaining confinement by the fuel/clad system. Dry storage requirements and technologies for U.S. commercial fuels, specifically zircaloy-clad fuels under inert cover gas, are well established.[1,2] Dry storage requirements and technologies for a system with a design life of 40 years for dry storage of aluminum-clad foreign and domestic research reactor fuels are being developed by various groups within programs sponsored by the DOE.[3]

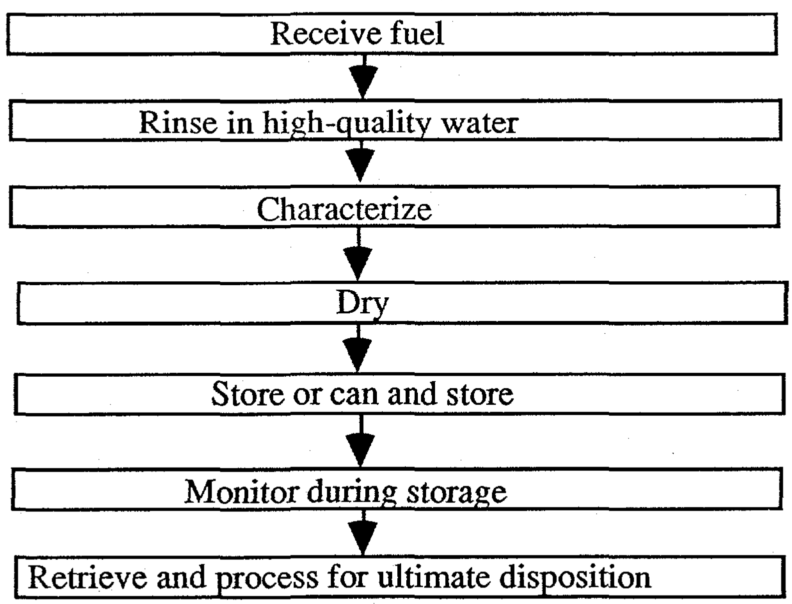
This paper summarizes the approach to develop acceptance criteria for dry storage of aluminum-clad spent nuclear fuels.

Background

Aluminum-clad spent fuels from foreign and domestic research reactors presently stored for extended times in basins may be subject to pitting under certain water chemistries with "high" impurity and conductivity levels. Acceptance criteria for dry storage of highly-enriched, aluminum-clad spent nuclear fuels are the combined set of drying criteria and storage criteria, even for those fuels containing minor cladding pits. For example, standards to dry the fuels to remove free water and to subsequently store the fuels at temperature/cover gas/humidity conditions within the limits of these criteria will avoid excessive degradation and maintain a primary confinement barrier of the fuel/clad system. Fuels with major cladding defects may require separate canning, treatment, and/or storage conditions to provide for and maintain a primary confinement barrier.

Acceptance Criteria for Drying and Storage of Pitted Fuels

A generalization of the steps likely to be involved in the process to dry-store aluminum-clad spent nuclear fuels is shown in the flow diagram below. A rinse step is anticipated to remove contaminants such as chlorides and sulphates that can promote pitting corrosion in moist environments.[4] Characterization is a step that may include several substeps such as non-destructive examinations of the fuel cladding, measurement of the heat output of the fuel assembly, etc. to verify the assumed conditions of the fuels to be stored.[5] Fuels that are highly degraded would be subjected to special handling and treatment (e.g. canned storage of an individual fuel assembly in an inert gas environment).



The acceptance criteria are comprised of criteria for the drying step, specifying the acceptable amount of free water present on the fuels, and the storage step, specifying the acceptable storage environment. As stated, the objective of these criteria are to avoid excessive degradation while in storage for a target period of 50 years. A limit on acceptable degradation is to be defined; as an example, it could be defined as corrosion of 10% of the cladding thickness for storage at conditions where general corrosion may occur. It is important that, in the establishment of a limit to acceptable degradation, an account of corrosion in the received condition of the cladding be made.

A program is being conducted at the Savannah River Technology Center to develop acceptance criteria for dry storage of aluminum clad fuels. The program includes analysis and testing activities to identify storage conditions under which degradation is acceptable and to specify the limit for these conditions; limits would be established based on the specific fuel matrix material.[6,7] Storage at cladding temperatures up to 200°C would be most limited by corrosion mechanisms affecting both the aluminum cladding alloys and any exposed fuel matrix materials. Corrosion testing is being performed to benchmark models of the corrosion behavior of aluminum clad aluminum-uranium fuels under high temperature (up to 200°C), high relative humidity (up to 100%) conditions and identify limits to the storage conditions to avoid excessive degradation for a period of 50 years. Fuels with more reactive matrix materials, such as uranium metal, would have to be thoroughly dried and stored under an inert cover gas to avoid significant corrosion.

Conclusions

Dry storage of aluminum-clad spent nuclear fuels will require constraints provided by acceptance criteria so as to avoid excessive degradation of the fuel/clad systems during storage. These criteria are being developed and will include limits on environmental exposure conditions for a target 50 year storage period. Corrosion of the cladding and fuel matrix materials is the limiting behavior for storage. Tests are in progress to provide the bases for specifying the degree of dryness and limits to the environments for fuel storage.

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