# —Summary—

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

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The U.S. Department of Energy (DOE) 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 SNFs must be shown to prevent any significant impacts to human health and the environment from nuclides that could be released from the SNF over very long periods (>$10^4$ years). The ultimate performance of the WP system depends upon the combined chemical behavior of the SNF and WP in the geochemical conditions of the repository disposal horizon. Since the miscellaneous SNF types vary widely in chemical characteristics and the quantities of any particular type are relatively small, the development and implementation of 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 the miscellaneous SNF wastes. When a sufficient quantity of depleted uranium dioxide ($DUO_2$) is added to SNF WPs, the overall, collective chemistry will be dominated and controlled by that of the $DUO_2$. All of the WPs will have consistent, predictable behaviors. These $DUO_2$-dominated WPs will behave in a manor similar to that observed for the well-studied packages of commercial light-water-reactor (LWR) SNF, in which the large quantities of $UO_2$ dominate the overall chemistry.

Several advantages could be derived from 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. The uranium on the exterior of the formation acts as a sacrificial-transport barrier to help maintain the interior uranium in an undisturbed form. In a WP, this mechanism allows the $DUO_2$ 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 contain enriched uranium and thus 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 degrade, the $DUO_2$ and its degradation products 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 steps in the treatment and packaging of miscellaneous 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-like particulate fill. Not all the miscellaneous DOE SNF would 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 (pyrophoricity, dispensability, thermal conductivity, chemical redox, solubility, etc.) which are much closer to the properties of $DUO_2$ than those of the DOE SNFs and their constituents.

Cermets consist of $DUO_2$ particulates embedded in a continuous-steel phase. They are currently being investigated to replace the steel components of the WP (Forsberg and Shappert, September 2001) including the structural shell and the basket. The outer WP layer of corrosion-resistant metal would remain unchanged. Cermets can be viewed as a means of making a ductile form of $DUO_2$ suitable for use as a WP material of construction. $DUO_2$ particulate fills are also being investigated (Forsberg March 2001) as a means of improving WP SNF performance by maintaining chemically reducing conditions within the WP, sorbing radionuclides within the uranium fill, and decreasing 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 SNF. While significant additional work would be required to define the limits of this waste management strategy, the initial results indicate that such an approach could reduce the costs and improve the overall performances of diverse DOE SNF WPs.

**References**

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