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FINAL REPORT

DECISION ANALYSIS SCIENCE MODELING FOR APPLICATION AND FIELDING SELECTION APPLIED TO EQUIPMENT DISMANTLEMENT TECHNOLOGIES

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DISCLAIMER

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EXECUTIVE SUMMARY

Dismantlement of equipment is a significant problem within the United States Department of Energy's Deactivation and Decommissioning Focus Area (DDFA) during the completion of D&D activities. The decommissioning of contaminated facilities requires the use of a combination of nuclear technologies and non-nuclear technologies adapted to the nuclear environment. A single information source comparing dismantlement technologies in the areas of safety, cost, and performance is not currently available.

This study identifies, evaluates, and provides information pertaining to standard technologies for equipment dismantlement. By producing this information, this project will aid in reducing risks to the environment and human health. This work will also support DOE's Environmental Management (EM) remediation objectives. Emerging technologies were also identified to determine their applicability to this project as well as to DOE site needs. Seven technologies were demonstrated at Florida International University's Hemispheric Center for Environmental Technology (FIU-HCET). The performance data generated by this project will assist DOE site managers in the selection of the safest, most efficient, and most cost-effective dismantlement technology to accomplish their remediation objectives. In addition, the documentation, field testing, and evaluation of these equipment dismantling technologies will ensure that a source of comparable information is available to project managers and will provide innovative technologists a source of information with which to determine areas requiring improvement.

Three thermal cutting technologies were evaluated as part of this project. These thermal technologies included

- Framatome Technologies' Oxy-acetylene torch that demonstrated a total cutting rate of 6.6 in/min.
- Framatome Technologies' Plasma Arc torch that achieved a total cutting rate of 11.72 in/min.
- Petrogen International's Oxy-gasoline torch that produced a total cutting rate of 8.01 in/min.

In addition, four mechanical cutting technologies were demonstrated as part of this project. These mechanical technologies included

- Framatome Technologies' Pneumatic Cut Off tool, which demonstrated a total cutting rate of 1.92 in/min.
- Framatome Technologies' Hydraulic Shear that achieved a total cutting rate of 5.12 in/min.
- Tri-Tool's Clamshell Lathe that produced a total cutting rate of 6.05 in/min.
- Wachs' Guillotine Saw that generated a total cutting rate of 1.63 in/sec.

1.0 INTRODUCTION

The dismantlement of radioactively contaminated process equipment is a major concern during the D&D process. There are an estimated 1,200 buildings in the DOE-EM complex that will require the dismantlement of equipment and various metal structures. As buildings undergo the D&D process, this metallic equipment contaminated with radionuclides such as uranium and plutonium must be size-reduced before final disposal. A single information source comparing dismantlement technologies in the areas of safety, cost, and performance is needed by DOE managers and is not currently available.

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. The purpose of this investigation was to evaluate commercially available and innovative technologies for equipment dismantlement and provide a comprehensive source of information to the D&D community in the areas of technology performance, cost, and health and safety.

2.0 CONCLUSION

This study provides a source of comparable data for equipment dismantlement technologies including innovative as well as commercially available nuclear and non-nuclear technologies. A summary of the data related to production rates achieved by the seven commercially available technologies that were evaluated is shown in the figures below. Production rates and cutting rates are given for each of the technologies evaluated based on the surrogates attempted by each of the technologies. The information presented in these bar charts should be used in combination with the information provided in Appendix C to determine the technology that should be selected based on site-specific health and safety, operations, and waste management factors. In addition, the reader should consult Appendix B for a complete glossary of terms used throughout this project and throughout the development of this final report.

Thermal technologies: Of the seven technologies tested, three were thermal technologies: Oxy-acetylene torch, Oxy-gas torch, and Plasma arc cutting.

Mechanical technologies: The remaining four technologies can broadly be classified as mechanical cutting processes, viz. Hydraulic shear, Clamshell lathe, Pneumatic cutting, and Guillotine saw.

As anticipated, thermal technologies were used on all ten surrogates, but mechanical technologies were not able to attempt all the surrogates. This is indicated in the figures by showing zero production and cutting rates for the surrogates that were not attempted by the mechanical techniques.

Figures 1 through 10 presented below show the individual production and cutting rates achieved by the seven technologies on the attempted surrogates dismantled. The figures presented in these charts are in inches per minute.

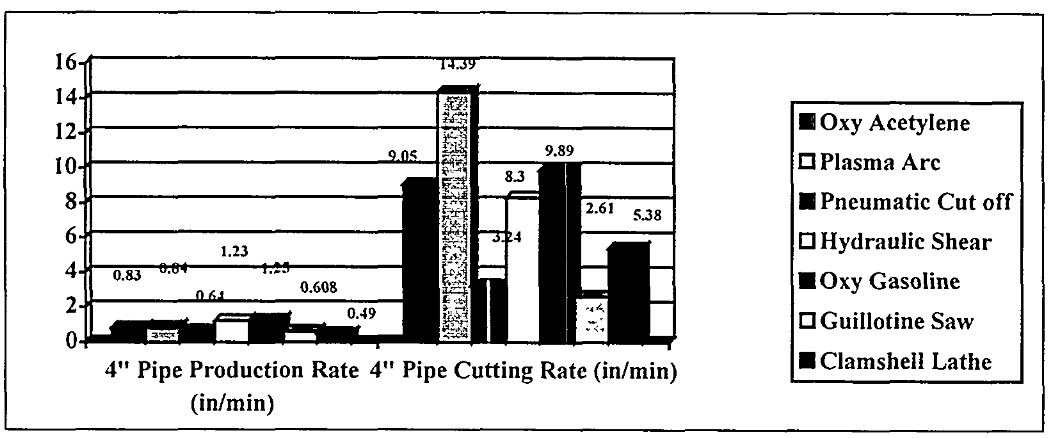

Figure 1. Production and cutting rates for 4" diameter pipe.

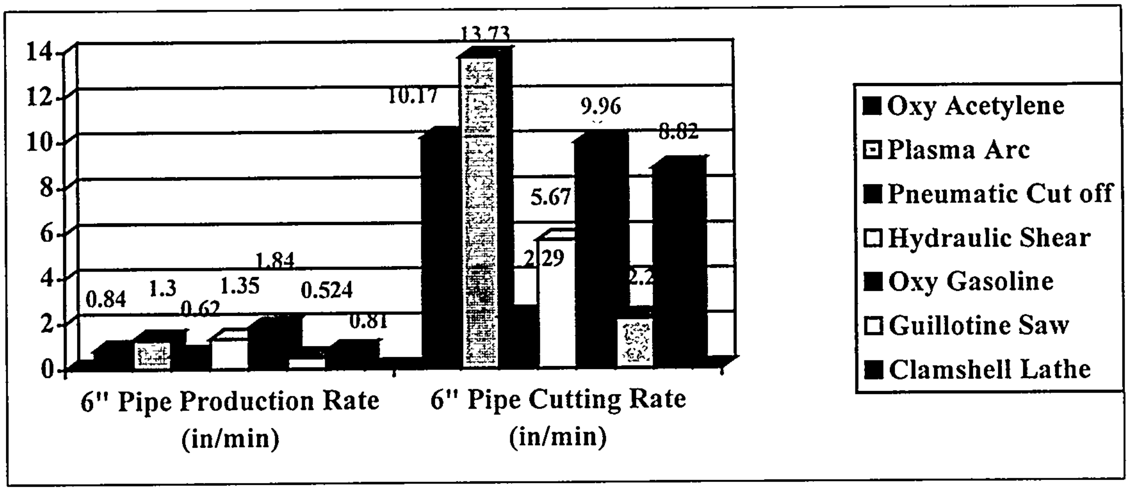

Figure 2. Production and cutting rates for 6" diameter pipe.

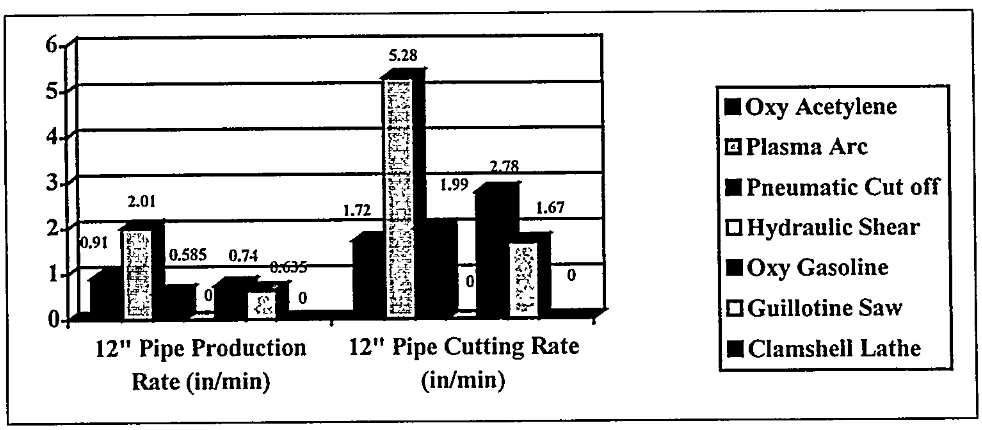

Figure 3. Production and cutting rate for 12" diameter drainage pipe.

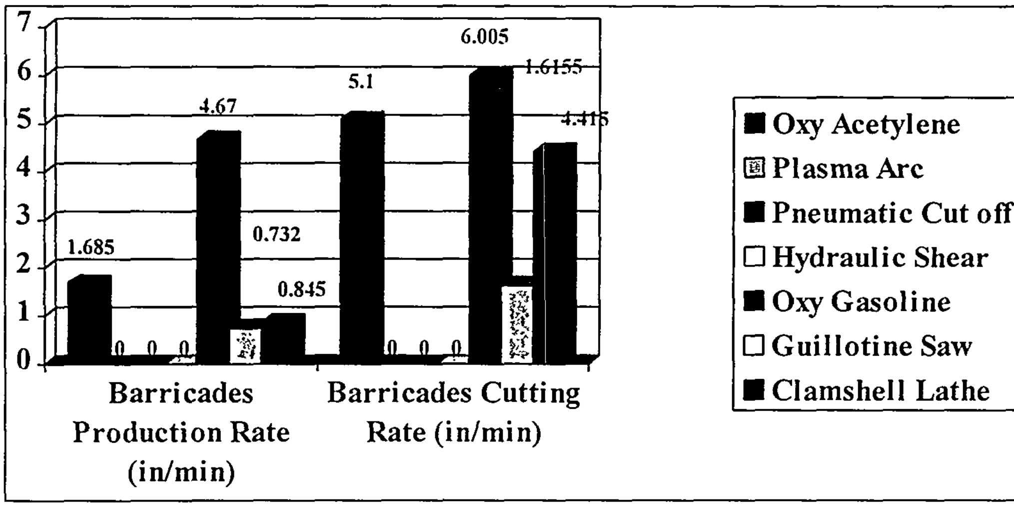

Figure 4. Production and cutting rates of barricades.

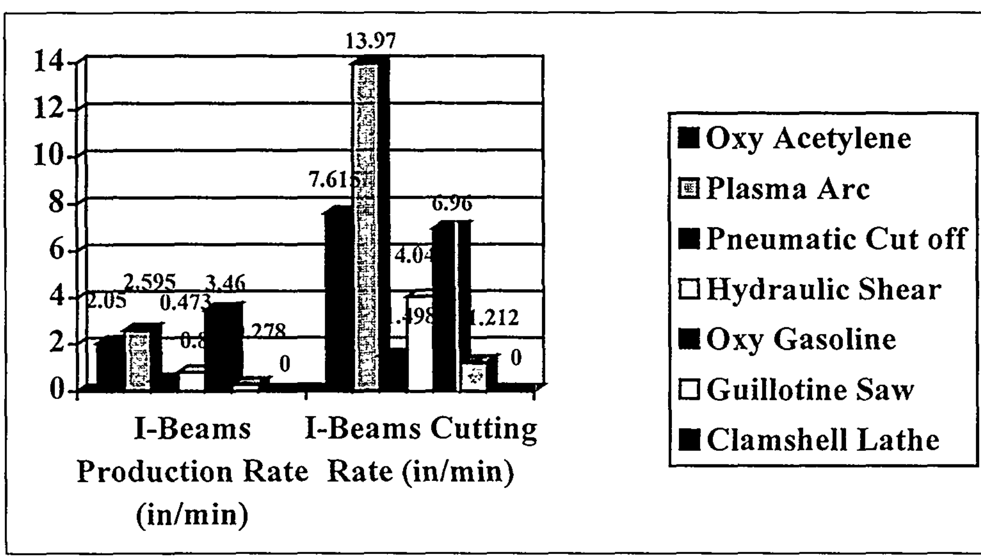

Figure 5. Production and cutting rates for W6 x 16 I-beams.

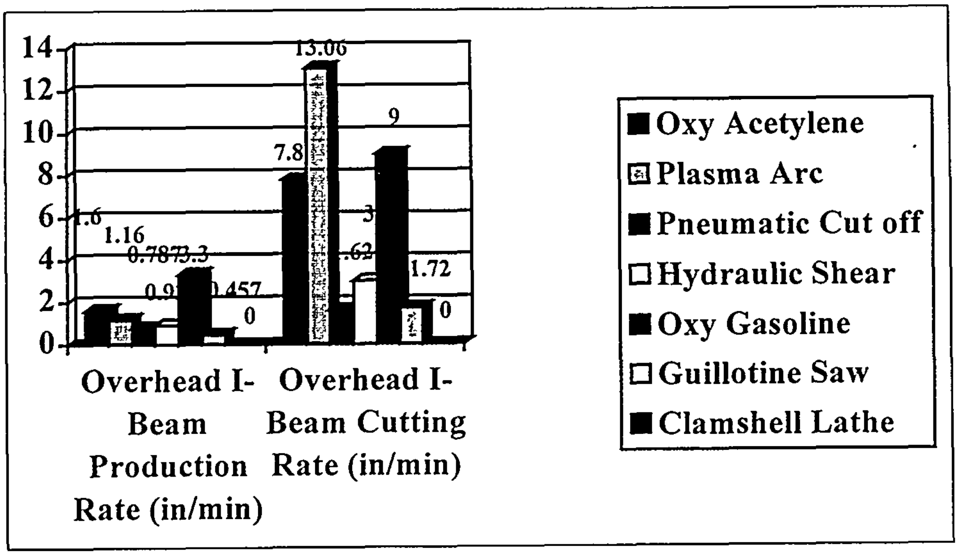

Figure 6. Production and cutting rates for W16 x 31 I-beam.

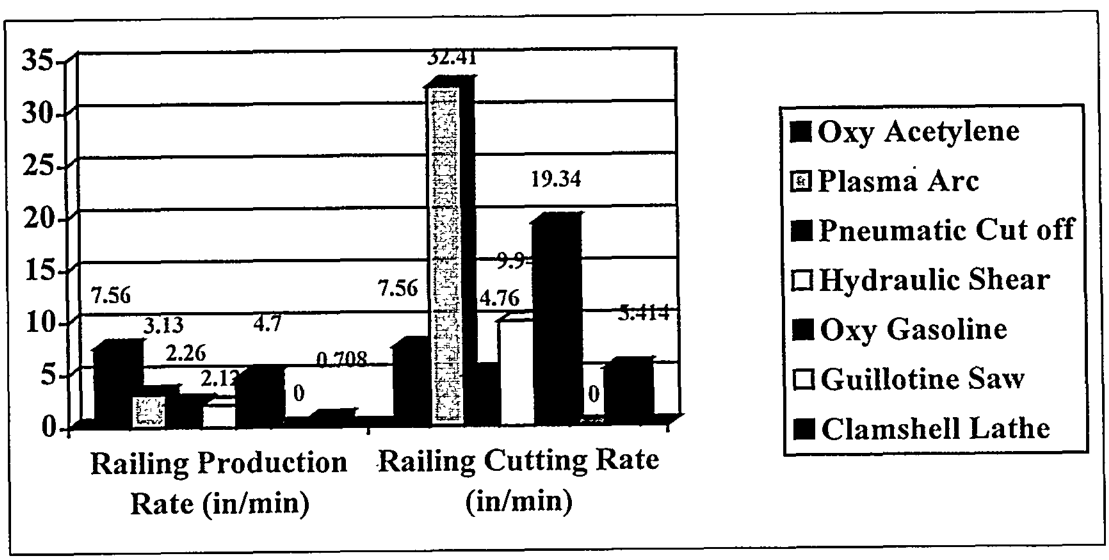

Figure 7. Production and cutting rates for railing.

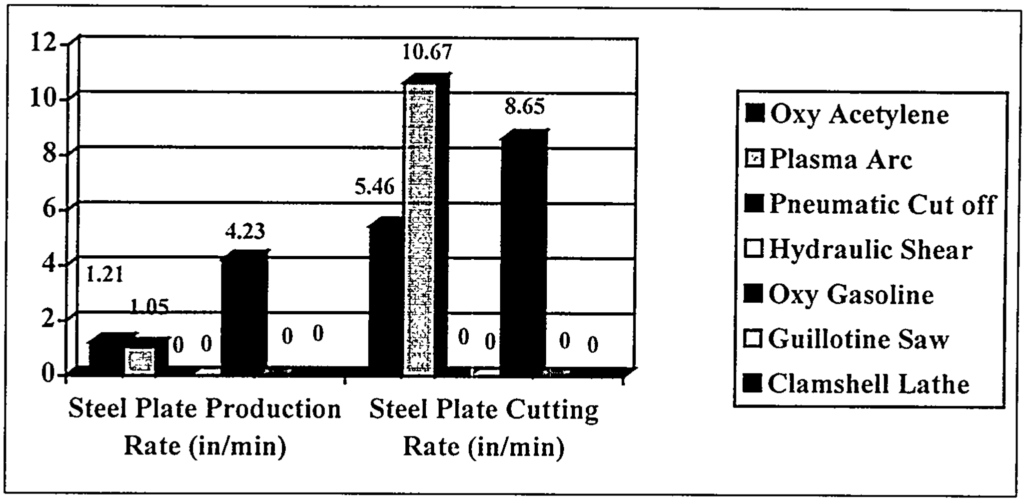

Figure 8. Production and cutting rates for steel plate.

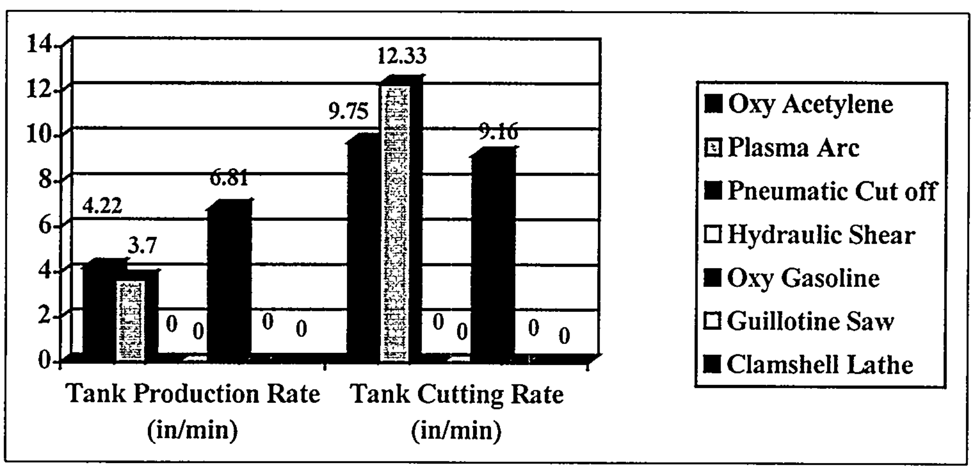

Figure 9. Production and cutting rates for tank.

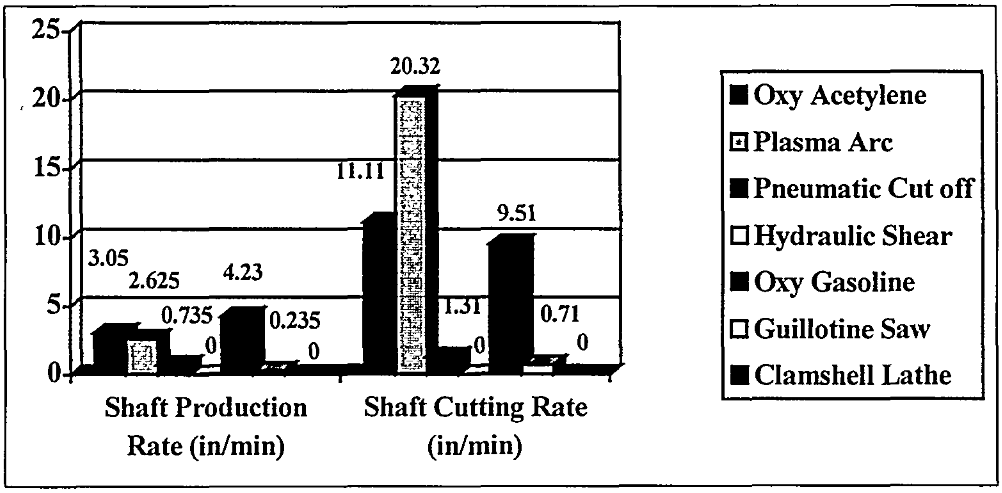

Figure 10. Production and cutting rates for steel shaft.

3.0 ENGINEERING STUDY APPROACH

3.1 STUDY OBJECTIVES

The objective of this task is to perform a comparative analysis of commercially available nuclear, non-nuclear, and innovative equipment dismantlement technologies applicable to the D&D sites for environmental restoration.

The definition of the terms used in the classification of the surrogates is listed in Appendix B.

3.1.1 Determining the Types of Technologies to be Tested

Established sources and databases were used for categorizing and performing the initial screening of technology types. These sources and databases included

- DOE/EM-0142P *Decommissioning Handbook* [1]
- ORNL/M-2751 *Oak Ridge National Laboratory Technology Logic Diagram* [2]
- EGG-WTD-11104 *Idaho National Engineering Laboratory Decontamination and Decommissioning Technology Logic Diagram* [3]
- Remedial Action Program Information Center (RAPIC) database.

These sources provided a screening based on the applicability of a technology for equipment dismantlement. Considering this review, a CBD ad was placed asking for vendors to respond with a letter of interest. From the responses that were received, the following thermal and mechanical technologies were selected and a request for proposal was sent to the technology vendors:

- Oxy-Acetylene torch
- Plasma arc torch
- Oxy-gas torch
- Pneumatic cutoff
- Split lathe cutting
- Hydraulic shear
- Guillotine saw.

3.1.2 Surrogate Selection and Preparation

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, FIU-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 and plates 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 constructions were hired for the construction of the test site. The test site comprised the following surrogates:

Table 3-1.
Test surrogate specifications

#	Item	Specification (L x W x H)	Material	Thickness (inches)	Diameter (inches)	Overall dimensions (inches)	Condition
1	I – Beam	W6 x 16	A 36 Steel	3 / 8 (Flange) ¼ (Web)	N.A.	Web : 6 ¼ Flange : 4 Length : 112	Coated with water based red oxide primer
2	I – Beam	W16 x 31	A 36 Steel	7 / 16 (Flange) ¼ (Web)	N.A.	Web :16 Flange : 5 ½ Length : 468	Coated with water based red oxide primer
3	Pipes	6" Diameter	Schedule 40	0.280	outer: 6.625 inner : 6.0625	Length of pipe: 458	N.A.
4	Pipes	4" Diameter	Schedule 40	0.237	outer: 4.5 inner: 4.026	Length of pipe: 467	N.A.
5	Pipes	12"Diameter	Cast Iron	0.36	outer: 13 1/8 inner: 12 ¼	Length of pipe: 120	N.A.
6	Barricades	6" Diameter	Schedule 40	0.280	outer: 6.625 inner: 6.0625	Length of pipe: 48	Coated with water based red oxide primer
7	Railing	1 ½" Diameter	Schedule 40	0.145	N.A.	96 x 42	Coated with water based red oxide primer
8	Steel Plate	8'x ¾"x4'	A 36 Steel	¾	N.A.	Length : 96 Width : 48	Coated with water based red oxide primer
9	GateValve	F-619 Nibco make, Flanged type.	As per MSS SP-70	N.A.	N.A.	Net Wt 88 lbs.	N.A.
10	Electrical Conduit (Rigid)	N.A.	Galvanized Rigid Conduit	N.A.	¾	N.A.	Galvanized
11	Tanks	Diameter : 45" Length : 50" Thickness: 1"	Carbon Steel	1	45	Diameter : 45 Length : 50 Thickness: 1	N.A.
12	Pipe Hangars	For conduit :26" L For 6"pipe : 10" L For 4"pipe : 18" L	N.A.	N.A.	For conduit :1/4" For 6"pipe : 5/8" For 4"pipe : 5/8"	N.A.	N.A.
13	Shaft	4" diameter	Carbon Steel	4	48	Length : 48 Diameter : 4	No coating

An actual test bay is presented in Figure 11. A total of 8 identical test bays were constructed to support the demonstration of the seven technologies selected.

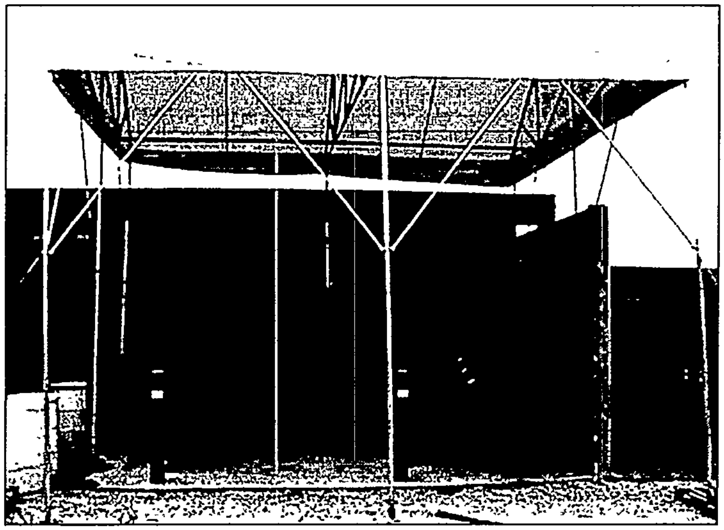

Figure 11. Assessment site for equipment dismantlement technologies.

3.1.3 Comparing the End Point Achieved to the Dismantlement Objectives

To ensure the results of this test were applicable to the different dismantlement objectives and to other environmental restoration sites, the technologies were employed in the most efficient manner as dictated by the vendor. The end achieved was compared to a set of predefined standards listed in Appendix B. These specifications are as follows:

The end point achieved was compared with the following criteria:

- Post-condition of the surrogate after the cut was made: The final geometry of the dismantled surrogates (the amount of repair work to be performed on the dismantled surrogate in order to be able to reuse the surrogate).
- Ability of the technology to cut different geometries.

3.2 EXPERIMENTAL DESIGN AND PROCEDURES

Each technology was tested on a single bay of actual operating time for each surrogate, providing sufficient time to collect the operational and safety information required for each technology. Additional data was collected on the capital costs, maintenance costs, and equipment staging/destaging times and health and safety by IUOE. The experimental design consisted of the following factors:

- Methods of obtaining technology vendors
- Test location and utility parameters
- Data requirements.

3.2.1 Methods of Obtaining Technology Vendors

The request for qualifications of prospective bidders was advertised in the *Commerce Business Daily* (CBD). The advertisement identified the type of work to be contracted and the minimum qualifications for bidders. Qualified and interested bidders were asked to submit an expression of interest. The purpose of the advertisement was to pre-qualify prospective bidders to determine if they would indeed meet the qualification standards. The qualifications for the bidders included the number of years of work experience in nuclear dismantlement and references of previous work performed using the proposed technology.

Following the bid opening, the bids were reviewed to ensure that the lowest apparent bidder was responsive and responsible. Determination of responsiveness was based on properly completing bid forms and acknowledging any amendments to the invitation for bid. The lowest apparent bidder was deemed responsible, if this bidder possessed the capability and experience required in the solicitation to perform the test in a safe and timely manner.

3.2.2 Test Location and Utilities Provided

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 13 surrogates described in section 3.1.2 and shown in Figure 11. Adjacent to the test bay is a trailer that served 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.

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

3.2.3 Data Requirements

General Information

General information included

- Technology description
- Equipment requirements.

Cost Information

Cost information included

- Capital cost for the purchase of equipment
- Utility cost
- Maintenance cost
- Unit/operating cost.

Operational Data

The operational data included:

- Production rates
- End point achieved
- Labor classification
- Limitations
- Utility requirements:
  - Power consumption calculations
  - Utility requirements
- Environmental conditions
- Secondary waste management:
  - Physical condition of secondary waste
  - Quantity of media used
- Equipment portability
- Measurement of fuel used
- Operation/maintenance requirements.

Implementation Data

The implementation data included

- Level of training required
- Availability of equipment and supplies
- Health and safety concerns (collected by the International Union of Operating Engineers).

3.3 TEST EQUIPMENT AND MATERIALS

FIU-HCET and IUOE supplied the following equipment and material:

- A light-duty fork lift (5,000 lb.) and operator
- A 60-psi, 6-gal/min, potable water supply and a 110-V, 15-amp electric supply
- Surrogate materials
- Monitoring instrumentation
- Project oversight
- Waste depositories and disposal.

The technology vendor supplied the following:

- All required and support equipment
- Trained operators
- Job safety analysis for each technology
- Operating procedures
- Media and other materials
- Site 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

3.4 SAMPLING AND ANALYSIS

Information was collected from commercial experience, vendor information, and field-testing. Time studies were conducted to collect some of the operational data. The end point conditions were compared to the specifications given in section 3.1.3 "Comparing the End Point Achieved to the dismantlement Objectives." Field measurements were taken to document waste generation and other measurable data requirements. Documentation provided by the vendors and interviews with the vendors provided other pertinent information. Table 3-1 presents the data requirements and the sample collection method.

The technology vendors were responsible for determining and providing information to FIU-HCET related to the estimated quantity of secondary waste that would be generated. The vendors were provided with the material safety data sheets on the paint products used in the development of the surrogate to aid in the dismantlement. FIU-HCET was responsible for the management and disposal of the generated waste.

Table 3-2.
Data requirements

Data Requirements	Sample Collection Method
COST DATA	
Estimated capital cost	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	Field verification
Set up time	Field verification
Cutting rate	Vendor supplied; field verification
End point achieved by the technology	Field observation
Wear rate of the cutting tool	Vendor supplied; field verification
Applicable Surrogates	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
Technology effectiveness rating	Field calculation
Environmental conditions	Vendor supplied, field inspection
Aerosol size and concentration produced*	Vendor supplied, field inspection, IUOE
Gas analysis (for thermal cutting technologies)*	Vendor supplied, field inspection, IUOE
Visible sparks*	Vendor supplied, field inspection, IUOE
Smoke, fumes, etc. generated*	Vendor supplied, field inspection, IUOE
Other hazards	Field observation
Secondary waste management	Vendor supplied, field inspection

Data Requirements	Sample Collection Method
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*

* International Union of Operating Engineers

4.0 TECHNOLOGY DESCRIPTIONS

4.1 OXY-ACETYLENE TORCH

The oxy-acetylene torch is a basic thermal cutting technique that can be used on carbon steel up to 3-4" thick. Cutting speeds up to about 10 inches per minute (as per the vendor-supplied information) can be obtained; the speed is a function of the material thickness and geometry. The torch burns the metal and coatings, producing smoke and fumes that may require control using portable HEPA filters, especially in radiologically contaminated environments. The torch can be manipulated by hand or can be placed on a motorized track for use in inaccessible or high radiation areas and long and uniform surfaces.

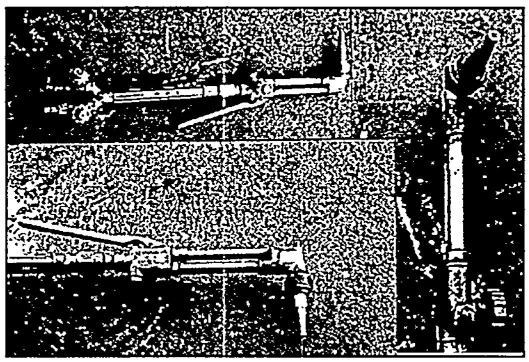

Figure 12. Oxy-acetylene torch.

Figure 13. Oxy-acetylene torch mounted on mobile tracks cutting a steel plate.

4.2 PLASMA ARC TORCH

The plasma arc torch is a powerful thermal cutting method that can be used where oxy-acetylene cutting is not applicable (i.e., stainless steel, aluminum, copper, and other non-oxidizing metals).

Plasma uses a high-powered electric arc in combination with high-velocity cutting gas to vaporize metal and create plasma. The high-velocity cutting gas propels the vaporized metal away from the cut. Plasma can be used in stainless steel as well as carbon steel and can cut underwater or in air. Cutting speeds up to 60 inches per minute (as per the vendor-supplied information) can be obtained. The plasma torch is typically manipulated on a track or by a robot. Manual cutting is possible in limited applications. The cutting effluent is highly energetic and must be contained and HEPA-filtered. Fire prevention and control methods must be used, such as fire barriers and removal of combustibles.

Figure 14. Plasma arc torch.

Figure 15. Plasma arc torch cutting an I-beam (W6x16).

4.3 OXY – GASOLINE TORCH

The oxy-gasoline torch system is a safe, reliable design that makes backflash up the fuel line impossible. The system uses a small pressure vessel that holds gasoline and air. The unit is then pressurized by either a self-contained hand pump or by an external source of compressed air. The liquid gasoline then moves through a ¼ inch, 2-braid hose designed specifically to send gasoline to the mixer. The mixer is a cone-shaped piece that fits into the torch head at the base of the tip. The mixer, which contains special grooves and wicks, receives both the preheat oxygen and the gasoline and combines them into the fuel mixture fed into the tip assembly. In the cutting tip the gasoline changes from liquid to vapor, increasing in volume by almost 200 times. The rapid expansion provides a strong force to the preheat flame. Since the gasoline is a confined liquid right into the cutting tip and liquid gasoline is stable, it cannot burn; backflash cannot occur.

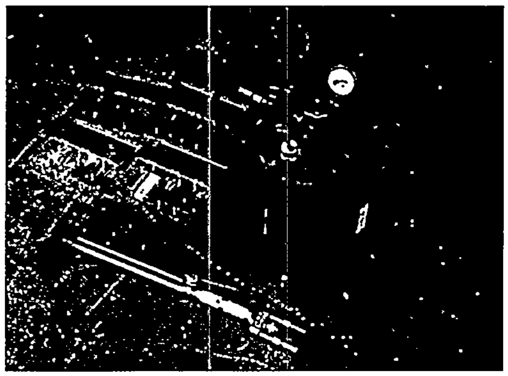

Figure 16. Oxy-gasoline torch, tool tips, and gas tank.

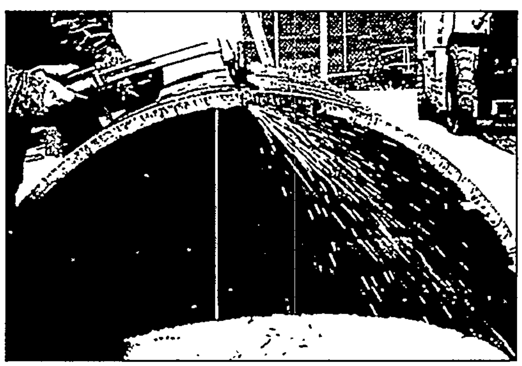

Figure 17. Oxy-gasoline torch cutting a 1" thick steel tank.

4.4 PNEUMATIC CUTOFF TOOL

The pneumatic cutoff tool is an air-powered, handheld, abrasive cutoff wheel. The tools come in a variety of sizes and can be adapted to cut most materials with the selection of the appropriate grinding disk. The cutoff wheel is a standard tool designed for close quarter work in the metal working industry. They are particularly good where conduits, pipes, ducts, etc. pass through bulkheads or frames. The grinders are very efficient at grinding weld bead and leaving a fine finish. This can be achieved by choosing the appropriate set of grinders, sanders, and polishers for smoothing, trimming, or removing metal in close quarter areas.

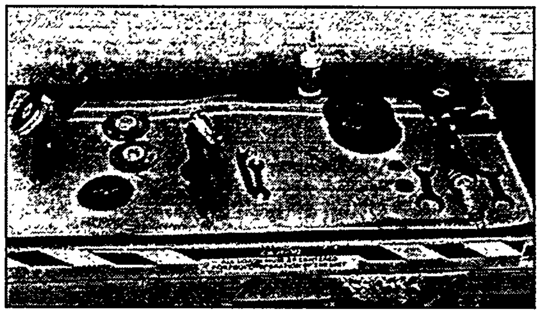

Figure 18. Pneumatic cutoff tools.

Figure 19. Pneumatic tool cutting a 4" diameter steel shaft.

4.5 SPLIT LATHE CUTTING

Split lathe cutting (also referred to as clamshell cutting) is a cold cutting method that can be used in controlled environments where thermal cutting methods are unacceptable. The lathe consists of two halves that can be mounted and clamped on the circular surface. After mounting, clamshells can be operated by remote control, making them perfectly suited for machining operations in nuclear, underwater, or other hazardous situations. They are able to produce machined surfaces without heat-affected zones and hold close diameter and face tolerances on end preps within thousands of an inch. Clamshells simplify the process of cutting to length and speeds and feed rates. A simple feed control provides optimal cut depth to match most materials. Tool blocks are heat treated for durability and parts that could be damaged, such as gears, pins, and bearings, are protected to reduce the chance of accidental damage.

Figure 20. Split lathe cutting tools.

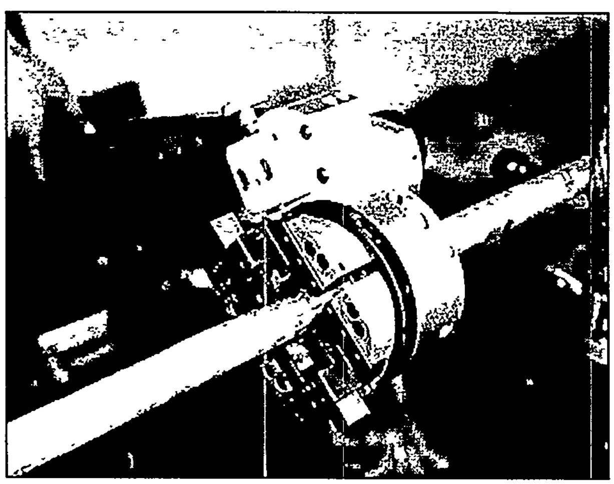

Figure 21. Split lathe cutting a 1" galvanized conduit.

4.6 HYDRAULIC SHEAR CUTTING

The hydraulic shear is a two-bladed or two-cutter tool that operates on the same principle as a conventional pair of scissors. A bladed shear primarily is used for inline cutting of sheet metal. The shears are a standard component in fire and police toolboxes. The shears come in a variety of sizes, produce no secondary waste, and are easy to use. The shear is powered by hydraulic pressure developed by a gasoline engine-driven pump. The hydraulic fluid lines are connected to the shear through male and female couplings connected to the tool. A two-way twist grip type control valve operates the shear. In order to operate the valve, the grip needs to be twisted either to the right or to the left appropriate to the movement desired from the tool. All control valves are equipped with a dead man's type feature, which causes them to automatically spring back to center as soon as the handle is released. The shear then stops and holds whatever force was exerted at the time the valve was released. The portable hydraulic shear was developed as rescue equipment.

Figure 22. Hydraulic shear tools (mega cutter on the extreme right).

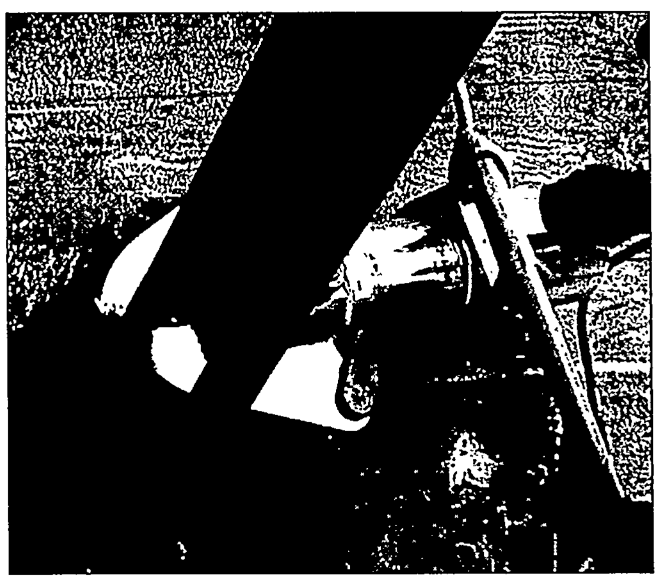

Figure 23. Hydraulic shear cutting an I-beam (W6x16).

4.7 GUILLOTINE SAW CUTTING

The guillotine saw is a cutting tool designed for fast precision on-site cutting of light or heavy wall pipe 2" through 8" outer diameters as well as solids such as bar stocks and rails. The guillotine saw utilizes a unique reciprocating action that lifts the blade from the cut on the return stroke, clearing the work piece for the cut stroke. The tool is easy to install with a very low installation and setup time (which is approximately 5 minutes). A chain pipe vise clamps the saw to the pipe. This V-saddle base assures square cuts at right angles, and the saw can be mounted in any position horizontally or vertically around the pipe.

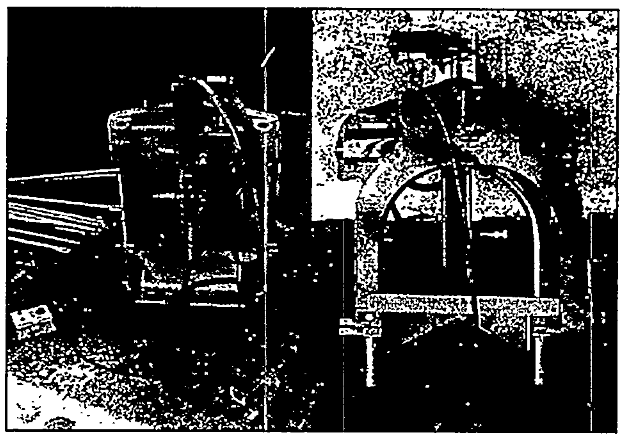

Figure 24. Guillotine saw (Left-model D; Right-model Super C).

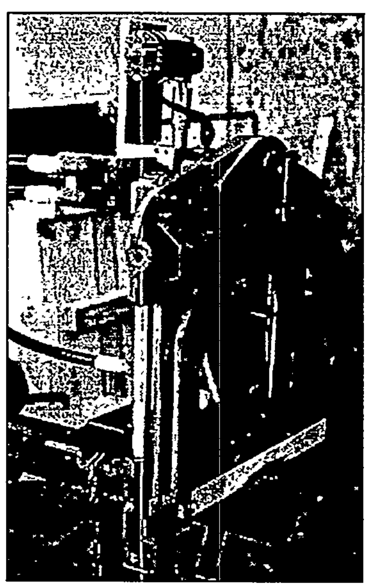

Figure 25. Guillotine saw (model Super C) cutting steel shaft.

5.0 DEVIATIONS

The test plan for this project called for the surrogates to be dismantled in a particular manner as described in the test plan document. Certain changes were made to the original scope, since the vendors felt that the method chosen was either unsafe or was not the generally followed practice in the industry. The deviations from the method suggested in the original test plan are listed below.

1. Tank: The original test plan listed that "Each technology must dismantle half the tank (appox. 25 inches) by cutting the tank and one of the covering plates into smaller parts. The radius of curvature of the smaller sections should not exceed 6 inches. The length of the curved section should be approximately 36 inches. The vendor must cut the tanks into smaller sections, not greater than 7 inches in width. (This width of the tank as measured along its length is 50 inches). The covering plate must be cut into four small sections of equal size." This was found to be an unsafe method of cutting the tank as there was the potential danger of the tank toppling over to one side after half the tank was cut. Hence, the vendors suggested that the tank be cut into two halves along the length. All the other specifications remained the same. Upon confirmation with the FIU-HCET project managers and the IUOE's Industrial Hygienist (IH), the tank was cut into two halves along the length instead of being cut along the diameter. Then subsequent cuts were made to one half.
2. Gate Valves: The gate valves were dismantled, but no data that was specifically related to the gate valve dismantlement could be collected since the gate valves were segregated and put aside but not dismantled. Hence, the gate valve is not counted as a surrogate. All the technology vendors dismantled the valve by cutting the pipes on which the gate valve was mounted.
3. Pipe Hangers: As per the test plan, the pipe hangers were to be dismantled from the ceiling. This surrogate was used largely to hold the pipes and the conduits in place. The technology vendors dismantled the pipes in sections. The dismantlement was done in stages, and this made the data collection of the cutting process for this surrogate very difficult. The data for the surrogate could only be partly recorded, as it was difficult to log all the activities taking place at the site simultaneously. Hence, this surrogate is disregarded for the reporting purposes. The vendor also opted for disassembling the pipe hangers (i.e., loosening the bolts and removing the bracket instead of cutting the hangers).
4. I-Beams: The test site included two sets of W6 x 16 size I-beams. One set was attached between the wall and floor, and the other set was attached between the wall and the ceiling. Data was to be collected separately for each of these sets, and then a comparison was to be made across all the technologies. This however was not possible as the technology vendors made the cuts on each of the I-beams in succession and the data collection for each individual I-beam became very difficult to log and record separately since the cutting process was extremely fast. Hence, the data for this surrogate was collected and is presented for all six I-beams in a consolidated form.
5. Drainage Pipe: At the time of developing the test plan, it was not known that the 12-inch drainage pipe had a concrete lining on the inside. This was later discovered when the vendors attempted to cut the drainage pipe. This increased the degree of difficulty of cutting the

drainage pipe, but all the technologies that attempted the dismantlement of this surrogate were largely successful.

6. Utility Requirements: The data regarding the utility requirements was supposed to be recorded per surrogate. But this was found to be unfeasible during the data recording stage, as it was difficult to record all the activities going on at the site by one or two evaluators. The data that was finally collected and recorded will be presented in a consolidated form as the utility requirements per technology instead of per surrogate. Measuring the amount of utilities consumed by cutting individual surrogates (i.e., one I-beam) was not feasible.
7. Operation Costs: The data regarding the operation costs was supposed to be recorded per surrogate. But this was found to be unfeasible during the data recording stage, as it was difficult to record all the activities and consumables at the assessment site by one or two evaluators since the technologies demonstrated were very quick in the dismantlement activities. The final operating cost presented is per technology for the entire dismantlement job.
8. End Point Achieved: The test plan and the scope of work documents described the end point achieved on the following parameters:

   - cutting speed
   - ability of technology to cut different materials
   - ability of the technology to cut different geometries.

   This definition was replaced with the terms described in Appendix B.

   - Post-condition of the surrogate after the cut was made: The final geometry of the dismantled surrogates (the amount of repair work to be performed on the dismantled surrogate in order to be able to reuse the surrogate).

6.0 TECHNOLOGY RECOMMENDATIONS

The intent of this section is to review the operation of each of the technologies tested and make recommendations on ways to improve the technologies based on the test results. It is important to note that some of the recommended changes may improve the system in one area of operation but may adversely impact the technology's ability to excel in another area.

All the technologies demonstrated as part of this study are commercially available and have been used for a long time in the nuclear environment; nevertheless, some recommendations are being made based on field observations.

The recommendations made for the technologies demonstrated at the FIU-HCET assessment site are listed below:

1. Specific recommendation: The hydraulic shear demonstrated was equipment used by police and fire departments for emergency rescue operations. The 130-lb. shear was not easy to deploy at the assessment site. The shear needed two persons to hold it in position to perform the cutting, and to dismantle surrogates above shoulder level, the shear was deployed by a forklift to raise it to the required height. The shear has a very specific application in the D&D activity and needs to be adapted for better deployment at the D&D facility. One method of deploying this tool is to mount it on a robotic arm that can access some areas of typical D&D facilities.
2. General recommendations for the technologies: The test plan developed for the technology assessment site did not require the technology vendors to simulate a nuclear-contaminated site, though the surrogates were designed to simulate a typical D&D facility. As such the technology assessments were conducted without any precautionary measures to prevent the containment of the airborne particles that were generated by the dismantlement activities. However, this would not be the case in a contaminated facility. While deploying the technologies in a contaminated facility, proper precautionary measures such as HEPA filters and waste containment must be considered.
3. Health and safety recommendations: The IUOE personnel who were present at the technology assessment site during the demonstrations looked into the health and safety aspect of the technologies demonstrated. Some of the aspects examined were
   - good housekeeping
   - ergonomic training to include techniques in lifting, bending, stooping, twisting
   - assessment of heat stress
   - use of PPE
   - adequate ventilation in the D&D work facility.

   For a detailed report of the health and safety aspect of the technologies, contact The Operating Engineers National HAZMAT program, 1293 Airport Road, Beaver, WV 25813 phone - (304) 253 8674, fax - (304) 253 7758. Contact person: Ms. Barbara McCabe.

7.0 LESSONS LEARNED

After having successfully conducted demonstrations of seven different technologies at the FIU-HCET test facility, the following points were observed and were considered worth mentioning as aspects to be looked into more closely in future demonstrations that would be conducted at the site.

1. At the time of construction of the test site, it would be desirable to have experts from the field to provide more input for the design and construction of the type of surrogates to be used for the test setup.
2. It was felt that more D&D site visits were needed before carrying on with the demonstrations; alternatively, the need for more input from the site personnel is needed.
3. While the demonstrations were on, it was noted that there were not enough data collectors at the test site. The data collection process requires a minimum of two data collectors to be present at the technology demonstration at all times.
4. The technologies demonstrated were quite fast in the dismantlement process. There were times when the data collectors could not keep pace with the technologies performing the D&D work. This gave rise to discrepancies in the data collection process. The data evaluators had to rely heavily on the video recordings for parts that were missed by the data collectors. At times even the recording was found wanting. Hence, it was felt that it would be better if the entire demonstration was recorded on video.
5. The logbook in which the data was recorded was designed specifically for this project. However, it was found during data recording that the workflow of the vendors at the site followed different patterns for each technology. This presented difficulties in the data recording for each individual surrogate. The need for a logbook that would capture the data flow as it was actually performed was felt.
6. The data evaluators were provided with some basic information and training at the start of the technology demonstrations. In spite of this, there were huge variations in the methods adopted by the evaluators during the data recording. The data evaluators need to be better informed and trained on the data collection procedures and the information that was desired from the technology demonstrations.
7. The technology demonstrations were conducted in summer. It would be preferable to conduct the demonstrations in cooler months of the year.
8. The technology demonstrations were performed over several consecutive weeks. This did not allow the collected data to be evaluated properly. Scheduling technologies in alternative weeks would allow collected data to be processed qualitatively. Vendors with several technologies could, however, demonstrate their technologies over consecutive weeks for convenience and to reduce costs.

8.0 REFERENCES

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Comparative Assessment of Several Dismantling Cutting Tools. Pilot. G.,[*] Bernard. J,[**] Lorin C.,[***] Ravera. J.P.[***]

[*]Institut de Protection at de Surete Nucleaire. Departement de Protection de l'Environment et des Inatallations, Service d'Etudes et de Recherches en Aerocontamination et en Confinement, IPSN/CEA, 91191 GIF SUR YVETTE CEDEX.

[**]Institut de Protection at de Surete Nucleaire, Departement de Protection de l'Environment et des Inatallations, Service Technique d'Equipements de Surete et de Radioprotection. IPSN/CEA, B.P. n^0 6 - 92265 FONTENAY AUX ROSES CEDEX.

[***]Direction du Cycle du Combustible (DCC/CEA), Unite de Demantelemane des Installations Nucleaires, CE/VALRHO, B.P. 171 - 30205 BAGNOLS SUR CEZE CEDEX.

Aerosols from Oxy-Acetylene Gas Cutting Operations on Metal Plates: A Laboratory Study. DOE-RAPIC, Principal Investigators - Wong. B.A, Newton. G.J, Obarski. G.E, Hoover. M.D.

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DOE/EM-0142P *Decommissioning Handbook* [1]

ORNL/M-2751 *Oak Ridge National Laboratory Technology Logic Diagram* [2]

EGG-WTD-11104 *Idaho National Engineering Laboratory Decontamination and Decommissioning Technology Logic Diagram* [3]

Remedial Action Program Information Center (RAPIC) database.

APPENDIX A

JOB SAFETY ANALYSIS

A.1 Job Safety Analysis

The Job Safety Analysis (JSA) forms filled by the technology vendor are presented in this section. Oxy-Acetylene Torch JSA form is presented in Table A-1, Plasma Arc Torch JSA form is presented in Table A-2, Oxy-Gasoline Torch JSA form is presented in Table A-3, Pneumatic Cut Off Tool JSA form is presented in Table A-4, Split Lathe Cutting JSA form is presented in Table A-5, Hydraulic Shear Cutting JSA form is presented in Table A-6, Guillotine Saw Cutting JSA form is presented in Table A-7.

Table A-1.
Oxy-Acetylene Torch JSA

JOB SAFETY ANALYSIS

JOB: FIU/HCET Demonstration			DATE: July 16, 1998, 1998
JOB TITLE: OXY-ACETYLENE TORCH Operator	DEPARTMENT: D&D Services		SECTION/GROUP:
SUPERVISOR: Kenneth Verble	ANALYSIS BY: Kenneth Verble	REVIEWED BY:	APPROVED BY:
REQUIRED AND/OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT: Safety glasses w/rigid sides, steel toe shoes and hard hat.			

SEQUENCE OF BASIC JOB STEPS	POTENTIAL ACCIDENT OR HAZARDS	RECOMMENDED SAFE JOB PROCEDURE
Using "A" Frame and support scaffolding, position as required for rigging.	Scaffolding, ladder, and lifting equipment failure	Secure scaffolding, ladders, and shifting equipment.
Assemble the cutting equipment.	Cutting equipment failure and hydraulic hose rupture	Inspect cutting equipment prior to use.
Verify oxy/fuel tanks are secure and the pressure setting is adequate for the material thickness to be cut.	Personal injury	Review job before task begins. Wear personal protective equipment. Keep clear of cutting blade paths.
Inspect cutting equipment.	Rigging equipment failure	Inspect rigging prior to task.
Verify rigging loads to be acceptable.		
Cut component as required to lower.		
Cut up components for disposal.		
Remove cutting equipment as required.		
Maintain good housekeeping.		

Table A-2.
Plasma Arc Torch JSA

JOB SAFETY ANALYSIS

JOB: FIU/HCET Demonstration			DATE: July 16, 1998
JOB TITLE: PLASMA ARC TORCH Operator	DEPARTMENT: D&D Services		SECTION/GROUP:
SUPERVISOR: Kenneth Verble	ANALYSIS BY: Kenneth Verble	REVIEWED BY:	APPROVED BY:
REQUIRED AND/OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT: Safety glasses w/rigid sides, steel toe shoes and hard hat.			

SEQUENCE OF BASIC JOB STEPS	POTENTIAL ACCIDENT OR HAZARDS	RECOMMENDED SAFE JOB PROCEDURE
Using "A" frame and support scaffolding, position as required for rigging.	Scaffolding, ladder, and lifting equipment failure	Secure scaffolding, ladders, and shifting equipment.
Set up Plasma Arc cutting equipment.	Cutting equipment failure and hydraulic hose rupture	Inspect cutting equipment prior to use.
Verify primary power to be adequate (75 amps).	Personal Injury	Review job before task begins. Wear personal protective equipment. Keep clear of cutting blade paths.
Inspect equipment for defects.	Rigging equipment failure	Inspect rigging prior to task.
Verify gas mixture to be Argon 65/Hydrogen 35 and Nitrogen.		
Verify rigging loads to be acceptable.		
Cut component as required to lower.		
Subsequent cut up.		
Disposal using fork truck.		
Remove Plasma cutting equipment.		
Maintain good housekeeping.		

Table A-3.
Oxy Gasoline Torch JSA

JOB SAFETY ANALYSIS

JOB: FIU/HCET Demonstration		DATE: August 14, 1998
JOB TITLE: OXY-GASOLINE TORCH Operator	DEPARTMENT: D&D Services	SECTION/GROUP:
SUPERVISOR: Kenneth Verble; ANALYSIS BY: M. Hernandez	REVIEWED BY:	APPROVED BY:
REQUIRED AND/OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT: Safety glasses w/rigid sides, steel toe shoes and hard hat.		

SEQUENCE OF BASIC JOB STEPS	POTENTIAL ACCIDENT OR HAZARDS	RECOMMENDED SAFE JOB PROCEDURE
Fill tank with gasoline, attach hoses from tank to torch, and oxygen cylinder to torch.	Filling tank and attaching hoses offers opportunity for gasoline spillage.	Fill tanks and attach hoses off site. Once hoses are attached, they need never be removed.
Light torch.	Lighting torch offers opportunity for gasoline spillage.	Proper lighting procedure is to first open preheat oxygen valve, then open gasoline valve until mist appears. Light the mist. Liquid gasoline need never be seen.
Cut steel.	Cutting steel offers opportunity for sparks and slags to fly into unexpected areas.	Learn proper cutting techniques. Same techniques pertain to all oxy-fuel cutting systems.
Shut down torch valves, tank valve, & oxygen cylinder.	Possible hazards if valves are not all shut.	Be sure all valves are closed: oxygen tank, gasoline tank, torch oxygen valve, torch gasoline valve. Any gasoline leak will create a visible wet spot.

Table A-4.
Pneumatic Cut Off Tool JSA

JOB SAFETY ANALYSIS

JOB: FIU/HCET Demonstration			DATE: July 16, 1998
JOB TITLE: PNEUMATIC CUT OFF TOOL Operator	DEPARTMENT: D&D Services		SECTION/GROUP.
SUPERVISOR: Kenneth Verble	ANALYSIS BY: Kenneth Verble	REVIEWED BY:	APPROVED BY:
REQUIRED AND/OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT: Safety glasses w/rigid sides, steel toe shoes and hard hat.			

SEQUENCE OF BASIC JOB STEPS	POTENTIAL ACCIDENT OR HAZARDS	RECOMMENDED SAFE JOB PROCEDURE
Using "A" frame and support scaffolding, position as required for rigging.	Scaffolding, ladder, and lifting equipment failure	Secure scaffolding, ladders, and shifting equipment.
Verify rigging loads to be acceptable.	Cutting equipment failure and hydraulic hose rupture	Inspect cutting equipment prior to use.
Subsequent cut up and disposal.	Personal injury	Review job before task begins. Wear personal protective equipment. Keep clear of cutting blade paths.
Disposal using fork truck.	Rigging equipment failure	Inspect rigging prior to task.
Verify compressor to be adequate and serviced ready for operation.		
Connect air hoses to compressor and cut off tooling.		
Wear safety shielding.		
Verify 90psi minimum pressure.		
Inspect equipment for defects.		
Remove cutting equipment.		
Maintain good housekeeping.		

Table A-5.
Split Lathe Cutting JSA

JOB SAFETY ANALYSIS

JOB: FIU/HCET Demonstration			DATE: August 14, 1998
JOB TITLE: SPLIT LATHE CUTTING Operator	DEPARTMENT: D&D Services		SECTION/GROUP:
SUPERVISOR: Kenneth Verble	ANALYSIS BY: Kenneth Verble	REVIEWED BY:	APPROVED BY:
REQUIRED AND/OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT: Safety glasses w/rigid sides, steel toe shoes and hard hat.			

SEQUENCE OF BASIC JOB STEPS	POTENTIAL ACCIDENT OR HAZARDS	RECOMMENDED SAFE JOB PROCEDURE
Using "A" frame and support scaffolding, position as required for rigging.	Scaffolding, ladder, and lifting equipment failure	Secure scaffolding, ladders, and shifting equipment.
Assemble and inspect the cutting equipment.	Cutting equipment failure and hydraulic hose rupture	Inspect cutting equipment prior to use.
Verify rigging loads to be acceptable.	Personal injury	Review job before task begins. Wear personal protective equipment. Keep clear of cutting blade paths.
Cut component as required to lower.	Rigging equipment failure	Inspect rigging prior to task.
Using chainfalls and come-alongs as required, lower components to the floor for subsequent cut-up and disposal. (NOTE: Rigging will make use of exalting support hangers to lower piping to floor).		
Cut up components for disposal.		
Remove cutting equipment as required.		
Maintain good housekeeping.		

Table A-6.
Hydraulic Shear Cutting JSA

JOB SAFETY ANALYSIS

JOB: FIU/HCET Demonstration			DATE: July 16, 1998
JOB TITLE: HYDRAULIC SHEAR CUTTING Operator	DEPARTMENT: D&D Services		SECTION/GROUP:
SUPERVISOR: Kenneth Verble	ANALYSIS BY: Kenneth Verble	REVIEWED BY:	APPROVED BY:
REQUIRED AND/OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT: Safety glasses w/rigid sides, steel toe shoes and hard hat.			

SEQUENCE OF BASIC JOB STEPS	POTENTIAL ACCIDENT OR HAZARDS	RECOMMENDED SAFE JOB PROCEDURE
Using "A" frame and support scaffolding, position as required for rigging.	Scaffolding, ladder, and lifting equipment failure	Secure scaffolding, ladders, and shifting equipment.
Verify rigging loads to be acceptable.	Cutting equipment failure and hydraulic hose rupture	Inspect cutting equipment prior to use.
Subsequent cut up and disposal.	Personal injury	Review job before task begins. Wear personal protective equipment. Keep clear of cutting blade paths.
Disposal.	Rigging equipment failure	Inspect rigging prior to task.
Maintain good housekeeping.		

Table A-7.
Guillotine Saw Cutting JSA

JOB SAFETY ANALYSIS

JOB: FIU/HCET Demonstration			DATE: September 4, 1998
JOB TITLE: GUILLOTINE SAW CUTTING Operator	DEPARTMENT:	SECTION/GROUP:	
SUPERVISOR: Todd Gilmore	ANALYSIS BY: J. Riley	REVIEWED BY:	APPROVED BY:
REQUIRED AND/OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT: Safety glasses w/rigid sides, steel toe shoes and hard hat.			

SEQUENCE OF BASIC JOB STEPS	POTENTIAL ACCIDENT OR HAZARDS	RECOMMENDED SAFE JOB PROCEDURE
Lift guillotine without saw blade installed onto pipe to be cut.	Injury from physical lifting, injury from faulty lift rigging	For model "Super C", we recommend the use of a lifting device or two workers lifting the machine onto the pipe. For models D and Super D, only a lifting device such as an overhead hoist or forklift truck is utilized. (NOTE: always use the provided eyebolts on the machine to attach a weight tested chain or strap for lifting purposes.)
While the machine is resting on the pipe, but still supported by the lifting device or a co-worker, take the loose end of the chain clamp and pull it tight engaging the closest cross pin all the way in the slot provided on the V Base Saddle. Tighten the nut on the chain with the provided wrench until the machine is secure on the pipe.	Machine may fall.	Use lifting device to hold machine in place to avoid falling machine.
Remove lifting device.		
Make sure the blade holder (Bow) is raised to its uppermost position. (Manual Operation) Turn the feed handle counter-clockwise until it stops. (Auto feed System) Plug in the electrical cord into a 110V outlet. On the control box, flip the toggle switch to the up position, turn the rheostat to #10 and monitor the rotation until the (Bow) is in the upper position.		

SEQUENCE OF BASIC JOB STEPS	POTENTIAL ACCIDENT OR HAZARDS	RECOMMENDED SAFE JOB PROCEDURE
Install the saw blade; make sure the teeth are set to cut to the left. Match the teeth to the blade installation decal.	Damage may occur if the blade is installed backward.	Match the teeth direction on the blade to the blade installation decal on the machine bows.
Tighten the blade-tensioning knob. A sharp, taut blade assures a straight clean cut.	Loose blade may buckle.	Tighten blade securely.
Attach the power source to the machine.	Machine failure	Use only power requirements stated in the manual to power the machine.
Turn on the power and feed the blade through the pipe by turning the feed handle clockwise (manual application) or by flipping the toggle switch on the remote control box to the down position. Set the rheostat on #5 to start the cut.	Machine may stall.	Feed blade into pipe slowly.
The rate of feed depends on the material being cut and the location of the blade in the cut. In cutting through solid material, we recommend that the feed handle (manual operation) or the feed screw (auto operation) be turned approximately 1/12 of a revolution for each cutting stroke of the blade. In light cutting such as through the center of ductile iron pipe it is possible to feed at a rate of 1/4 turn of the feed handle (manual operation) or the feed screw (auto-operation) per blade cutting stroke. After making a few cuts, the operator can determine the rate at which cutting can be done most effectively with the least strain on the machine.	Blade may bind or machine may stall if feed is too great. Cut may not be square if feed rate is too fast; blade will have a tendency to walk out.	Slow feed rate.
When the cut has been completed, raise the blade by reversing the feed handle rotation (manual operation) or flipping the control box toggle switch to the up position.		
Turn off the power and disconnect.		
Using a lifting device, remove the machine from the pipe.		

APPENDIX B

B.1 END POINT ACHIEVED CONDITION DEFINITION TERMS

The terms and definitions defined in this section are from field observations made during the technology demonstrations of the dismantlement technologies. The terms are not as per any standards nor do they follow any set specifications. The classification and identification of the various end points was made in order to facilitate the easy classification and identification of the various end point conditions achieved that were observed during the technology demonstrations.

- **Crushed**: The cut ends of the surrogate are distorted out of shape and the openings of the surrogate are closed, either partly or completely. A considerable amount of repair work is needed to reuse the surrogate.

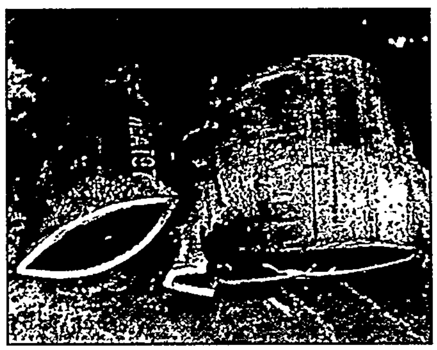

Figure 26. Crushed ends of the 4"& 6" diameter pipes.

- **Jagged edges**: The cut ends of the surrogate (all geometries) are not uniformly cut and the surrogate has sharp edges. The surrogate can be reused after the jagged edges are smoothed out by doing some repair work.

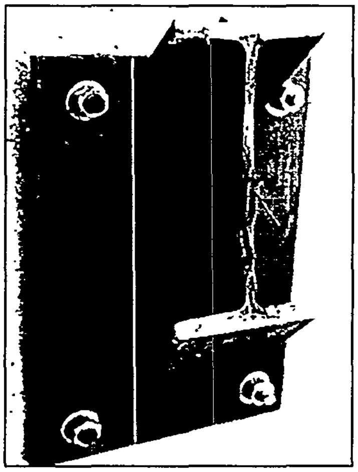

Figure 27. Jagged edges of the cut I-beam.

- Smooth finish: The surrogate has an even finish, exactly like the original geometry of the surrogate with no distortion and uneven edges on the cut surface. The surrogate can be reused in this condition.

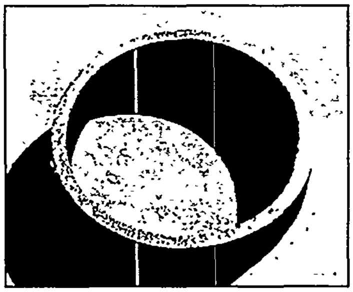

Figure 28. Smooth finish of the cut pipe.

- Melted ends: The surrogate is not completely distorted out of shape, but the edges are uneven. The uneven surface of the surrogate is due to the molten metal and other slag deposits that remain on the cut edge. The surrogate can be reused after the ends are reworked into the original shape (either by machining or some other cutting process).

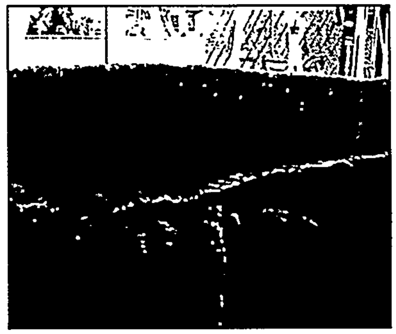

Figure 29. Melted and uneven surface of the cut tank.

- <u>Machined finish</u>: The surrogate has been cut very smoothly, and the cut end of the surrogate appears to have a smooth and even finish, like it was machined. This can be reused without any rework.

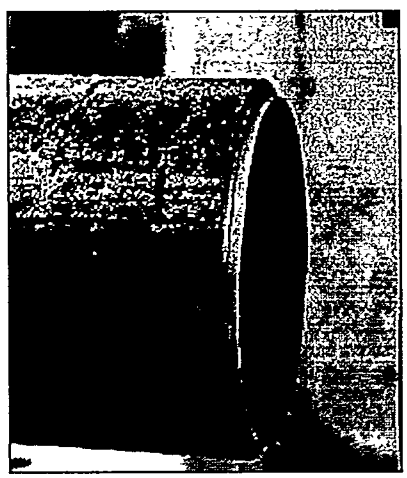

Figure 30. Machined finish of the cut pipe.

B.2 TECHNOLOGY DATA REQUIREMENTS: DEFINITIONS

COST DATA

Capital cost

This section presents the cost of the equipment as listed by the technology vendor.

Utility cost

The utility cost of the technology includes cost of the utilities required to operate the technology.

Maintenance cost

The maintenance cost of the technology includes the cost of maintaining the technology at its optimum operating performance levels. The vendors provided this data.

Unit/operating cost

The unit operating cost includes the cost of operating the technology per surrogate dismantled at the test site.

Technology descriptions

This section presents a summary of each technology tested. The technologies are described by operating principles and equipment used and by the benefits and limitations of each technology. Capital equipment and costs are described.

Technology benefits and limitations

Technology benefits and limitations will be determined by conducting field demonstrations and performing a literature search of the individual technologies. If a conflict exists between published information and field demonstration, the data obtained in the field testing were used.

EQUIPMENT REQUIREMENTS

Support equipment requirements

The vendor provided an overview of the major pieces of equipment required to support the operation of the technology.

Production rate

The total number of surrogates dismantled (this would be recorded as the sum of the length of cut for each surrogate) divided by the total number of hours required to complete the task at a given site. Site-specific production time begins immediately following equipment mobilization and ends at job completion, just prior to equipment demobilization. Site-specific production time includes breaks taken by operators, equipment adjustments and maintenance, rigging equipment adjustments (for surrogates that need to be rigged), handling of removed media, and consultations with test site administrators. Site-specific time does not include extended operator breaks (such as meals), test interruptions resulting from inclement weather, or the time required correcting major equipment failure.

Length of cut made on each surrogate

The length of every single cut made on the surrogates will be measured after the surrogate has been dismantled.

Cutting rate

The total number of surrogates dismantled (this would be recorded as the sum of the length of cut for each surrogate) divided by the total number of hours of equipment operation required to complete the task. Absolute production time includes only the time the equipment is in operation and does not include time spent in site-specific activities or maintenance.

End point achieved

The end point achieved was compared to the criteria of the final geometry of the dismantled surrogates, the amount of repair work to be performed on the dismantled surrogate in order to be able to reuse the surrogate, and the ability of the technology to cut different geometries.

Wear rate of the cutting tool

The vendor is expected to supply an estimated life expectancy of the tool that is used. This will also be field-verified.

Ability of the technology to cut different materials

The technology's ability to cut different material will be recorded.

Applicable surrogates

The first item in this line identifies the surrogate type and configuration (e.g., I-beam, pipes, conduits, and plates). The second item indicates the end point achieved for this group of technologies. It is important to note these end points achieved during the review of the technologies presented to ensure that the technologies are reviewed on an equal basis.

Labor classification

The number of operators, such as technicians, operators, engineers, and general laborers, required to operate the equipment at the test site will be recorded.

Utility requirements

The vendor is expected to provide the types of utilities required to operate the technology. In many cases, optional power sources are available for each type of equipment. All the optional power sources that can be used must be listed.

Power consumption calculations

The power consumption of the technology will be calculated based on the power rating of the equipment used at the test site during the technology demonstration.

Measurement of fuel used

The fuel used by the technology will be measured at the end of predetermined time intervals. It is important that all the equipment like generators, gas tanks, and other fuel containers have gauges on them so that the readings can be seen easily.

Environmental conditions

A description of the work environment created by the operation of the technology is provided. These descriptions include presence or absence of visible emissions, water fog created in enclosure, visible air turbulence, aerosol size and concentration produced, gas analysis (for thermal technologies), visible sparks, smoke and fumes generated, and other hazards.

Secondary waste management

The vendor is expected to provide with the details of the type of waste generated by the technology. This will also be recorded in the field.

Volume of waste generated

The volume of the secondary waste generated will be measured in the field.

Quantity of media used

The vendor is expected to provide the quantity of media required per hour of operation, and the quantity of media used will also be recorded at the test site during the technology demonstration.

Equipment portability

Equipment portability is broken down into four categories. These categories include equipment that can be moved by one person; equipment that requires two people to move; equipment that requires a forklift to move; or trailer-mounted equipment.

Operational maintenance requirements

The operational/maintenance requirements will provide an account of the types of operational and maintenance activities to be performed routinely.

Level of training required

The level of training and the skills that are required for the operators of the technology.

Availability of equipment and supplies

The availability of the equipment in the market along with the spare parts and the media required to operate the equipment.

Health and safety concerns

A separate report will be available from the International Union of Operating Engineers related to the health and safety issues of the technology. Please contact the IUOE at 304-253-8674 to obtain this report.

APPENDIX C

DATA SECTION

Table C-1.
Technology Overview (part 1)

Technology Category	*Name*	*Description*	*Model Number*	*Useful Life Expectancy*	*Equipment Portability*
Thermal Cutting	Oxy Acetylene	Oxy-fuel Gas Cutting (OFC) processes sever or remove metal by the chemical reaction of oxygen with the metal at elevated temperatures. The necessary temperature is maintained by a flame of fuel gas burning in oxygen.	The Cutter	Tips-1 to 3 yrs of normal use, hose -3 to 5 yrs	1 person needed
Thermal Cutting	Plasma Arc	Plasma Arc Cutting (PAC) process severs metal by using a constricted arc to melt a localized area of a work piece, removing molten material with a high-velocity jet of ionized gas issuing from the constricting orifice. The ionized gas is a plasma, hence the name of the process.	PAC 45 & MV4Xi (Dynapak 4Xi)	power supply-5 to 10 yrs, cable- 5 yrs, electrode-20 hrs Tips- 1 to 3 yrs. of normal use.	forklift needed
Mechanical Cutting	Pneumatic Cut off	Right angle grinder	77A60P107, HA120RP1045, HXA120RP64	Tool body- 5 yrs, 20 to100 hrs- average wheel life	1 person needed
Mechanical Cutting	Hydraulic Shear	Heavy duty portable hydraulic shear	AMK-HP60	5 years normal use, blade -100 to 200 hours	2 person needed
Thermal Cutting	Oxy Gasoline	An oxy-fuel cutting torch using gasoline	N/A	Tips-1 to 3 years of normal use, hose -3 to 5 yrs	1 person needed
Mechanical Cutting	Guillotine Saw	Reciprocating Saw (portable)	Model Super C, Model D	20 years (25 max. cuts/blade)	forklift needed
Mechanical Cutting	Clamshell Lathe	A split lathe cutting is a pneumatically powered split frame clamshell device containing a gear driven machine	Upgraded model 606 unit/ Standard model 602 unit	10 years normal use, cutter inserts- 5 to 20 hours	1 person needed

Table C-2.
Technology Overview (part 2)

Technology Name	*Equipment Portability*	*Maneuverability*	*Health and Safety Concerns*
Oxy Acetylene	1 person needed	The oxy acetylene torch is hand carried. It is portable. The equipment can access most areas with relative ease.	Airborne particles and gases present. Good ventilation and PPE are required. Projectile hazard of sparks and fire.
Plasma Arc	forklift needed	The plasma arc torch is hand carried. It is portable. The equipment can access most areas with relative ease.	Airborne particles and gases present. Good ventilation and PPE are required. Possible electrical and tripping hazards. Projectile hazard of sparks and fire.
Pneumatic Cut off	1 person needed	The pneumatic cut off is hand carried. The cutting tool can access only those areas where the operator can position himself within touching distance of the surrogate.	General caution should be taken to stay clear cutting blade while in operation, and the operator should always use eye protection. Airborne particles present. Good ventilation and PPE are required. Projectile hazard of sparks and fire.
Hydraulic Shear	2 person needed	The hydraulic shear requires two persons holding the 133 lbs. equipment and can not be lifted over the operators' shoulders without lifting support. This restricts the accessibility Options. The shear has a blade width of 5 inches.	General caution should be taken to stay clear of machine while in operation, and the operator should always use eye protection. Back protection required for lifting technology. Projectile hazard.
Oxy Gasoline	1 person needed	The oxy gasoline torch is hand carried. It is portable. The equipment can access most areas with relative ease.	Airborne particles and gases present. Good ventilation and PPE are required. Projectile hazard of sparks and fire.
Guillotine Saw	forklift needed	The guillotine saw model Super C requires two persons to place it in position, and model Super D requires a lifting mechanism to position it on the surrogates. The tool can be positioned at the surrogate if there exists a clearance of minimum 2 inches.	General caution should be taken to stay clear of machine while in operation, and the operator should always use eye and hearing protection. Back protection required for lifting technology. Possible electrical and tripping hazards.
Clamshell Lathe	1 person needed	The clamshell lathe is compact equipment that fits over the circular profiles only. It can easily be fitted onto most pipes with 6 inches axial and 5 inches radial clearance.	Technology uses rotating equipment and generates metal chips while cutting. General caution should be taken to stay clear of machine while in operation, and the operator should always use eye and hearing protection. Sharp edges.

Table C-3.
Cost of Equipment

Technology Name	*Equipment 1*	*Cost for Equipment 1*	*Equipment 2*	*Cost for Equipment 2*	*Equipment 3*	*Cost for Equipment 3*
Oxy Acetylene	Kit which includes gauges, hose, goggles, & medium duty cutting torch	$400.00		$0.00		$0.00
Plasma Arc	PAK 45	$25,000.00	Support Equipment	$7,000.00		$0.00
Pneumatic Cut off	77A60P107	$1,100.00	Compressor	$300.00		$0.00
Hydraulic Shear	Shear (Amkus Mega Cutter)	$9,500.00	extension hose	$1,000.00	power unit	$2,900.00
Oxy Gasoline	Kit	$845.00	oxygen regulator	$145.00		$0.00
Guillotine Saw	Super C w/ optional 110V AC auto feed	$16,070.00	Model D w/ optional 110V AC auto feed	$17,790.00		
Clamshell Lathe	Model 606	$13,750.00	Air caddy	$360.00	Model 602	$9,200.00

Table C-4.
Technology Benefits

Technology Name	*Benefit 1 (Cost)*	*Benefit 2 (Performance)*	*Benefit 3 (Setup/destaging)*	*Benefit 4 (Health & Safety)*	*Benefit 5 (Maintenance)*	*Benefit 6 (Additional)*
Oxy Acetylene	Low capital and operating cost	Fast cutting	Portable, quick setup		Low maintenance	Easily adapted for remote operation
Plasma Arc	Low operating cost	Fast cutting	Portable			Easily adapted for remote operation
Pneumatic Cut off	Low capital and operating cost		Portable, quick setup		Low maintenance	
Hydraulic Shear	Low operating cost	Fast cutting	Quick setup	No airborne particles	Low maintenance	Easily adapted for remote control
Oxy Gasoline	Low capital and operating cost	Provide greater fuel availability	Portable, quick setup		Low maintenance	
Guillotine Saw		Capable of cutting all material		No airborne particles	Low maintenance	Easily adapted for remote operation
Clamshell Lathe	Low operating cost	Capable of cutting all cylindrical metals	Portable, quick setup	No airborne particles	Low maintenance	

Table C-5.
Technology Limitations

Technology Name	*Company's Name*	*Limitation 1 (Vendor Supplied)*	*Limitation 2 (Vendor Supplied)*
Oxy Acetylene	Framatome Tech	16" thick ferritic material, will cut only metal that oxidizes readily	
Plasma Arc	Framatome Tech	4" thick material, 100ft reach	
Pneumatic Cut off	Framatome Tech	Cut limited to the blade's radius	Access to desired cut line
Hydraulic Shear	Framatome Tech	Maximum jaw opening 8", maximum shear force 67,900 lbs.	Access to desired cut line
Oxy Gasoline	Petrogen	18" thick metal, will cut only metal that oxidizes readily	
Guillotine Saw	E.H.Wachs	** Needs approximately 3" clearance in order to be mounted onto cutting surface.	Access to desired cut line
Clamshell Lathe	TriTool Inc.	Radial and axial clearances need to be reviewed to determine mounting location on pipe and equipment model considerations for specific sizes.	Access to desired cut line

Table C-6.
Technology Maintenance

Technology Name	*Maintenance Requirement 1*	*Maintenance Requirement 2*	*Maintenance Cost*
Oxy Acetylene	Inspect each use	Clean tips	Replace tips and hoses as needed
Plasma Arc	Clean nozzle		$5,000/year
Pneumatic Cut off	Inspect each use	Lubricate	$300
Hydraulic Shear	Inspect each use		$50/20 hours service
Oxy Gasoline	Inspect each use	Clean tips	Replace tips and hoses as needed (tips=$35 each)
Guillotine Saw	Inspect each use	Lubricate	est. @ $0.25 / cut
Clamshell Lathe	Periodic cleaning and grease required		$200/year

Table C-7.
Technology Performance

Technology Name	*Surrogate Type*	*End point achieved*	*Total Length of Cut (in)*	*Total Cutting Time (min-sec)*	*Total Production Time (min)*	*Total Cutting Rate (in/min)*	*Total Production Rate (in/min)*
Oxy Acetylene	All Surrogates	Melted Ends	1991.75	328 -26	1072min	6.06	1.86
Plasma Arc	All Surrogates	Melted Ends	1661.25	141 -44	835min	11.72	1.99
Pneumatic Cut off	All Surrogates	Jagged Edges	714.05	372 -41	1168min	1.92	0.61
Hydraulic Shear	I-beams, railing, & pipes	Crushed	450.0	87 -54	414min	5.12	1.09
Oxy Gasoline	All Surrogates	Melted Ends	1834.75	228 -59	596min	8.01	3.08
Guillotine Saw	All Surrogates	Smooth Finish	742.7	455 -40	1717min	1.63	0.43
Clamshell Lathe	Railing, Pipes & Barricades	Machined Finish	427.6	70 -41	722min	6.05	0.59

Table C-8.
Utility/Media

Technology	*Utility (1)*	*Utility (2)*	*Measurement of fuel used*	*Quantity of media used*
Oxy Acetylene	Oxygen, Acetylene		N/A	2.83 bottles Acetylene(130 cu. Ft. / bottle) @ $29.70 ea., 4.89 bottles Oxygen (280 cu. Ft. / bottle) @ $18.5 ea.
Plasma Arc	Nitrogen, Hydrogen/Argon	Fuel (Generator)	113.7 gallons @ $1.1/gal	1.725 bottles Nitrogen (304 cu. Ft. /bottle) @ $21.50, 1.485 bottles Hydrogen/Argon (270 cu. Ft. / bottle) @ $98.00 ea.
Pneumatic Cut off	Fuel (Compressor)		26.5 gallons @ $1.1/gal	10-Thin disks @ $4.37 ea., 5-Self mounted disks @ $9.30 ea.
Hydraulic Shear	Fuel (Hydraulic Compressor)		3 gallons @ $1.1/gal	Shear blade @ $338 ea. Life expectancy 5 yrs. Prorated cost at demo $0.0226.
Oxy Gasoline	Oxygen, Gasoline		1.25 gallon @$1.1/gal	2.425 bottles Oxygen (280 cu. Ft. / bottle) @ $18.5 ea.
Guillotine Saw	110V A.C. Elect. (or 220V A.C. Elect.), Fuel (Compressor)	Fuel (Hydraulic Compressor) (also available-Pneumatic)	5 gallons @ $1.1/gal	5-Super C blades @ $96 ea., 3-Model D blades @ $124 ea.
Clamshell Lathe	75 cfm of compressed air at 90 Psi		12.5 gallons @ $1.1/gal	8 Cutter inserts @ $12 ea.

APPENDIX D

VENDOR INFORMATION

Table D-1.
Vendor Information

TECHNOLOGY NAME	OXY-ACETYLENE	PLASMA ARC	PNEUMATIC CUT OFF	HYDRAULIC SHEAR	OXY-GAS TORCH	SPLIT LATHE CUTTING	GUILLOTINE SAW
VENDOR NAME	FRAMATOME TECH	FRAMATOME TECH	FRAMATOME TECH	FRAMATOME TECH	PETROGEN	TRITOOL INC	E.H.WACHS
VENDOR ADDRESS	3315 Old Forest Road, Lynchburg, VA 25506-0935	3315 Old Forest Road, Lynchburg, VA 25506-0935	3315 Old Forest Road, Lynchburg, VA 25506-0935	3315 Old Forest Road, Lynchburg, VA 25506-0935	P.O.Box 1592, Richmond CA 94802	3806 Security Park Dr. Rancho Cordova CA 95742	100 Shepard Ave, Wheeling IL 60090
PHONE NUMBER	(804) 832-2517	(804) 832-2517	(804) 832-2517	(804) 832-2517	(510) 237-7274	(800) 323-8185	(800) 345-5015
FAX NUMBER	(804) 832-3660	(804) 832-3660	(804) 832-3660	(804) 832-3660	(510) 237-7275	(847) 520-1168	(916) 351-0372
SERVICES	engineering, design, inspection, repair and decommissioning of nuclear facilities	engineering, design, inspection, repair and decommissioning of nuclear facilities	engineering, design, inspection, repair and decommissioning of nuclear facilities	engineering, design, inspection, repair and decommissioning of nuclear facilities	manufacture, sell	sell, rent, lease, train	Split lathe cutters and machining
WEBSITE	www.framatech.com	www.framatech.com	www.framatech.com	www.framatech.com	www.petrogen.com	www.tritool.com	www.wachsco.com