



National Security and
International Affairs Division

B-281720

February 16, 1999

The Honorable Larry E. Craig
United States Senate

Subject: Environmental Protection: Research and Development of Plasma Arc
Technology Used to Treat Hazardous Waste

Dear Senator Craig:

As you requested, we are providing information on three selected research and development initiatives using a technology called plasma arc¹ to treat waste materials. As agreed with your office, our objective was to compare characteristics of the largest of the Department of Energy initiatives and both Department of the Navy shore and ship initiatives.

BACKGROUND

The high heat of a plasma arc causes fundamental changes in materials exposed to it. For example, some materials become a molten mass, which hardens into a rock-like substance, while others are vaporized. Such heat was first used in metal processing about 100 years ago. Beginning in the 1980s, the Departments of Energy and Defense began research for treating hazardous waste using heat from a plasma arc torch designed to reduce some hazardous compounds to benign basic elements. Some elements might remain hazardous but could be trapped in a hardened rock form. Gases and particles that are given off during the process may require further treatment.

RESULTS IN BRIEF

In summary, the three initiatives use a similar source of heat to treat waste, but have different goals and equipment designs. Although the initiatives' goals and

¹Plasma arc technology involves the conversion of electrical energy into an intensely hot gas of several thousand degrees centigrade. Plasma is the term given to the condition of the gas at the highest temperature in the arc. The arc is like a sustained lightning discharge and does not require oxygen in the way that a fire does.

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designs for systems' inputs, furnaces, and outputs differed, the contractor responsible for the Energy and Navy shore initiatives incorporated technology from prior Energy research into the Navy shore initiative. Table 1 shows major characteristics of the three initiatives. See enclosure I for information on the plasma arc process in hazardous waste treatment and details on the Energy and Navy initiatives.

Table 1: Characteristics of Selected Energy and Navy Initiatives

Characteristic	Energy	Navy shore	Navy ship
Phase	Research	Development	Research
Goal	Obtain research data, including data on radioactive waste	Treat hazardous, nonradioactive waste on shore	Treat nonhazardous waste on ships
Input	Individual 55-gallon drums	Up to 5-gallon containers	Feed from other waste systems
Furnace	6.5-foot square fixed-hearth with a movable 1.2-megawatt torch	8-foot diameter rotating-hearth with a movable .75-megawatt torch	3-foot by 1-foot diameter hearths with two fixed 175-kilowatt torches
Output system	Treatment for mostly benign gases and particles	Treatment for wider range of gases and particles using a second plasma torch	Treatment for mostly benign gases and particles

Note: Defense and Energy waste categories include nonhazardous materials such as food, paper, and glass; hazardous material such as paint, solvents, and metals; radioactive elements such as plutonium and materials contaminated by radioactivity; and mixed waste consisting of commingled hazardous and radioactive waste.

SCOPE AND METHODOLOGY

We obtained information on plasma arc research and development initiatives at the headquarters of the Departments of Defense (Washington, D.C.) and Energy (Germantown, Maryland) and at pertinent Defense, Energy, and government contractors' locations. To compare Energy and Navy initiatives, we included the highest-cost Energy initiative and both the Navy shore development and the Navy ship research initiatives cited in the request. We focused on the goals of the initiatives and designs for equipment inputs, furnaces, and outputs. The primary Department of Defense (DOD) offices were the Directorate of Defense

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Research and Engineering and the program offices for the Environmental Security Technology Certification Program and the Strategic Environmental Research and Development Program.

We also talked with staff from the offices of the Naval Sea Systems Command, Naval Facilities Engineering Command, and Naval Research.


We performed our work from June through December 1998 in accordance with generally accepted government auditing standards.

AGENCY COMMENTS AND OUR EVALUATION

We requested comments on a draft of this product from the Secretaries of Defense and Energy or their designees. In oral comments, a DOD official in the office of the Directorate of Defense Research and Engineering stated that DOD concurred with our presentation of DOD information in the draft. DOD also provided technical comments, which we have incorporated as appropriate. In written comments, the Energy Department said that it had no issues with our review. Enclosure II contains Energy's written comments.

We are providing copies of this report to the Departments of Defense, the Navy, and Energy. We will make copies available to other interested parties upon request. If you have questions, please contact Charles Patton, Jr., Associate Director, on (202) 512-8412 or Uldis Adamsons, Assistant Director, on (202) 512-4289. Other major contributors to this report were Bruce Brown, Ed Soniat, Johnnie Phillips, and Peter Kraut.

Sincerely yours,


David R. Warren, Director
Defense Management Issues

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PLASMA ARC PROCESS USED FOR HAZARDOUS WASTE TREATMENT
AND DETAIL ON SELECTED INITIATIVES

PLASMA ARC PROCESS OVERVIEW

Hazardous waste is present in numerous materials, including building materials, soiled rags, solvents, paint, dirt, oil, lubricants, batteries, blast media, electroplating sludge, incinerator ash, and adhesives, that present risks to human health and the environment. Radioactive materials, such as plutonium or uranium, also present such risks. Research has been funded using the plasma arc technology for treating one or a number of these materials (including surrogates for radioactive materials).

The initiatives that we compared involve the treatment of hazardous waste in a furnace heated by a plasma torch.¹ The maximum heat is within a relatively small area surrounding the arc, and furnace designs may move the hearth or the torch. Some hazardous compounds may be carried in gases produced when the material is vaporized, necessitating further treatment of the gases by filtering or other treatments.

Research initiatives for the treatment of hazardous waste have involved furnaces with hearths ranging from less than 2 feet in diameter to 8 feet in diameter and electrical power levels from 150 kilowatts to over 1 megawatt. They have involved continuous or batch feed systems for small items or large 55-gallon drums of material. Research has been conducted with fixed-hearth furnaces as well as with hearths that rotate.² Gas treatment has ranged from simple systems in the case of benign or less hazardous gases to complex systems for wider ranges of gases or radioactive material.

Among various plasma arc research initiatives by Energy and Defense over the past 10 years for hazardous waste, only two in the United States have reached the implementation stage. The two are the Navy shore project included in our comparison and an asbestos destruction project that is ongoing at Port Clinton, Ohio. The others, including the Navy ship project, are still in the research stage.

The following sections describe the largest of the Department of Energy plasma arc initiatives, and both the Navy shore and ship initiatives.

¹Other plasma arc research involves treating contamination beneath the earth's surface.

²In addition to Energy's fixed-hearth initiative which we compared to the Navy's shore initiative, the contractor also developed a rotating hearth furnace for Energy. The contractor used the rotating hearth design for the Navy shore initiative.

DEPARTMENT OF ENERGY RESEARCH INITIATIVE

The Energy Department's research initiative involved a fixed-hearth furnace located at a contractor site in Ukiah, California, and small-scale testing at other locations. The goal of the projects was to gather research data on the treatment of radioactive waste, nonradioactive hazardous waste, and mixtures of the two. The research involved limited types of waste, primarily contaminated soil and construction material. Although the research focused on radioactive waste, the experiments used surrogates to simulate the radioactive materials. The initiatives began in 1991, became operational in 1996, and were last funded in 1997. The Energy initiative's total cost to date is \$35 million.

The equipment input design provides for the feeding of 55-gallon drums of material into the fixed-hearth furnace. The feeder is bolted shut and may be unbolted to receive the next drum of material after the first moves out of the feeder. The hearth remains stationary, while the torch is moved to apply heat uniformly. The hearth is equipped with a tilt and pour system that can separate recoverable metals from other molten material. The output system is designed to filter mostly benign gases that resulted from the experiments.

NAVY INITIATIVE TO DEVELOP
A WASTE TREATMENT SYSTEM ON SHORE

The Navy's shore initiative involves constructing a rotating-hearth furnace system at the Norfolk Naval Base to destroy mixed solid and liquid hazardous materials and to obtain operational data to determine the cost-effectiveness of the process. The hazardous material will come from the Norfolk Naval Base and from ships returning to the base. The initiative began in 1995, and the Navy plans to complete the facility by 2000. Thus far, \$5.5 million has been obligated for the initiative. Another \$4 million is planned before facility operations begin.

The input design provides for the continuous feed of mixed liquid and solid hazardous waste. Up to 5-gallon containers of hazardous material can be manually loaded into a shredder that feeds material into the hearth by means of a screw feed mechanism, while liquids can be poured into a separate opening. The furnace hearth rotates during the treatment of the hazardous material, while the torch is moved to apply heat. The output system includes a chamber with a second plasma torch that is intended to treat a wide range of gases and particles generated in the initial treatment phase. In addition to the second torch, the system includes filters to remove remaining hazardous particles carried by the gases.

NAVY SHIP RESEARCH INITIATIVE

The Navy's ship initiative is to develop a compact unit to treat and reduce the volume of solid nonhazardous waste on ships. Development of the unit is projected to be completed by 2004, and the unit is planned for installation on a ship by 2005. The project began in 1995, and \$3.6 million has been obligated to date. Although the initiative was not funded during fiscal year 1998, funding is anticipated for fiscal 1999. An additional \$13.2 million is planned for fiscal years 1999 to 2001, and no estimate has been made for costs for 2002 and beyond.

The planned input design provides for separate continuous feeders and separate hearths—one for organic solids such as food and paper and one for inorganic solids such as glass or metal. The Navy plans to use existing shredders and pulpers to process such material before heat treatment. Although the ship system would require substantial space, the hearths are smaller than Energy and Navy shore systems and the Navy reports that its design is on the order of one-tenth the weight and one-third the volume of conventional marine incinerators of the same throughput. The output system is to include a second chamber, where gases and particles generated after the initial treatment of nonhazardous materials would be treated.

COMMENTS FROM THE DEPARTMENT OF ENERGY



Department of Energy

Washington, DC 20585

FEB 4 1998

Mr. David R. Warren, Director
Defense Management Issues
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Warren:

We have reviewed the January 1999 draft General Accounting Office (GAO) report, "ENVIRONMENTAL PROTECTION: Research and Development of Plasma Arc Technology Used to Treat Hazardous Waste," in which Department of Energy (DOE) work was used for comparative information during GAO's review of research involving plasma arc technology in the Department of Defense and of high-heat systems by the Navy.

We have no issues with the review results described in the draft report, which points out the differences in goals and equipment designs of the three initiatives. The report also points out that technology from DOE research was leveraged in the Navy development project.

If you need additional information, please contact me or Lana Nichols of my staff on (301)-903-8493.

Sincerely,

Gerald G. Boyd
Acting Deputy Assistant Secretary
for Science and Technology
Office of Environmental Management

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