

Depleted Uranium in Repositories

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M. Jonathan Haire and Allen G. Croff

Chemical Technology Division
P.O. Box 2008
Oak Ridge National Laboratory*
Oak Ridge, Tennessee 37831-6180

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DEPLETED URANIUM IN REPOSITORIES

M. Jonathan Haire and Allen G. Croff

Chemical Technology Division
P.O. Box 2008
Oak Ridge National Laboratory*
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Introduction

For uranium to be useful in most fission nuclear reactors, it must be enriched (i.e. the concentration of the fissile isotope ^{235}U must be increased). Therefore, depleted uranium (DU)—uranium which has less than naturally occurring concentrations of ^{235}U —is a co-product of the enrichment process. Four to six tons of DU exist for every ton of fresh light-water reactor fuel. There were ~407,000 MgU [~407,000 metric tons (t)] of DU stored on U.S. Department of Energy (DOE) sites as of July 1993 (ref. 1). If this DU were to be declared surplus, converted to a stable oxide form, and emplaced in a near-surface disposal facility, the costs are estimated to be several billion dollars. However, the U.S. Nuclear Regulatory Commission has stated that near-surface disposal of large quantities of DU tails is not appropriate². Thus, there is the possibility that disposition via disposal will be in a deep geological repository. One alternative that may significantly reduce the cost of DU disposition is to use it beneficially. In fact, DOE has begun the Beneficial Uses of DU Project to identify large-scale uses of DU and to encourage its reuse. Several beneficial uses, many of which involve applications in the repository *per se* or in managing the wastes to go into the repository, are summarized below.

Uses Away from Repository

- Historical uses. DOE originally undertook the long-term storage of DU because it could be used in the future as feed for further enrichment. This use has been indefinitely delayed. DU can be used as a fertile material in fast breeder reactors to create plutonium which would then be used for fuel in other nuclear reactors. However, recycle of nuclear fuel would require a change in national policy to implement this use. DU metal has been used as tank armor and armor-piercing projectiles and for other purposes, but these consume only a small fraction of the DU inventory.

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- Counterweights. Because of its high density, DU has been used to make small (but heavy) counterweights for the aircraft industry and other industries. DU counterweights for forklift trucks are being developed and have the potential to consume a large portion of the DU inventory.
- Heavy concrete casks. One attractive DU shielding concept involves making “heavy” concrete using a DU compound as one of the components. The most advanced DU concrete technology involves converting the DU to uranium dioxide (UO_2) particles, aggregating the particles into briquettes, and sintering the briquettes with a special sintering aid to form a dense aggregate called DUAGG™ (ref.-3). The DUAGG™ is combined with conventional concrete-forming materials (e.g. cement, sand, and water) to form an ultra-high-density concrete named DUCRETE™. Among other proposed uses, DUCRETE™ has been proposed for use in constructing dry spent-fuel storage casks for on-site storage of civilian reactor fuel. In this application, the use of DUCRETE™ results in smaller shield size and lower weight than the use of conventional concrete. Conceptual design studies⁴ have shown that the diameter of a ventilated storage container for dry spent nuclear fuel is reduced by about 1 m (40 in.)—from about 3.3 m (130 in.) to 2.3 m (90 in.). The total weight is reduced from about 135 Mg (135 t) to about 100 Mg (100 t).

Uses at a Repository

- Waste package shielding. DU heavy concrete, as previously described, can be used as the primary component of shielding around spent fuel or waste packages in the repository. In one variant, the shielding is in the form of an overpack: The spent fuel or waste package is inserted into the overpack before its emplacement in the repository. Such shielding might be integrated into a new multipurpose package. Another variant uses the heavy concrete as a major component of a drip shield by emplacing an unshielded waste package in the drift and then inserting a DU-bearing, open-ended, half-cylinder over the package. Some potential advantages to the repository are allowing human entry into drifts once waste packages are emplaced, providing protection to the package from any water entering from above, providing uranium in a reduced form to beneficially alter the chemistry of groundwater that might enter the package, and providing DU to isotopically dilute any enriched uranium released from the package.
- Invert. Repository drift “invert” is material placed on the bottom of the tunnel to form a flat foundation for operating equipment and waste packages. High-density concrete made with DU compounds could be part of the floor material. Potential advantages to the repository are isotopic dilution of enriched uranium that was dissolved by groundwater and has exited the package by downward flow, thereby reducing the probability of an external criticality event.
- Backfill. Once all waste packages are in place in the repository and it is decided that in situ monitoring and human activities cease, the repository tunnels would be loaded with material termed “backfill,” which is crushed native rock. Repository backfill material could contain DU. The advantages are similar to those of using DU as a component of waste package shielding. The benefits of DU are expected to be enhanced the closer the DU is to the spent fuel and waste package.
- Fill. Scientists have proposed a new spent fuel package “fill” technology in which depleted UO_2 is placed in the voids of spent fuel waste containers for storage, transport, or disposal⁵. In this concept, empty waste packages would be loaded with spent fuel. The void space between the fuel pins and outer void between spent fuel assemblies and the inner waste package wall would be filled with small depleted UO_2 particles. The repository waste package would then be sealed. Some benefits to the

repository are that the fill provides some shielding, reduces the potential for repository nuclear criticality events, and reduces the long-term release of radionuclides from SNF at the repository. The use of fill material (not uranium oxides) has been extensively investigated for Canadian waste packages⁶.

These relatively new concepts for DU use in repositories have not been fully evaluated, nor have they yet been factored into repository designs, although independent reviewers have recommended that the new concepts be incorporated into new repository designs (ref. 7). Key issues are the preferred high-density concrete formulation, potential health-hazard implications to workers for repository invert and backfill applications, and the mixture of particle sizes and the insulating effect on the waste package for the fill concept.

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