—Summary—

CONVERTING MISCELLANEOUS SNF INTO A "SINGLE" WASTE FORM BY PACKAGING IN DEPLETED URANIUM

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The U.S. Department of Energy has ~230 types of spent nuclear fuel (SNF) and related wastes (sludges, etc.) that currently require disposal in the proposed Yucca Mountain Repository (YMR). The repository waste packages (WPs) for these many types of spent fuels must be shown to mitigate any significant impacts to human health and the environment from the release nuclides from the SNF over very long periods (>10^5 years). During these long periods, the ultimate performance of a waste and its package components depends upon their combined chemical behavior in the geochemical conditions of the disposal horizon and of the potential transport paths. Since these large numbers of the DOE SNF types varies widely in chemical characteristics and they have relatively small, individual quantities, designing and implementing many optimum WP designs could make storage and disposal of these SNF wastes extremely expensive on a per unit mass basis.

Therefore, a uniform packaging approach is being investigated to address the long-term disposal of these miscellaneous SNF wastes. When a sufficient quantity of depleted uranium dioxide (DUO_2) is added to SNF WPs, the overall, collective chemistry is dominated and controlled by that of the DUO_2. Then, all of the WPs will have consistent, predictable behaviors. These DUO2 dominated WP's will behave like those well-studied packages that are used for commercial light water reactor SNF in which the large quantities of uranium dioxide dominate their overall chemistry.

There are several advantages to driving the WP chemistry toward that of DUO_2.

- *Repository studies*. Uranium dioxide is the only material whose behavior has been studied in extensive detail in the geochemical environment of the proposed YMR. The YMR is designed to accept 63,000 metric tons of commercial LWR SNF.

- *Uranium ore-bodies*. The interiors of natural uranium ore deposits in environments similar to the YMR have remained intact for long periods. As the uranium on the exterior of the formation acts slowly as a sacrificial-transport barrier. In a WP, this mechanism allows the DUO_2 package to help preserve and protect the inner SNF. The WP begins to behave more like a uranium ore body.

- *Nuclear criticality*. Many of the DOE SNFs have enriched uranium and raise concerns about the possibility of nuclear criticality during and after storage and disposal. By using DUO_2, the resulting WPs as a whole will have lower net ^{235}U enrichment levels. As the WPs' outer shells degrade, the DUO_2 will mix with higher-enriched SNF and isotopically dilute the ^{235}U. This minimizes the potential for post-closure criticality in the repository. (Forsberg September 2000).

The proposed treatment and packaging for DOE SNF are to (1) dry it, (2) place it in a WP made of a DUO_2 cermet, and (3) fill the WP void-spaces, including the coolant channels in the SNF, with a DUO_2-sand. Not all miscellaneous DOE SNF may require all of these steps. For badly degraded SNF and sludges from SNF degradation, the waste would be (1) mixed with DUO_2 particulates and selected stabilization-additives, (2) heated to drive off water, (3) compressed, and (4) placed in the cermet WPs. The mixing-stabilization process is designed to provide a chemically-inert matrix that will have overall properties of pyrophoric character, dispensability, thermal conductivity, chemical redox, solubility, etc., which is much closer to that of DUO_2 than those of the DOE SNFs and their constituents.

An important component of the proposed WP shells and internals, Cermets consist of DUO_2 particulates embedded in a continuous-steel phase. They are currently being investigated as a material of construction for WPs (Forsberg and Shappert, September 2001). Cermets can be viewed as a method to make a ductile form of DUO_2 suitable for use as a WP material of construction. DUO_2-fills are also being investigated (Forsberg March 2001) as a method to improve WP SNF performance by maintaining reducing conditions within the WP, ad/absorbing radionuclides within the uranium fill, and reducing the groundwater flow through the compromised WP.

Initial results indicate that this uniform approach has the potential to improve and simplify the disposal of miscellaneous DOE SNF. While significant additional work is required to define the limits of this waste management strategy, the initial results have shown this approach can reduce the costs and improve the overall performances of diverse DOE SNF waste packages.

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