Beneficial Uses of Tails from Nuclear Fuel Production into Spent Fuel Storage Cask Manufacturing

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The depleted uranium (DU) inventory in the U.S. exceeds 500,000 metric tons (tonnes). This paper analyzes the U.S. Department of Energy's research on the use of its inventory of DU as neutron and gamma shielding as uranium oxide in nonmetallic matrices, (e.g., concrete). This study shows that a large portion of the U.S. inventory of DU can be used in the fabrication of nuclear shielding for the storage, transport, and disposal of spent nuclear fuels (SNF). Just in the storage of commercial U.S. SNF, the cumulative amount of DU oxide (DUO_2) that could be used in nonmetallic matrix dry-storage casks though 2020 is over 408,455 tonnes (360,058 tonnes of DU).

The purpose of this U.S. research is to develop a DU shielding technology and to demonstrate the technical basis for deployment of steel/concrete casks based on DU shielding. This study (1) establishes the ability to manufacture DU aggregates for heavy concretes; (2) optimizes the design and costs of preconceptual fabrication facilities; and (3) promotes confidence in the long-term reliability, safety, and physical stability of the DU aggregate. In addition, the neutron-shielding characteristics of these DU aggregates and their binders (DUCRETE) can be enhanced through choices of formulations and additives.

Aggregates made of UO_2 are combined with cementitious binders that enhance neutron shielding and result in high strengths. Uranium is a very effective gamma shield because of its high density and high atomic number (Z). Binders considered in this study include Portland cement, blast furnace slag, and pozzolanic cements. These DU-based shielding materials greatly reduce the size and weight of storage, transport, and disposal casks. The economic advantage gained through using smaller and lighter casks offsets the increased fabrication costs.

This report describes the production of this shielding material and documents measurements of DUO_2–aggregates' physical properties and chemical durability. In addition, this paper reports cost studies of preconceptual production facilities for Steel/DUCRETE SNF storage casks. Current testing at the Oak Ridge National Laboratory is measuring the extent and rates of surface reactions of the aggregates with the cement binders under the expected service temperatures and the simulated chemical environments. Intact DUO_2–aggregates were tested for chemical reactivity with the cement paste using a modified American Society for Testing and Materials C289-94 method to measure reactions with concrete pore liquids.