



U.S. Department of Energy
Office of Inspector General
Office of Audit Services

Audit Report

Potential Uses for Depleted Uranium Oxide

DOE/IG-0810

January 2009




Department of Energy

Washington, DC 20585

January 9, 2009

MEMORANDUM FOR THE SECRETARY

FROM:


Gregory H. Friedman
Inspector General

SUBJECT:

INFORMATION: Audit Report on "Potential Uses For Depleted Uranium Oxide"

BACKGROUND

The Department of Energy's Office of Environmental Management (EM) manages approximately 700,000 metric tons of depleted uranium hexafluoride at the gaseous diffusion plants located near Paducah, Kentucky, and Portsmouth, Ohio. It plans to convert the depleted uranium hexafluoride to a stable material. The conversion process will produce approximately 551,000 metric tons of depleted uranium oxide – a relatively stable form that can be handled and disposed of by direct burial or, potentially, used in various materials or products. Over a period of about 13 years, the Department has conducted research which established that the oxide could possibly be used in catalysts, semiconductors, nuclear repository applications and radiation shielding products.

In August 2002, the Department awarded a contract to Uranium Disposition Services, LLC (UDS) to perform the conversion. In July 2004, UDS started construction of conversion facilities in Paducah and in Portsmouth. As of June 2008, UDS planned on a May 2010 start date for full operations at Portsmouth and a September 2010 start date for operations at Paducah. The current life cycle cost of the conversion project is approximately \$3.5 billion, including costs to dispose of the oxide by burial.

The Department developed a strategy which included a continuing effort to explore potential uses for the converted product. We initiated this audit to determine whether the Department had adequately followed through on identifying potential uses for depleted uranium oxide.

RESULTS OF AUDIT

Our audit disclosed that the Department had not taken adequate action to facilitate development of depleted uranium oxide-based products. In spite of finding potential uses that have shown promise, the Department plans to dispose of virtually the entire 551,000 metric tons of depleted uranium oxide produced by the conversion process as low-level waste at an estimated cost of about \$428 million. In particular, we noted that:

- Beyond basic research, little action had been taken to develop practical applications for, or products involving the oxide;



- For the single application area where research had extended to preliminary development and testing, all funding from outside sources had been expended. Yet, the Department had provided only a small portion of promised funding and had no plans for providing additional funding. Such funding would have supported the development of working or scale models to evaluate patented nuclear repository applications.

Between 1994 and 2006, the Department evaluated multiple uses for the depleted uranium oxide. However, only one of these uses, spent nuclear fuel (SNF) shielding applications, was pursued to the point of being demonstrated as useful for application. In November 2006, researchers at the Oak Ridge National Laboratory reported, based on a 27-month study, that depleted uranium aggregate could be successfully combined with concrete to produce a product known as DUCRETE, providing effective radiation shielding. Researchers noted that this product could be useful for a number of SNF applications in both the Federal and commercial sectors.

Management officials informed us, however, that the Department had discontinued funding research for alternative uses for depleted uranium oxide in 2005 because EM's technology development budget had been significantly reduced. They also noted that the Department was not actively pursuing other uses because it believed that there were no alternatives that would consume the entire depleted uranium oxide inventory. In short, a piecemeal approach was unacceptable. Finally, they indicated that the Department had concluded that it was now the responsibility of the private sector to continue research and development for finding alternative uses for depleted uranium oxide. As discussed in the attached report, we did not find these reasons to be compelling in light of the potential to avoid significant disposal costs.

Despite the results of research over the past few years demonstrating that there are viable re-use options, the Department currently does not plan to pursue any alternatives. Thus, absent additional action, the Department will be forced to incur \$428 million in disposal costs over a 25-year period. The programmatic competition for the Department's finite resources is often intense; yet, the potential to avoid significant disposal costs through alternative uses of conversion oxides offers the promise of directing funds now targeted for disposal to other high-priority mission needs.

To address the issues described in our report we made several recommendations designed to help increase the potential for reuse of the converted materials and avoidance of direct disposal costs.

MANAGEMENT REACTION

Management concurred with our recommendations. Although Management stated that it currently could see no commercial use for the depleted uranium oxide, it agreed that it may be beneficial to reassess interest as conversion facilities near completion and can be expected to begin producing significant quantities of the oxide. To that end the Office of Environmental Management committed to issuing an expression of interest by January 2010 to identify potential interest from industry for uses of depleted uranium oxide.

Management's comments are summarized in the body of the report and are attached as Appendix 2.

Attachment

cc: Acting Deputy Secretary
Under Secretary of Energy
Chief of Staff
Team Leader, Office of Internal Review, CF-1.2
Audit Liaison, Environmental Management, EM-33
Audit Liaison, Portsmouth/Paducah Project Office, PPPO

REPORT ON POTENTIAL USES FOR DEPLETED URANIUM OXIDE

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ALTERNATIVE USES FOR DEPLETED URANIUM OXIDE

Investigating Alternative Uses

The Department of Energy (Department) had not adequately followed through on investigating potential uses for the disposition of the depleted uranium oxide. While several potential uses have been identified and considered, we found that little had been done to pursue these alternatives. Only one technology, the use of depleted uranium oxide for shielding applications, was studied to the point of proven viability. However, rather than pursue this alternative, the Department plans to dispose of the majority of the oxide as low-level waste at an estimated disposal cost of approximately \$428 million.

Potential Alternatives

As required by a February 1998 Consent Order, the Department reports annually to the Ohio Environmental Protection Agency (EPA) on the status of its depleted uranium hexafluoride (DUF₆) conversion activities, including its efforts to identify alternative uses. In its December 2007 report, the Department noted that a number of beneficial uses for the depleted uranium oxide conversion product had been identified to date. Among these were the use of depleted uranium in catalysts, semiconductors, repository applications and radiation shielding products.

In 2000, the Department introduced the potential use of depleted uranium catalysts to decompose a range of volatile organic compounds. Research continued and in 2004 the Department reported that a catalyst formulation, based upon a mixed titanium uranium oxide, was found to be competitive with noble metal catalysts. However, the Department terminated further research at the beginning of Fiscal Year 2004. It was also believed that depleted uranium oxide had electronic properties equivalent to or better than conventional semiconductor materials. The Department conducted limited research to measure the semiconducting properties of solid-crystal depleted uranium dioxide and construct and test a uranium-based diode and transistor. In 2004, while research was in its fundamental stage and the concept not yet proven, the Department terminated efforts on this alternative.

The Department also began evaluating the use of depleted uranium oxide for spent nuclear fuel (SNF) repository and shielding applications. These applications included using depleted uranium dioxide particulates as fill material for SNF repositories, as replacement components for steel in constructing the SNF waste packages, and as a chemical sorption barrier in SNF repositories. For example, using funding from the Department of State in 2003, Russian scientists initiated experiments resulting in a 2006 report

which showed that depleted uranium oxide can be successfully used as a chemical and physical sorption barrier in SNF repositories to reduce radionuclide releases. However, all available funding has been expended and work on the use of depleted uranium oxide for repository applications has now been discontinued.

The other application which showed significant promise was the use of depleted uranium oxide for radiation shielding products, specifically SNF casks. In 2003, the Department's research became focused on uses that had the potential to consume a significant portion of the stored inventory of DUF₆ and in September 2004, the Acting Assistant Secretary for Environmental Management (EM) approved \$420,000 of funding for the development of a new production technology for fabrication of depleted uranium aggregate. This new technology used an approach that had the potential to be a low-cost, high-throughput method for production of depleted uranium aggregate. Ultimately, only \$125,000 of these funds was provided to the project and those funds have now been expended.

In November 2006, researchers at the Oak Ridge National Laboratory (ORNL) reported, based on a 27-month study, that depleted uranium aggregate could be successfully combined with concrete (DUCRETE) to provide adequate radiation shielding and was useful for a number of SNF applications in both the federal and commercial sectors. For example, using DUCRETE to construct nuclear casks would not only provide adequate shielding but would result in smaller cask size and reduced weight. This could significantly reduce the cost of storage container loading by eliminating the need for transfer casks that have specific weight and size restrictions. Further, it could reduce occupational radiation dose associated with handling the SNF for transportation.

Funding for Potential Alternatives

In its 2007 report to the Ohio EPA, the Department stated it had approved \$1 million of funding to fabricate and test a prototype DUCRETE transport and storage cask and that the work continued into 2007. However, we noted that the Department had not provided the funding to fabricate and test a DUCRETE cask. In fact, despite the success of the research over the past few years and the potential to reduce disposal costs, the Department currently does not plan to pursue any of the previously described alternatives. Currently, the Department plans to utilize about 1,200 metric tons for the mixed oxide fuel project, recycle a portion of

DUF₆, and dispose of the remaining volume as low-level waste. The Department's estimated cost for disposing of the oxide over a 25-year period is approximately \$428 million, if the inventory of DUF₆ prior to conversion is not reduced by recycling or re-use.

Discontinuation of Research Funding

The Department decided to curtail its pursuit of uses for depleted uranium oxide in 2005 because: its Technology Development budget had been significantly reduced since 2002; it believed there were no alternatives that would consume the entire oxide inventory; and, it was now the responsibility of the private sector to continue research and development into finding alternative uses for the material.

Reduction in Budget

From 2002 through 2005, EM's Technology Development budget was reduced nearly 71 percent from approximately \$200 million to \$58 million. In 2007, the budget was further reduced to approximately \$21 million. With limited funding, EM's management did not consider the effort for DUF₆ to be a high priority. While funding may be limited, based on discussions with the ORNL Project Manager, modest investments sufficient to continue the research for alternative use for depleted uranium oxide have the potential to avoid significant disposal costs. For example, in addition to avoiding disposal costs, using depleted uranium oxide for DUCRETE in nuclear shipping and storage casks provides additional benefits in other program areas that may not have been fully considered. Further, as confirmed by ORNL's recent study, the use of depleted uranium oxide as a radiation shielding material appears to be a viable alternative that has the potential to reduce the life-cycle cost of the DUF₆ conversion project.

Consumption of Inventory

Management officials also indicated that another factor leading to their decision to discontinue research in uses of depleted uranium oxide was that the technologies under consideration would only make piecemeal or incomplete use of the entire inventory. However, our review disclosed that the ORNL study showed that the use of depleted uranium aggregate in radiation shielding has the potential for consuming the entire depleted uranium inventory. In addition, the studies for repository applications noted that these applications could consume half or more of the depleted uranium inventory.

Engagement of the Private Sector

The Department stated that it believed it is now the responsibility of the private sector to continue research and development for finding alternative uses for depleted uranium oxide. Further, management officials informed us that even if there was a potential use for the depleted uranium oxide, they did not believe that there was a market for it. However, we found that the Department had not engaged private industry on further development of alternatives since 2005. Specifically, between 2003 and 2005, the Department pursued several Cooperative Research and Development Agreements (CRADAs) to commercialize the use of DUCRETE with SNF cask vendors. However, two of the CRADAs were never finalized because the parties either lacked the resources and manpower to complete the work at the time or the project extended beyond the company's business planning cycle. Even though the technology for DUCRETE has now been proven by ORNL, the Department has not re-engaged the private sector since 2005 and has no intention of doing so.

Impact on Disposal Costs of Depleted Uranium Oxide

The Department has the potential to significantly reduce disposal costs. For example, developing DUCRETE casks could reduce the planned disposal costs. According to the ORNL Project Manager, depending on the option taken, the effort to build, test, and license the DUCRETE cask is estimated to be somewhere between approximately \$7 to \$15.1 million. Conversely, the estimated cost to treat the material as low-level waste and bury it is approximately \$428 million. While we recognize that additional costs may be required to commercialize SNF casks made from DUCRETE, the delta is significant enough to warrant the consideration of pursuing this and other alternatives further.

RECOMMENDATIONS

To help ensure that potential alternatives of depleted uranium oxide are fully evaluated, we recommend that the Assistant Secretary, Environmental Management:

1. Re-engage industry on developing alternative uses for depleted uranium oxide; and,
2. Clarify the current status of research for alternative uses for depleted uranium oxide to the Director of the Ohio EPA.

**MANAGEMENT
AND AUDITOR
COMMENTS**

The Acting Assistant Secretary for Environmental Management concurred with the recommendations in the final report. Regarding recommendation 1, management stated that the Department will issue an expression of interest, by January 2010, related to the depleted uranium oxide to identify any potential interest from industry. Management also agreed to inform the Director of the Ohio EPA that work on the DUCRETE transport and storage cask in Russia has stopped and no further actions are expected for the foreseeable future due to lack of commercial interest. Our draft report also included an additional recommendation that the Department review and evaluate the feasibility to continue funding research for spent nuclear fuel shielding applications. In commenting on this recommendation, management stated that sufficient evaluation of alternative uses for depleted uranium oxide has been conducted and that it was not EM's mission to develop and/or implement commercial applications.

We consider Management's comments and planned actions to be responsive to the report's recommendations. Although the Department felt sufficient research had already been conducted, the issuance of an expression of interest should aid in the identification of any useful and economical commercial applications. For this reason, our recommendation to review and evaluate the feasibility of continuing funding for research of spent nuclear fuel shielding was removed from the final report.

Management's verbatim comments are included in Appendix 2 of the report.

Appendix 1

OBJECTIVE

The objective of this audit was to determine whether the Department of Energy (Department) had adequately followed through on investigating potential uses for the depleted uranium oxide.

SCOPE

We conducted the audit from November 2007 through August 2008, at Department Headquarters in Washington, D.C., and the Portsmouth/Paducah Project Office in Lexington, Kentucky. The audit scope included all depleted uranium oxide disposition efforts since the inception of the program.

METHODOLOGY

To accomplish the audit objective, we:

- Reviewed regulations, directives, contract requirements, and performance measures relating to the DUF₆ program and oxide disposition;
- Evaluated internal controls over the program;
- Reviewed prior audits and reviews relating to the depleted uranium hexafluoride (DUF₆) program;
- Reviewed disposition alternatives identified by the Department with the associated studies, funding, risks, requirements, and current status; and,
- Held discussions with key Department officials responsible for disposition of the depleted uranium oxide.

We conducted this performance audit in accordance with generally accepted Government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objective. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objective. The audit included tests of controls and compliance with laws and regulations necessary to satisfy the audit objective. Because our review was limited, it would not necessarily have disclosed all internal control deficiencies that may have existed at the time of our audit. The disposition project for the depleted uranium oxide did not have specific performance measures associated with the *Government Performance and Results Act of 1993* therefore we could not assess the Department's efforts in meeting these measures. Also, we did not rely upon computer processed data to accomplish our audit objective.

Management waived an exit conference.



Department of Energy

Washington, DC 20585

November 26, 2008

MEMORANDUM FOR RICKEY R. HASS
ASSISTANT INSPECTOR GENERAL
FOR ENVIRONMENTAL, SCIENCE,
AND CORPORATE AUDITS
OFFICE OF THE INSPECTOR GENERAL

FROM: INÉS R. TRIAY *Inés Triay*
ACTING ASSISTANT SECRETARY FOR
ENVIRONMENTAL MANAGEMENT

SUBJECT: Draft Report on "Audit of Potential Uses for Depleted
Uranium Oxide"

Thank you for the opportunity to review the draft report on the subject audit. The report states that the Department has not adequately followed through on investigating potential uses for depleted uranium oxide, and that while several potential uses have been identified and considered, little has been done to pursue these alternatives. The report also states that the Department plans to dispose of the majority of the oxide as low-level waste. We have evaluated the contents of the draft report and provide the following for your consideration.

The Department considers that sufficient evaluation of alternative uses for depleted uranium oxide has been conducted and that no substantive basis exists for pursuing new studies at this time. The lack of commercial interest in the use of this material does not warrant further investigation at this time.

The Depleted Uranium Research and Development Activities for Fiscal Year 2007 report sent to the Ohio Environmental Protection Agency (EPA) notes that work on the DUCRETE transport and storage cask in Russia continued in 2007 but the long-term viability of the project is contingent upon finding a United States commercial cask supplier company with which to partner. The Department of Energy (DOE) expects to inform the Ohio EPA in the 2008 report that this work has stopped and no further actions are expected for the foreseeable future due to lack of commercial interest.

While we currently see no commercial use for the depleted uranium oxide, we believe it may be beneficial to reassess interest as the conversion facilities near completion and can be expected to begin producing significant quantities of oxide. To this end, the DOE Office of Environmental Management will issue an expression of interest related to the depleted uranium oxide to identify any potential interest from industry for this material. DOE expects to issue this expression of interest by January 2010.



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Recommendations:

Recommendation 1. Re-engage industry on developing alternative uses for depleted uranium oxide;

EM RESPONSE: EM will issue an expression of interest related to the depleted uranium oxide to identify any potential interest from industry for this material. Due Date: January 2010.

Recommendation 2. Review and evaluate the feasibility to continue funding for the shielding applications associated with the storage, transport and disposal of spent nuclear fuel;

EM RESPONSE: Development and/or implementation of commercial applications are not an appropriate mission of EM. The current state of research and development in this area is mature enough for industry to develop commercially viable applications. No action required.

Recommendation 3. Clarify the current status of research for alternative uses for depleted uranium oxide to the Director of the Ohio EPA.

EM RESPONSE: Portsmouth/Paducah Project Office will clarify the current status of research regarding potential uses for the depleted uranium oxide in the 2008 annual report to the Director of the Ohio EPA. Due Date: January 30, 2009.

We believe these actions are responsive in addressing the concerns identified in the report.

Additional comments are provided in the attachment.

If you have any further questions, please call me at (202) 586-0738 or Mr. Barry Smith, Director, Office of Site Support at (301) 903-4482.

Attachment

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