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# Decision Analysis Science Modeling for Application and Fielding Selection Applied to Equipment Dismantlement Technologies

**Topical Report**
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# Disclaimer

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# TABLE OF CONTENTS

## ACRONYMS

| | |
|---|---|
| D&D | Decontamination and Decommissioning |
| DOE | U.S. Department of Energy |
| DOE-EM | U.S. Department of Energy-Environmental Management |
| DOE-OST | U.S. Department of Energy-Office of Science and Technology |
| FIU | Florida International University |
| FIU-HCET | Florida International University-Hemispheric Center for Environmental Technology |
| FY97 | fiscal year 1997 |
| FY98 | fiscal year 1998 |
| HCET | Hemispheric Center for Environmental Technology |
| INEL | Idaho National Engineering Laboratory |
| IUOE | International Union of Operating Engineers |
| MODM | multi-objective decision making |
| ORNL | Oak Ridge National Laboratory |
| PC | personal computer |
| RAPIC | Remedial Action Program Information Center |

## NOMENCLATURE

| | |
|---|---|
| psi | pound per square inch |
| ft | foot |
| V | volt |
| amp | ampere |

# EXECUTIVE SUMMARY

The purpose of this 2-year investigation is to field test innovative as well as commercially available nuclear and non-nuclear technologies for equipment dismantlement, thereby ensuring that the safest and most cost-effective options are developed and subsequently used during the decontamination and decommissioning (D&D) of U.S. Department of Energy (DOE) sites. Comprehensive and comparable data will be collected in the areas of health and safety, operations, and secondary waste management. The technologies tested will include innovative as well as commercially available nuclear and non-nuclear technologies that have the potential to meet the environmental restoration objectives.

This report summarizes the activities performed during fiscal year 1997 (FY97) and describes the planned activities for fiscal year 1998 (FY98). Accomplishments for FY97 include the following:

- Design and construction of the equipment dismantlement technologies test site at the Hemispheric Center for Environmental Technology
- Identification of over 100 equipment dismantlement technologies
- Pre-selection of dismantlement technologies
- Identification of surrogate material for technology demonstration

It is expected that a total of seven technologies will be tested during FY98. After the completion and compilation of the technology demonstration results, a decision will be made at a later stage whether to evaluate and test additional technologies and whether to develop interactive computer software during fiscal year 1999. The decision support model will allow site-specific parameters and technology performance data to be considered when determining the best option given site-specific conditions.

# 1.0 INTRODUCTION

The dismantlement of radioactively contaminated process equipment is a major concern during the D&D process. As buildings undergo the D&D process, metallic equipment contaminated with radionuclides such as uranium and plutonium must be dismantled before final disposal. The primary objective for equipment dismantlement is to reduce the potential for personnel and environmental exposure to contaminants during the decommissioning of the nuclear facility.

The selection of the appropriate technologies to meet the dismantlement objectives for a given site is a difficult process in the absence of comprehensive and comparable data. Choosing the wrong technology could result in increased exposure of personnel to contaminants and an increase in D&D project costs.

Innovative technologies are being developed with the goal of providing safer and more cost-effective alternatives that generate less secondary waste, thereby decreasing the operating costs for dismantlement. During the development and implementation process, performance indicators for the success of these technologies must be reviewed to ensure that these aims are being met. This project provides a mechanism for the assessment of innovative and commercially available nuclear and non-nuclear technologies for equipment dismantlement.

## 1.1 PURPOSE OF THIS INVESTIGATION

The purpose of this investigation is to field test innovative and commercially available nuclear and non-nuclear technologies for equipment dismantlement. Evaluating the selected technologies under standard non-nuclear conditions will ensure that the safest and most cost-effective options are being developed for the D&D of the DOE's environmental restoration sites.

Assessments of selected technologies will be conducted under the supervision of HCET and the International Union of Operating Engineers (IUOE) on the campus of Florida International University (FIU) in Miami, Florida. Comprehensive and comparable data will be collected in the areas of health and safety, operations, and waste management. The technologies tested will include those funded by the U.S. Department of Energy-Environmental Management (DOE-EM) as well as commercial nuclear and non-nuclear technologies that have the potential to meet the decontamination objectives of reducing personnel and environmental exposure or reducing the contamination levels to those for unrestricted use.

The test conditions developed for the assessment of these technologies are consistent with baseline testing performed under the contract with DOE. The data gathered as part of the testing of commercially accepted technologies will be used to compare the performance of the innovative technologies. This will allow a direct comparison of data related to production rates, health and safety issues, waste generation, and other performance factors.

## 2.0 PROJECT DESCRIPTION

The project goals for this project are:

- to evaluate innovative as well as commercially available nuclear and non-nuclear technologies.
- to develop a multimedia information system for dismantlement technologies.

To facilitate the completion of these goals, the following tasks have been established:

- Develop a test area to evaluate innovative as well as commercially available nuclear and non-nuclear technologies under conditions found at DOE Complex facilities (scheduled for completion in February1998).
- Determine technology assessment requirements.
- Develop a list of potential equipment dismantlement technologies to be evaluated.
- Develop and maintain a multimedia information system for equipment dismantlement technologies (FY98).
- Perform field assessments of seven innovative and commercially durable nuclear and non-nuclear technologies during FY98.
- Document performance results of technologies tested (FY98).
- Develop interactive computer software that uses the collected performance data and site-specific data to facilitate the decision-making process in selecting a decontamination technology (FY99).

# 3.0 RESULTS

The required preparatory work to help complete the field testing of innovative and commercially available nuclear and non-nuclear technologies was completed during FY97. These activities included the following:

- Selecting and preparing surrogates
- Comparing the end point achieved to the assessment objectives
- Determining the types of technologies to be tested
- Establishing a test location and utility parameters
- Establishing data requirements.

## 3.1 SELECTING AND PREPARING SURROGATES

A preliminary review of DOE sites indicated a wide variability in the types of equipment used. This variability made it difficult to choose the proper design for the construction of the test areas. To develop the test site, HCET personnel's experience and consultations with DOE professionals were used during the surrogate selection and test site design. Photo albums from the Fernald and Hanford sites were also reviewed. To provide uniformity in testing, schedule 40 steel was selected for the 4″ × 6″ diameter pipes and A-36 grade steel was selected for the I-beams to construct the items in the test sections.

The test site was designed in-house and was approved by Shrum and Ali Associates, who also provided architectural drawings for the construction of the test site. VRV contractor was hired for the construction of the test site. The test site includes the following equipment:

1. Railing
2. Tank
3. Large equipment (i.e. glove boxes)
4. Large overhanging I-beam (and support) (W 16 × 31)
5. Electrical conduit
6. 12-ft cast-iron drainage pipe
7. Pipe hanger
8. 6-ft pipe (schedule 40)
9. 4-ft pipe (schedule 40)
10. 6-ft I-beam (W 6 × 16)
11. Gate valve
12. Barricade

The schematic layout of the test site is shown in Figure 1, and the actual test site is presented in Figure 2.

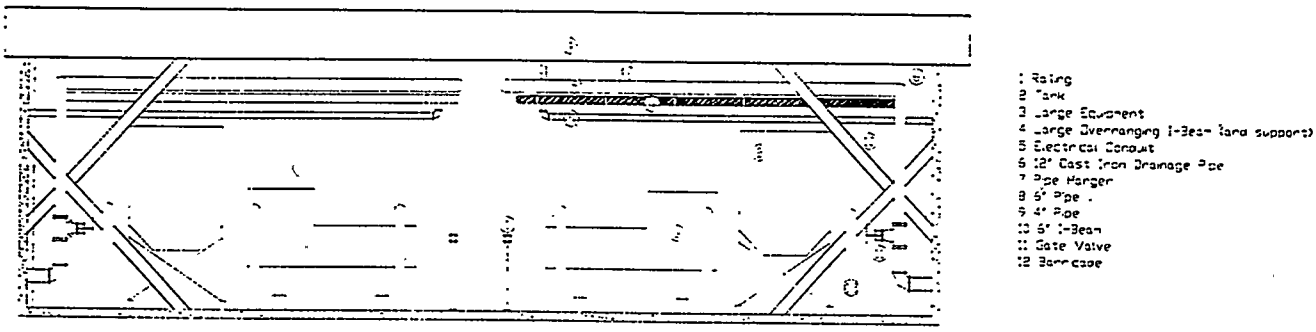


**Figure 1. Schematic of test site (front view).**

**Figure 2. Test site for Equipment Dismantlement Technologies.**

## 3.2 COMPARING THE END POINTS ACHIEVED TO THE ASSESSMENT OBJECTIVES

The end point achieved will be compared with the following criteria:

- The technology's cutting speed
- The technology's ability to cut different materials
- The technology's ability to cut different geometries

## 3.3 DETERMINING THE TYPES OF TECHNOLOGIES TO BE TESTED

To facilitate the determination of the type of technologies to be tested, various publications and databases were reviewed. These publications and databases included:

- DOE/EM-0142P *Decommissioning Handbook*
- ORNL/M-2751 *Oak Ridge National Laboratory Technology Logic Diagram*
- EGG-WTD-11104 *Idaho National Engineering Laboratory Decontamination and Decommissioning Technology Logic Diagram*
- Remedial Action Program Information Center (RAPIC) database

In addition, through interaction with other D&D professionals and by searching nuclear industry journals, other potential innovative technologies have been located. It is anticipated that throughout the next year of this project, additional innovative and commercially available nuclear and non-nuclear technologies will be identified and reviewed for possible inclusion for future study. The criteria used for inclusion in the testing include state of maturity, cost of the demonstration, potential benefit to the DOE Complex, and availability of the testing sections. Established sources and databases were used for categorizing and performing the initial screening of technology types.

To date, the following technologies have been identified for possible inclusion in the study:

- Oxy-gas torch
- Cutting/electric arc eroding
- Remote grinding
- Plasma cutting
- Crushing/shearing
- Ice sawing
- Hydraulic impulse generator and abrasive waterjet technology
- Abrasive waterjet technology

During FY97, an advertisement was placed in the *Commerce Business Daily* (*CBD*). The technologies located through responses to this advertisement are presented in Table 1.

**Table 1.**
**Technologies for Equipment Dismantlement**

| | TECHNOLOGY NAME | COMPANY |
|---|---|---|
| 1 | Cutting/Electric Arc Eroding | NUKEM |
| 2 | Remote Grinding | NUKEM |
| 3 | Plasma Cutting | NUKEM |
| 4 | Crushing/Shearing | NUKEM |
| 5 | Ice Sawing | NUKEM |
| 6 | Hydraulic Impulse Generator and Abrasive Waterjet Technology | Waterjet Technology, Inc. |
| 7 | Abrasive Waterjet Technology | Waterjet Technology, Inc. |

## 3.4 TEST LOCATION AND UTILITY PARAMETERS

The FIU-HCET technology bay consists of a concrete pad with 10-ft-high concrete walls on three sides and a concrete ceiling covering half of the pad. All masonry walls, floors, and ceilings at the assessment site are 8 in. thick. The test site contains a series of test areas, each consisting of the 12 surrogates described in section 3.1 and shown in Figure 2. Adjacent to the test bay is a trailer that serves as a field office, changing facility, and a cool-down area for the technologists and the technology assessment team. A fence restricting access to the area surrounds the trailer and the test area.

A 60-psi, 6-gal/min, portable water supply and a 110-V, 15-amp electric supply is available for use by the vendors. The vendors will provide any other utilities (e.g., 220 or 480 V electricity, diesel fuel, compressed air, etc.).

### 3.4.1 Test Equipment, Personnel, and Materials

HCET and the IUOE will supply the following:

- A Light-duty fork lift (5,000 lb)
- A 60-psi, 6-gal/min, portable water supply and a 110-V, 15-amp electric supply
- Surrogate materials
- Monitoring instrumentation
- Project oversight
- Sample and data collectors

The technology vendor is required to supply the following:

- All required and support equipment
- Trained operators
- Job safety analysis for each technology
- Operating procedures
- Media and other materials
- Project manager
- Information required to complete the data requirements section
- Transportation of all equipment, materials, and personnel to FIU
- Per diem for all vendor personnel
- Rigging equipment to support surrogates during equipment dismantlement

## 3.5 DATA REQUIREMENTS

Extensive data will be collected on each technology. The data will be obtained from vendor contacts and vendor literature. The technologies will be demonstrated to validate the data collected and to collect additional data needed by DOE project managers. Table 2 presents the data to be collected and the sample collection method.

## Table 2.
## Data Requirements

| Data Requirements | Sample Collection Method |
|---|---|
| COST DATA | |
| Capital cost for the purchase of equipment | Vendor supplied |
| Utility cost | Vendor supplied: measurement of fuel used; gallons of water used (flow meter); electric meter calculation |
| Maintenance cost | Vendor supplied |
| Unit/operating cost | Vendor supplied: generated from operational data calculations |
| OPERATIONAL DATA | |
| Technology description | Vendor supplied; field inspection |
| Technology benefits | Vendor supplied; field inspection |
| Technology limitations | Vendor supplied: field inspection |
| Main equipment requirements | Vendor supplied: field verification |
| Support equipment requirements | Vendor supplied: field verification |
| Production rates | Time studies |
| Length of cut | Field inspection |
| Number of cuts | Vendor supplied: field verification |
| Set up time | Vendor supplied; field verification |
| Actual cutting time | Field inspection |
| Total dismantle time per surrogate | Field inspection |
| Cutting Speed | Vendor supplied: field verification |
| Forms of cut | Field inspection |
| Quality of cut | Field inspection |
| Effect of job conditions on the technology (End point achieved by the technology) | Field observation |
| Equipment configuration changes | Field observation |
| Portables required at site | Field observation |
| Other setup facilities required | Field observation |
| Total area required for the entire setup | Field observation |

**Table 2.**
**Data Requirements (Continued)**

| | |
|---|---|
| Wear rate of the cutting tool | Vendor supplied; field verification |
| Ability of technology to cut different metals | Field observation |
| Work space required for each cut/job | Field observation |
| Labor classification | Vendor supplied; field verification |
| Utility requirements | Vendor supplied; field verification |
| Power consumption calculations | Field calculation |
| Measurement of fuel used | Field calculation |
| Environmental conditions | Vendor supplied, field inspection |
| Aerosol size and concentration produced | Vendor supplied, field inspection |
| Gas analysis (for thermal cutting technologies) | Vendor supplied, field inspection |
| Visible sparks | Vendor supplied, field inspection |
| Smoke, fumes, etc. generated | Vendor supplied, field inspection |
| Other hazards | Field observation |
| Secondary waste management | Vendor supplied, field inspection |
| Physical condition of secondary waste | Field observation |
| Volume of secondary waste | Field calculation |
| Quantity of media used | Field calculation |
| Characteristics of media | Media material safety data sheet |
| Equipment portability | Vendor supplied; field verification |
| Operation/maintenance requirements | Vendor supplied; field verification |
| IMPLEMENTATION DATA | |
| Level of training required | Vendor supplied |
| Availability of equipment and supplies | Vendor supplied; verification |
| Health and safety concerns | Vendor supplied, IUOE |

## 3.6 MULTIMEDIA INFORMATION SYSTEM

The multimedia information system to support dismantlement activities provides a means of accessing data related to operation and maintenance, cost, and performance data; health and safety; and secondary waste management in the form of an interactive computer-based system. The information system also provides video clips and photographs of the technologies assessed.

This system of consolidated information will allow a complete and comprehensive comparison of technologies during the technology selection process.

## 4.0 ACTIVITIES PLANNED FOR FY98

The activities planned for FY98 include the field testing of seven innovative and commercially available technologies for equipment dismantlement and the development of a multimedia information system for equipment dismantlement technologies. The activities planned for FY98 are listed below.

Task 1. Construct the test site

Task 2. Develop the test plan

Task 3. Develop the scope of work for the technology demonstration

Task 4. Provide quality assurance for technology testing

Task 5. Develop a multimedia information system for dismantlement technology

Task 6. Procure and field test technology

Task 7. Perform a literature survey on decision models

Task 8. Conduct technology demonstrations

Task 9. Prepare report for technology testing.

## 5.0 CONCLUSIONS

The preliminary activities needed to begin the evaluation of dismantlement technologies are complete. These activities include preparing the test site, developing the performance indicators, and contacting technology vendors for inclusion in the study. Second-year activities will generate the bulk of the deliverables for this project. The evaluation of seven technologies and the development and implementation of a multimedia information system for assessing the technology will occur during FY98.

## 6.0 REFERENCES


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Aerosols from Metal Cutting Techniques Typical of Decommissioning Nuclear Facilities - Experimental System for Collection and Characterization. Newton.G.J, Hoover.M.D, Edward.B.B, Brian.A.W, and Ritter.P.D. Inhalation Toxicology Research Institute, Lovelace Biomedical and Environmental Research Institute, P.O. Box 5890, Albuquerque, NM, 87185.

# APPENDIX A

## TECHNIQUES FOR DISMANTLEMENT

# TECHNIQUES FOR DISMANTLEMENT

**Table A.1**

| CUTTING TECHNIQUE | INNOVATIVE/ COMMERCIALLY AVAILABLE | POSSIBLE VENDORS |
|---|---|---|
| **THERMAL** | | |
| **Gas Processes** | | |
| Oxy Propane | Commercially available | Ge Ga Lotz (UK) 0044 1283 214181<br>Messer Grieshiem (UK) 0044 1670 737444<br>Remotely deployed-AEA<br>Technology - Mike Wareing |
| Oxy Acetylene | Commercially available | Ge Ga Lotz (UK) 0044 1283 214181<br>Messer Grieshiem (UK) 0044 1670 737444<br>Remotely deployed-AEA<br>Technology - Mike Wareing |
| Oxy fuel gas injection cutting | Commercially available | Messer Grieshiem - standard unit 0044 1670 737444<br>AEA Technology - -low flow unit - Mike Wareing |
| Thermic/thermite Lance | Commercially available | |
| **Arc Processes** | | |
| Plasma Arc | Commercially available | Messer Grieshiem (UK) 0044 1670 737444<br>Thermal Dynamics (USA)<br>Remotely deployed –AEA<br>Technology - Mark Wareing<br>CEA (France) 00331 6908 6347<br>BNF plc (UK) 0044 19467 28777 |
| Thermal Arc Water Jet | Innovative Technology | L-Tec Corporation 803-664-4397 |
| **Miscellaneous** | | |
| Laser/Advanced Laser | Innovative Technology | AEA Technology (Use of CO Lasers)<br>0044 1235 463638<br>CEA ($CO_2$ and YAG under water) 0033169086347<br>EM-50 - LB Spiegel (ETEC) 818 586 8886<br>Hobart (US)<br>Lumonics (US)<br>US Laser Corp (US) |

**Table A.1 (Continued)**

| CUTTING TECHNIQUE | INNOVATIVE/ COMMERCIALLY AVAILABLE | POSSIBLE VENDORS |
|---|---|---|
| MECHANICAL | | |
| Abrasive | | |
| Cold High Pressure Abrasive Water Jet | Commercially available | Aqua Blast (UK) 0044 1493 330140<br>Hydro Cleaning 713-478-5255<br>Bay Decking 510-769-6033<br>Blasters 813-985-4500<br>Applied Radiological Control 610-367-6792<br>Canberra Nuclear Products 203- 238-2351<br>Ice Solv 717-838-2351<br>University of Hanover, Prof Bach 0049 511 7620 |
| Abrasive Water Jet | Commercially available | Aqua Blast (UK) 0044 1493 330140<br>Hydro Cleaning 713-478-5255<br>Bay Decking 510-769-6033<br>Blasters 813-985-4500.<br>Applied Radiological Control 610-367-6792<br>Canberra Nuclear Products 203- 238-2351<br>Ice Solv 717-838-2351<br>University of Hanover, Prof Bach 0049 511 7620 |
| Disc Grinder | Commercially available | Grainger<br>McMaster Carr<br>Bosch<br>Black and Decker<br>Remote use - AEA Technology<br>Mark Wareing |
| Circular Diamond Saw | Innovative technology | Marcrist Industries (UK) 0044 1302 467266<br>Diamant Boart (Belgium) 0032 348 3211 |
| Diamond Wire | Innovative technology | Marcrist Industries (UK) 0044 1302 467266.<br>Diamant Boart (Belgium) 0032 348 3211<br>Trentec 513 677 0800. |
| Saws | | |
| Toothed saw e.g. Hack saw, Band saw, reciprocating saw. | Commercially available | Grainger<br>McMaster Carr<br>Bosch.<br>Black and Decker<br>Remote use - AEA Technology 0044 1235 434350<br>SCK.CEN (Belgium) 0032 1433 2661<br>EH Wachs (USA) |

**Table A.1 (Continued)**

| CUTTING TECHNIQUE | INNOVATIVE/ COMMERCIALLY AVAILABLE | POSSIBLE VENDORS |
|---|---|---|
| Tungsten Carbide Tipped circular Saws. | Commercially available | Grainger<br>McMaster Carr<br>Bosch,<br>Black and Decker<br>Remote use - AEA Technology 0044 1235 434350<br>SCK.CEN (Belgium) 0032 1433 2661<br>EH Wachs (USA)<br>Marcrist Industries 0044 1302 467266 |
| Oxy Arc | Commercially available | Thermadyne (UK) 0044 1257 261755 |
| Contact Arc | Innovative technology | CEA, France 00331 6908 6347 |
| Electro Discharge Machining | Commercially available | Spark Tec (Europe) ltd (UK) 0044 121 422 0243<br>Remote deployed - AEA Technology 0044 1235 434350<br>EM-50. |
| Arc Saw | Commercially available | Toshiba Corporation Hideaki Heki<br>University of Birmingham 0044 121 414 3541. |
| PCT Circular Saw | Commercially available | Marcrist Industries 0044 1302 467266<br>Remote use - AEA Technology 0044 1235 434350<br>SCK.CEN (Belgium) 0032 1433 2661<br>EH Wachs (USA) |
| **Shears and Nibblers** | | |
| Hydraulic Shear (open jawed) | Commercially available | Enerpac Ltd. (UK) 0044 1233 639871<br>Lucas (Germany)<br>Hydr'am. (France) 0033 72489005<br>BNF plc (UK) 0044 19467 28777 |
| Hydraulic Shear (closed anvil) | Commercially available | Enerpac Ltd. (UK) 0044 1233 639871 |
| Hydram Shear | Innovative technology | Hydr'am. (France) 0033 72489005 |
| Crimp Shear. | Innovative technology | BNF plc (UK) 0044 19467 28777. |
| Continuous Punch Shear | Innovative technology | Hydr'am (France) 0033 72489005 |
| Nibbler | Commercially available | Remote use - AEA Technology 0044 1235 434350. |
| Milling and Orbital Cutters | Commercially available | Furmanite 0044 1539 729009 Tube Runner 0044 1869 246681<br>Reekie Machine Tools 0044 1418 120411 |
| Swage Cutter | Commercially available | Semi remote – Rigid<br>Rigid Tool (UK) 0044 1869 485335 |
| Explosive Cutting | Innovative technology | Royal Ordance 0044 1257 265511<br>Royal Military College 0044 1793 785323<br>Nitrobickford<br>CEA 00331 6908 6347 |
| Ice Sawing | Innovative technology | Kernkraftwerke |