

DOE/IG-0564

AUDIT
REPORT



U.S. DEPARTMENT OF ENERGY
OFFICE OF INSPECTOR GENERAL
OFFICE OF AUDIT SERVICES

ADVANCED VITRIFICATION SYSTEM

AUGUST 2002



U. S. DEPARTMENT OF ENERGY
Washington, DC 20585

August 20, 2002

MEMORANDUM FOR THE SECRETARY

FROM: Gregory H. Friedman (Signed)
Inspector General

SUBJECT: INFORMATION: Audit Report on "Advanced Vitrification System"

BACKGROUND

The Department of Energy (Department) faces an environmental remediation task of unprecedented scope and technical complexity. Current estimates are that the clean-up effort will eventually cost more than \$230 billion and take decades to complete. At your direction, the Department recently completed a comprehensive evaluation of its remediation effort with a goal of finding a way to reduce associated costs, as well as the time needed to complete the task. Given the nature of the work, the effort will likely involve many as yet untested technologies. In this vein, the Assistant Secretary for Environmental Management has established a priority to identify breakthrough technologies with the potential to dramatically reduce the Department's remediation mortgage costs.

In a desire to expedite and reduce the cost of clean-up activities, the Radioactive Isolation Consortium, LLC, a private company, made an unsolicited proposal to the Department in 1998 relating to a technology it called the Advanced Vitrification System (AVS). According to the proposal, this technology could accelerate the clean-up schedule at the Department's Hanford site, and save tens of billions of dollars across the complex. The Department awarded a multi-year contract to Radioactive Isolation Consortium, LLC, and to date, about \$10 million has been expended on or committed to AVS. The Department recently granted an extension of the contract through January 2003 and is actively considering providing \$30 million in additional funding for technology demonstration and construction of a pilot AVS test facility.

In March 2002, the Office of Inspector General received information that raised concerns about the effectiveness and usefulness of the AVS technology. Based on these concerns and because of the importance of vitrification technology to the remediation of high-level waste, we initiated this audit to identify issues that could prevent successful deployment of the AVS.

RESULTS OF AUDIT

The audit disclosed that there are a number of significant unresolved technical issues affecting the ability to develop and deploy AVS. We concluded that these challenges should be addressed before the Department funds additional research on the technology. Evaluations conducted by independent reviewers and by Department staff over the past five years have raised serious doubts about the viability of AVS and the likelihood that it will deliver on the benefits promised. One review, for example, concluded that the Radioactive Isolation Consortium, LLC failed to prove that the AVS process produced a waste form

acceptable for storage in a permanent repository. Other studies indicated that potential cost savings were substantially overstated and that planned reductions in the risk of exposure to workers could not be substantiated. While one independent study concluded that the AVS process had merit, its authors identified at least 15 significant uncertainties or technical challenges that would need to be overcome.

Also, the Department had not developed specific performance measures relating to the evaluation and selection of alternative vitrification technologies. To its credit, the Department planned to initiate a business plan evaluation of the AVS technology. Hopefully, the review will provide a more definitive assessment as to the viability of using AVS in the Department's environmental remediation efforts.

We recognize the need to explore new technologies, take responsible risks and, at the same time, apply taxpayer-provided resources to the most promising alternatives. With these objectives in mind, we believe that the Department should ensure that all of the significant issues raised in prior studies could be successfully addressed before deciding to commit additional funds to AVS. To help achieve this goal, the Department should adopt additional performance measures to allow it to better gauge the progress in the evaluation and selection of an effective vitrification technology. project as well as take steps to hold its contractor more accountable for program success.

MANAGEMENT REACTION

Management agreed with the conclusions reached and the appropriateness of the recommendations. Planned corrective actions include developing an action plan, which will establish an Independent Project Evaluation Team and a Business Analysis Team. Among other planned actions, the Independent Project Evaluation Team will conduct a plausibility review of the AVS. Management's comments have been included in their entirety at Appendix 1.

Attachment

cc: Chief of Staff
Under Secretary for Energy, Science and Environment
Assistant Secretary for Environmental Management

ADVANCED VITRIFICATION SYSTEM

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Overview

INTRODUCTION AND OBJECTIVE

The Department of Energy (Department) stores a substantial quantity of high-level radioactive waste, requiring treatment and eventual disposal, at its Hanford Site in Richland, Washington. The Department has adopted a multi-phased approach to treating this waste, and plans to vitrify about 10 percent of it into borosilicate glass through the use of a joule-heated melter in the project's first phase. Remaining site high-level waste will be treated in the subsequent phase, and may not necessarily use the same melter technology. Consequently, the Department is examining other melter technologies that could reduce costs without significantly increasing long-term environmental risks. A Departmental official also indicated that other vitrification technologies are being considered for treating high-level waste at Hanford and other potential locations (Savannah River Site and Idaho National Engineering and Environmental Laboratory).

In a 1998 unsolicited proposal to the Department, the Radioactive Isolation Consortium, LLC, a private company, claimed that a technology it was developing would accelerate the Hanford vitrification schedule and save tens of billions of dollars across the complex. The process was known as the Advanced Vitrification System (AVS) and had been under development for some time. In several reviews conducted on AVS, both prior to the proposal and since, Department officials as well as independent reviewers questioned the viability of the technology. Nevertheless, the Department elected to fund the research in AVS technology and awarded a contract to Radioactive Isolation Consortium, LLC. Since 1998, about \$10 million has been expended on or committed to the project. The Department recently granted a contract extension through January 2003 and is considering providing \$30 million in additional funding for technology demonstration and construction of a pilot AVS test facility. Since inception, the AVS project has generated significant interest from reviewers and observers both internal and external to the Department.

The Office of Inspector General (OIG) has undertaken a series of reviews designed to evaluate performance of the Department's environmental management program. Based on this work, we concluded in our *Special Report on Management Challenges at the Department of Energy*, (DOE/IG-0538, December 2001) that Environmental Standards and Stewardship, including the disposal of high-level waste, is one of the most significant challenges the Department faces. We initiated this audit to identify issues that could prevent successful deployment of the AVS.

**CONCLUSIONS AND
OBSERVATIONS**

The potential development and deployment of AVS faces a number of significant challenges that should be addressed prior to funding additional research. Between December 1996 and July 2001, three independent evaluations initiated by the Department concluded that the AVS process was unlikely to be viable. One of these evaluations also recommended discontinuation of project funding. These reviews and other testing of the AVS process identified problems with producing an acceptable waste form. Reviewers also noted overstated estimates of potential cost savings and overly optimistic predictions regarding reduction of risk to workers. While a fourth independent study performed in 1997 concluded that the process had merit, it identified at least 15 significant uncertainties or technical challenges that would need to be overcome.

During the audit, the OIG learned that the Department is planning a business plan evaluation to determine whether AVS has a role in the remediation of high-level waste. We, therefore, recommended that Environmental Management design this review to fully address and, to the extent possible, resolve the challenges and uncertainties raised in previous studies prior to funding additional research on AVS.

Management should consider the issues discussed in this report when preparing its yearend assurance memorandum on internal controls.

(Signed)
Office of Inspector General

Research and Development Challenges

Technical and Management Challenges

The AVS technology faces significant technical and management challenges that could prevent or hinder its development and deployment. The Department has sponsored research of AVS since 1998, but the proposed technology has yet to satisfy a number of essential technical requirements. Specifically, independent evaluations (see Appendix 2) have concluded that technical, cost, and programmatic issues may jeopardize the viability of the process.

Technical Issues

A key consideration for any vitrification technology is that the end product must meet technical specifications for disposal in a geologic repository. Despite multiple attempts, the AVS contractor could not successfully demonstrate that the waste product met the Department's minimum requirements for chemical composition and stability. While the contractor was permitted to amend its original report of results on two separate occasions, an independent panel of experts convened in 2001 was unable to conclude that the vitrified waste produced by the AVS process satisfied waste specifications. The review team specifically noted that it was unable to determine the chemical composition and stability of the vitrified sample at various temperatures, and the contractor was unable to provide additional data that would change the review team's conclusion.

Additionally, a number of independent studies conducted between 1996 and 2001 concluded that the AVS technology was immature and that many significant technical issues needed to be overcome before the process could be seriously considered as an alternative to current vitrification technology. Specifically:

- A 1996 Department study noted that AVS, if successful, would require a greater number of waste canisters than the current vitrification process. Reviewers noted that the number of canisters would increase two to three times over the current process and would increase the estimated cost of vitrification by about \$7.3 billion. The study also noted uncertainties stemming from the immaturity of the technology and the absence of analytical data.
- A 1997 American Society of Mechanical Engineers study indicated that the project was scientifically sound, but that project staff had "...barely begun to investigate and evaluate engineering and implementation issues." The study concluded that the technology would not be available in the near term.

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- A 1999 evaluation commissioned by Environmental Management and composed of a number of public and private sector experts, found that the claimed advantages and benefits of the AVS process were "...largely theoretical, unproven, and not substantiated by convincing objective evidence." The report also stated that key aspects of the proposed AVS system had not yet been tested at the bench scale level.
 - A 2001 report by the Department's Environmental Management Tanks Focus Area found that a significant amount of development and demonstration work was required in order for the AVS technology to be adequately judged, and many significant technical issues identified during the review would need to be overcome before the technology could be seriously considered.

The contractor also had not addressed a number of potential environmental, safety and health issues. As detailed in the cited 1999 study, the contractor's hazardous materials processing analysis was incomplete and could impact certain aspects of worker protection. For example, the contractor inappropriately proposed to use contact handling methods for highly radioactive material that could only be safely manipulated using remote handling techniques. The study also determined that researchers did not adequately address relevant environmental protection regulations established by the Environmental Protection Agency, Occupational Safety and Health Administration, Washington Department of Ecology or Resource Conservation and Recovery Act. Further, the panel concluded that AVS did not produce a vitrified waste product that met specifications necessary for acceptance at a geologic repository.

Projected Savings

Studies also identified a number of uncertainties relating to AVS projected cost savings. For example, AVS researchers claimed that the technology would accelerate the Hanford cleanup schedule and save the government and taxpayers tens of billions of dollars. Yet, two of the cited reviews indicated a substantial likelihood that such savings may not be achievable. Reviewers noted that:

- Cost estimates did not include key design features or grossly underestimated the complexity of the features. The excluded components and factors could end up doubling the original capital cost estimate;

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- The research proposal contained a number of omissions, faulty assumptions and technical and programmatic unknowns that required correction before an objective life cycle cost analysis could be developed;
 - Cost data were fragmented, inconsistent, and not summarized in a logical manner;
 - Development cost estimates were incomplete and confusing; and,
 - Conflicting information on the number of canisters needed for the AVS treatment process dramatically affected projected cost savings.

Based on these and other comments, the contractor's assertion that billions of dollars will be saved appeared tenuous.

Programmatic Viability of AVS

In July 2001, Environmental Management's Tanks Focus Area Group reviewed a number of vitrification technologies and concluded that AVS was not a practical solution to Hanford's long-term vitrification needs. The Group reviewed at least 14 distinct technologies and compared them to the process then in use at Hanford. The study found that there are currently only two practical options to meet Hanford's long-term needs: (1) improving the currently used ceramic melter and (2) a technology known as the Advanced Cold Crucible melter. The Group categorized AVS as one of the "other melter technologies" and did not consider it to be a serious candidate for handling Hanford's high-level waste. Similarly, previous studies performed in 1996 and 1999 found that AVS was not a viable competitor for backup or replacement of the current vitrification technology because of significant uncertainties.

Program Performance

Resolution of the identified challenges associated with AVS will require additional scientific analysis and prompt attention from senior Department managers. We noted certain issues that, if promptly addressed, could help the Department ensure that its approach to vitrification research in general, and AVS technology more specifically, optimizes program performance regarding the treatment of highly radioactive waste.

The Department had not developed specific performance measures related to the evaluation and selection of an alternative vitrification technology. While a measure related to the production of high-level waste canisters used for vitrification at the Savannah River Site was in place, it was not sufficient to permit measurement of progress in the effort to develop an alternative vitrification technology. As we noted in our recent report on *Environmental Management Performance Measures*, (DOE/IG-0561, June 2002), corporate performance measures for the environmental program were insufficiently detailed and covered only about 32 percent of overall program investment. Specific measures in this area may have focused senior management's attention on the problems and uncertainties associated with the AVS project.

We also learned that the Office of Environmental Management plans to initiate a business plan evaluation that would determine whether AVS has a role as an alternative/backup technology for Hanford high-level waste. The study is scheduled to begin in the summer of 2002 and is expected to last several months. It is to be coordinated by the Richland Operations Office, and will involve participation by both independent experts and Departmental officials. In our judgment, the new study offers an appropriate vehicle for the Department to address concerns raised in previous reviews. A successful outcome of this study would be a definitive determination by the Department as to the likelihood that AVS can overcome the challenges it faces and ultimately become a viable technological advancement.

Funding Resolution

As of June 2002, the Department had committed about \$10 million on AVS, and Environmental Management was considering whether to devote another \$30 million to the project over a period of 30 months. The additional money would fund a pilot facility intended to demonstrate the ability of AVS to vitrify high-level waste consistent with the Department's waste acceptance criteria.

The President's Management Agenda for Fiscal Year 2002 notes that science and technology are critically important to keeping our nation's economy competitive and for addressing challenges we face in, among other areas, environmental restoration. The Agenda specifies, however, that every Federal research and development dollar must be invested as effectively as possible and that the Government needs to measure

whether its research investments are effective. It was noted that the Government can rarely show what its investments have produced and that information about performance is not linked to decisions about funding.

The Office of Inspector General recognizes the importance of Environmental Management's efforts to address its most serious waste cleanup challenges faster and less expensively. However, we believe that the unresolved technical issues identified over the last five years must be addressed and, to the extent possible, resolved before the Department provides additional funding for the technology demonstration and construction of an AVS test facility.

RECOMMENDATIONS

We recommend that the Assistant Secretary for Environmental Management:

1. Delay funding decisions on AVS until major uncertainties have been addressed;
2. Develop specific, focused performance measures to more fully gauge progress in the evaluation and selection of an alternative or advanced vitrification technology; and,
3. Address all technical, programmatic, and financial challenges and uncertainties identified in previous studies during the upcoming business plan evaluation.

MANAGEMENT REACTION

Management agreed with the conclusions reached and the appropriateness of the recommendations. Management's comments have been included in Appendix 4.

AUDITOR COMMENTS

Management's comments and proposed corrective actions are responsive to our recommendations.

memorandum

DATE: July 30, 2002

REPLY TO
ATTN OF:

EM-54 (Gerdes, 3-7289)

SUBJECT:

Draft Inspector General Report on "Advanced Vitrification System"

TO:

William S. Maharay, Assistant Inspector General for Audit Services
Office of Inspector General

The Office of Environmental Management (EM) has reviewed the subject report and agrees with the findings and recommendations. Our proposed steps for addressing the Inspector General's recommendations are:

IG Recommendation: Delay funding decisions on the Advanced Vitrification System until major uncertainties have been addressed.

EM Response: Environmental Management is currently developing an Action Plan that describes its approach to evaluating and developing immobilization alternatives for treating high-activity waste across the Department of Energy complex. An intensive Department of Energy review and selected research and development activities will be conducted over the next 12 months using the expertise from the Department's Field Offices, specifically the Office of River Protection and Savannah River's High-Level Waste Division. The results of this research will provide the basis for a decision by the Assistant Secretary for Environmental Management on which alternatives should be developed.

IG Recommendation: Develop specific, focused performance measures to more fully gauge progress in the evaluation and selection of an alternative or advanced vitrification technology.

EM Response: The Action Plan mentioned above will establish an Independent Project Evaluation Team which will initially establish a technical baseline and then conduct a series of technical reviews. The team will consist of scientists with expertise in glass chemistry, vitrification, and design/operation of a treatment plant. Team members will be drawn from both the Department of Energy and external sources. The reviews to be conducted include:

1. plausibility review of the Radioactive Isolation Consortium Advanced Vitrification System;



2. technical comparison of the Radioactive Isolation Consortium Advanced Vitrification System vs. the current baseline for the Office of River Protection; and
3. consideration of alternative waste forms and melters.

IG Recommendation: Address all technical, programmatic, and financial challenges and uncertainties identified in previous studies during the upcoming business plan evaluation.

EM Response: In addition to the Independent Project Evaluation Team technical reviews mentioned above, the Action Plan will establish a Business Analysis Team to conduct a cost analysis of the immobilization alternatives approved by the Office of River Protection for further evaluation. The Independent Project Evaluation Team will provide technical assumptions to address the uncertainties, thereby providing a basis for the business analysis. The Business Analysis Team will focus on evaluating whether or not any of the approved alternatives offer significant cost savings over the current baseline. If possible, the Business Analysis Team will also perform some analyses considering an alternate waste form. The Business Analysis Team will be led by a Savannah River designated individual, since Savannah River possesses a good understanding of cost considerations from their previous work supporting the Defense Waste Processing Facility, and can adapt current Hanford cost information to future improvements.

If you wish to discuss these responses or need additional information, please contact Jeffrey Walker of my staff at (301) 903-8621.


Jessie Hill Roberson
Assistant Secretary for
Environmental Management

EVALUATIONS

- December 1996 – Independent Assessment of an Alternative Process for Tank Waste Remediation using Small In-Tank Processing and Small Modular In-Can Vitrification.
- July 1997 – Consensus Report of the Review Panel for Small Modular In-Can Vitrification and Small In-Tank Processing Modules.
- November 1999 –Department of Energy Report of Overall Evaluation and Gate 3 Review of Radioactive Isolation Consortium, LLC, Advanced Vitrification System.
- July 2001 – TANKS FOCUS AREA High-Level Waste Melter Review Report.
- July 11, 2001, August 8, 2001, and December 19, 2001 – Independent Evaluation of the Results of Additional Tests of the Advanced Vitrification System.

Appendix 3

SCOPE

The audit was conducted from April 2002, through June 2002, at Department of Energy Headquarters and at the National Energy Technology Laboratory (NETL) in Pittsburgh, PA and Morgantown, WV. We focused our review on actions taken and planned by Department officials, not the contractor.

METHODOLOGY

To accomplish the audit objective we:

- Reviewed specific contract requirements for the Radioactive Isolation Consortium, LLC, AVS project;
- Reviewed various reports, studies, and/or evaluations related to AVS technology to determine the technical, financial, and programmatic concerns of this technology;
- Held discussions with Department Headquarters and NETL officials to obtain the status of the AVS project and understand the technical workings of the AVS technology;
- Held discussions with Department Headquarters and NETL officials to obtain their opinions on the viability/maturity of AVS and how it compares to other viable technologies;
- Reviewed applicable Department guidance for evaluating and managing environmental technologies;
- Reviewed an independent evaluation of the Department's Waste Acceptance Product Specifications; and,
- Determined if the Department established performance measures related to the evaluation and selection of alternative vitrification technologies.

The audit was conducted in accordance with generally accepted Government auditing standards for performance audits and included tests of internal controls and compliance with laws and regulations to the extent 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. Also, we did not rely on computer-processed data to accomplish our audit objective.

We held an exit conference with Environmental Management officials on August 1, 2002.

RELATED REPORTS

OFFICE OF INSPECTOR GENERAL REPORT

- *Idaho Operations Office Planned Construction of a Waste Vitrification Facility*, (DOE/IG-0549, April 2002). The Department had not adequately considered potentially less costly alternatives to constructing the vitrification facility, including several proposed by the National Research Council.

GENERAL ACCOUNTING OFFICE REPORTS

- *Department of Energy's Hanford Tank Waste Project---Schedule, Cost, and Management Issues*, (GAO/RCED-99-13, October 1998). The General Accounting Office (GAO) concluded that remediating Hanford's radioactive tank waste will be difficult and very costly. In addition, given the nature of the tank waste and the challenges associated with converting it to a more stable form for long-term storage, the project involves substantial risk of encountering problems that could result in further increases in schedule and cost.
- *Further Actions Needed to Increase the Use of Innovative Cleanup Technologies*, (GAO/RCED98-249, September 1998). GAO noted that after congressional hearings in May 1997, the Office of Environmental Management initiated changes in its organization and processes to increase the deployment of innovative technologies.

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