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INNOVATIVE TECHNOLOGY
Summary Report

High-Speed Clamshell Pipe Cutter

Deactivation and
Decommissioning Focus Area

Prepared for
U.S. Department of Energy
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Office of Science and Technology

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INNOVATIVE TECHNOLOGY
Summary Report

High-Speed Clamshell Pipe Cutter

OST Reference #1807

Deactivation and
Decommissioning Focus Area

Demonstrated at
Hanford Site
Richland, Washington

INNOVATIVE TECHNOLOGY
Summary Report

Purpose of this Document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine if a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

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SECTION 1

EXECUTIVE SUMMARY

The Hanford Site C Reactor Technology Demonstration Group demonstrated the High-Speed Clamshell Pipe Cutter technology, developed and marketed by Tri Tool Inc. (Rancho Cordova, California). The models demonstrated are portable, split-frame pipe lathes that require minimal radial and axial clearances for severing and/or beveling in-line pipe with ranges of 25 cm to 41 cm (10 in. through 16 in.) and 46 cm to 61 cm (18 in. through 24 in.) nominal diameter. The radial clearance requirement from the walls, floors, or adjacent pipes is 18 cm (7 in.). The lathes were supplied with carbide insert conversion kits for the cutting bits for the high-speed technique that was demonstrated. Given site-specific factors, this demonstration showed the cost of the improved technology to be approximately 30% higher than the traditional (baseline) technology (oxyacetylene torch) cost of $14,400 for 10 cuts of contaminated 41-cm and 61-cm-diameter pipe at C Reactor. Actual cutting times were faster than the baseline technology; however, moving/staging the equipment took longer. Unlike the baseline torch, clamshell lathes do not involve applied heat, flames, or smoke and can be operated remotely, thereby helping personal exposures to be as low as reasonably achievable.

■ Technology Summary

This section summarizes the demonstration of an improved technology developed and marketed by Tri Tool Inc. (Rancho Cordova, California) that is used to cut large-bore piping and conduits. This improved technology was demonstrated for the U.S. Department of Energy's (DOE) C Reactor Interim Safe Storage (ISS) Large Scale Demonstration and Deployment Project (LSDDP) for the DOE Hanford Site at Richland, Washington. DOE's Office of Science & Technology/Deactivation and Decommissioning Focus Area, in collaboration with the Environmental Restoration Program, is undertaking a major effort of demonstrating improved technologies at its sites nationwide. If successfully demonstrated at the Hanford Site, these improved technologies could be implemented at other DOE sites and similar government or commercial facilities.

The Tri Tool Inc. high-speed units are portable split-frame pipe lathes that can sever and/or bevel in-line pipes 25-cm to 61-cm (10-in. through 24-in.) nominal diameter. A key feature of the high-speed units is field-adjustable bearings that pre-load and stabilize the rotating head to improve life, stability, and precision and reduce the amount of maintenance required. The improved technology demonstrated can sever pipe with higher cutting speeds than conventional clamshell lathes.

The demonstration was first conducted with uncontaminated, mild steel 41-cm and 61-cm (16-in. and 24-in.) nominal diameter pipe sections, using Model 616 RBL and Model 624 RBL lathes, respectively. Then the Model 616 RBL lathe was used to make a number of cuts of contaminated 41-cm (16-in.)-diameter mild steel pipe in the gas pipe tunnel.

Problem Addressed

The DOE is in the process of decontamination and decommissioning (D&D) many of its nuclear facilities throughout the country. As facilities are dismantled, demolition waste must be sized into manageable pieces for handling and disposal. Typically, the facilities undergoing D&D are contaminated, either chemically, radiologically, or both. In its D&D work, the DOE Hanford Site was in need of a tool capable of cutting pipe up to 61 cm (24 in.) in diameter. The tool had to be easy, safe, and economical to operate without applied heat, flames, or smoke. The cutting times for the improved technology needed to be comparable to the baseline technology (oxyacetylene torch). Finally, the tool had to be easy to decontaminate using conventional equipment.

Major Features of the Improved Technology

Features compared to baseline torch and conventional clamshell pipe cutters:

- Drive gears and bearing surfaces are covered for operator safety and are sealed to prevent dust and chip interference.

- Operator controls are away from the rotating head for operator safety and follow as low as reasonably achievable (ALARA) practices. (However, setup is not remote.)

- Does not involve flames, smoke, or applied heat.
- Field-adjustable bearings/tracking modules that allow out-of-round pipe cutting.
- Only 18-cm (7-in.) radial clearance is required at maximum pipe diameter for the machine.
- Interchangeable hardened tool-steel cutting bits, or carbide inserts (that are used for dry, high-speed cutting).
- Modular hydraulic power source uses low-toxicity mineral oil.

Potential Markets/Applicability

This tool represents an improved technology that can be used at DOE sites, and the U.S. Nuclear Regulatory Commission and the U.S. Environmental Protection Agency have the potential for wide use of this technology at nuclear facilities and at other similar public and commercial facilities in which pipes must be segmented to facilitate removal or disposal. The units tested are ideally suited for cutting pipe or conduit up to 61-cm (24-in.) diameter (larger units are available), especially where semi-remote operation is desired. Since this technology generates minimal heat and no open flames, it is particularly valuable for work in dusty or inert environments or on pipes that may be internally or externally contaminated or that may be covered with a hazardous coating (e.g., lead-based paint). Private-sector remediation and demolition contractors will also be interested.

Advantages of the Improved Technology

The following table summarizes the advantages and shortfalls of the improved technology against the baseline (traditional) tool, an oxyacetylene torch, in key areas:

Category	Comment
Purchase Cost	25 cm through 41 cm (10 in. through 16 in.) = $21,800 46 cm through 61 cm (18 in. through 24 in.) = $25,300 Baseline (torch) costs less than 10% of the Clamshell. The cost of using the improved technology is 10% to 30% higher than baseline technology costs.
Performance	Cutting rate faster than the baseline torch: 15.6 min vs. 16.8 min for 61-cm cut; 11.5 min vs. 15 min for 41-cm cut; but setup time longer -- 24 min vs. less than 5 min.
Implementation	No special site services are required.
Secondary Waste	Generates metal shavings that may be contaminated.
ALARA/Safety	May be operated remotely, thus supporting ALARA principles. Produces minimal heat and acceptable noise levels. Does not generate airborne contamination or smoke. Baseline torch and gas bottles are potential fire hazards and hot-work permit is needed.
Ease of Use	Easy to use, but heavier than the baseline tool (55 kg [120 lb] for heaviest component vs. lightweight torch). Two persons set it up. Uses one less worker than the baseline, because no fire watch is needed.
Skill Level	Workers learn the cutting technique quickly without having to be qualified as welders.
Flexibility	Limited to circumfential cuts only.

Operator Concerns

The clamshell pipe cutter was too large and heavy to set up for cutting piping located in a portion of the pipe tunnel that has low head room. Also, setup time is longer for the lathes versus the torch.

Skills/Training

Training of D&D workers is minimal if the trainees have basic operational knowledge of cutting tools. Training prior to and during the demonstration was completed in less than an hour.

■ Demonstration Summary

The baseline technology was demonstrated at the C Reactor north and south water pipe tunnels August 19 through 22, 1997. The improved technology was demonstrated in the gas pipe tunnel December 15 through 19.

Demonstration Site Description

The improved technology was demonstrated on pipes in the gas pipe tunnel at the Hanford Site C Reactor. This tunnel was approximately 4 m (13 ft) wide and 4.6 m (15 ft) high, and contained two parallel pipes.

Regulatory Issues

The improved cutter is a segmentation (cutting) tool used for pipe cutting. No special regulatory permits are required for its operation and use, unlike the baseline technology, which requires a hot work permit. This system can be used in daily operation under the requirements of the *Code of Federal Regulations* (CFR) 10 CFR, Parts 20, 835, and proposed 834 for protection of workers and the environment from radiological contaminant and 29 CFR, Occupational Safety and Health Administration (OSHA) worker requirements.

Technology Availability

The High-Speed Clamshell Pipe Cutter is patented by Tri Tool Inc. and is available commercially, off-the-shelf.

Technology Limitations/Needs for Future Development

Because of their weight and the access requirements, clamshell lathes are not ideal for use in areas with limited clearance. Reducing the overall weight of the system would make handling easier. Future assessment may be warranted to evaluate the cost/benefit of liquid-cooled operation versus dry operation. To optimize operations, future efforts should focus on reducing setup and cutting time, and increasing cutting bit life. At present, the required setup time could preclude use in very high-radiation areas.

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Other
All published Innovative Technology Summary Reports are available at http://em-50.doe.gov. The Technology Management System, also available through the EM-50 Web site, provides information about OST programs, technologies, and problems. The OST Reference # for the High-Speed Clamshell Pipe Cutter is 1807.

TECHNOLOGY DESCRIPTION

■ Overall Technology Definition

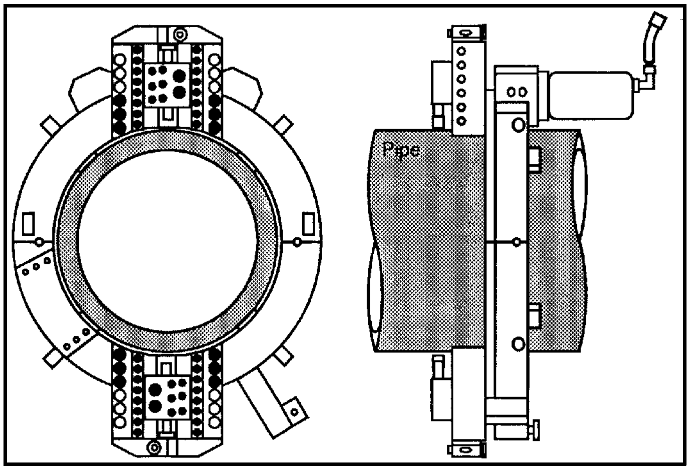

Figure 1. High-Speed Clamshell Pipe Cutter.

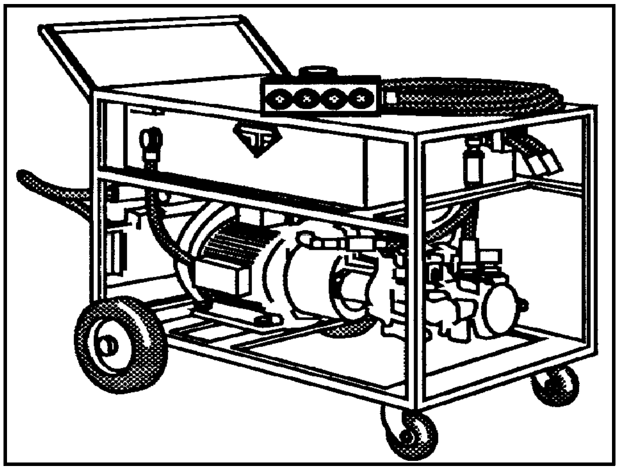

Figure 2. Hydraulic power supply.

The High-Speed Clamshell Pipe Cutter technology has been used successfully in the oil and gas industry to quickly sever large piping segments. These tools offer the advantages of high-speed cutting, no smoke or particulates, remote operation, and clean smooth edges suitable for capping.

The Tri Tool Inc. High-Speed Clamshell Pipe Cutter technology is characterized by the following features and configuration:

Safety/ALARA Exposure

- Drive gears and bearing surfaces are covered for operator safety and are sealed to prevent dust and chip interference.
- Operator controls are located away from the rotating head for operator safety and in accordance with ALARA practices. (However, setup is manual.)
- Operation of the cutter does not involve flames, smoke, or applied heat.

***Physical features**: high-speed clamshell pipe cutter models 616 RBL and 624 RBL*

- Split-frame clamshell pipe cutter model 616 RBL accommodates pipe 25 cm through 41 cm (10 in. through 16 in.) and the model 624 RBL accommodates pipe 46 cm through 61 cm (18 in. through 24 in.) in diameter. (These are the manufacturer's standard size ranges that have proved to be practical designs.
- Field-adjustable precision 90°-Vee bearings that pre-load and stabilize the rotating head to improve life, stability, and precision and reduce the amount maintenance required.
- Approximate weight:
  - Model 616 RBL: 72 kg (159 lb)
  - Model 624 RBL: 94 kg (207 lb)
  - The heaviest component is 55 kg (120 lb).

- Axial and radial clearance requirements are minimal. For the 624 RBL model adjusted for this demonstration, radial clearance was only 18 cm (7 in.).

- Power source description: 240/460 volts alternating current (VAC) for hydraulic pump.

- Auto-feed star wheels and adjustable slideways help maintainability, life, and operator safety, with minimal operator training.

- Interchangeable hardened tool, steel-cutting bits, or carbide inserts (that are used for dry, high-speed cutting).

- Optional hinge available with remote or manual-closing screw to reduce setup/breakdown time.

- Outer-diameter tracking modules use a spring-loading system to track directly on the surface of the pipe. The tool bit feeds from the spring-loaded side. This system allows the tool bit to stay in the cut for the full circumference of the pipe, even for severely out-of-round pipe (typical for large-bore, thin-wall pipe).

- Modular hydraulic power source (765 RVC) uses Chevron ATF mineral oil.

■ System Operation

The work crew consisted of one supervisor, two D&D workers who performed the cutting, and one radiological control technician (RCT) who monitored the radiological conditions during the activity. In addition, one additional RCT and two D&D workers were on standby outside the contamination zone.

Setup Procedure

- Lay the tarp on the floor to capture shavings.
- Install temporary wood cribbing underneath piping.
- Set clamshell halves in place and tighten the clamps.
- Connect the hydraulic lines.
- Install the tool bits.
- Adjust the lathe settings.

Piping Segmentation

- Open the hydraulic valve.
- Standby for automatic, remote cutting.
- Close the hydraulic valve, remove the lines, and unclamp the clamshell halves.

Demonstration Overview

Demonstration Site Description

As part of the D&D mission at DOE sites nationwide, DOE and its environmental contractors must remove large quantities of piping and conduit (much of which is contaminated) from the inside and outside of hundreds of buildings and facilities. The Tri Tool Inc. High-Speed Clamshell Pipe Cutter technology could be a viable alternative to conventional methods for segmenting large-bore pipe circumferentially. The technology was demonstrated as part of DOE's Hanford Site C Reactor ISS Project in the underground gas pipe tunnel of the C Reactor. The purpose of this demonstration was to compare the capabilities of this improved technology with those of the baseline technology, the oxyacetylene torch. The gas pipe tunnel was approximately 4 m (13 ft) wide and 4.6 m (15 ft) high and contained two parallel pipes.

Performance Objectives

The High-Speed Clamshell Pipe Cutter technology for segmenting large-bore piping should be able to perform as follows:

- Circumfentially cut steel and stainless steel pipe up to 61 cm (24 in.) in diameter.
- Make cuts remotely.
- Operate in ambient temperatures from 3°C to 40°C (37°F to 104°F).
- Be easily decontaminated using conventional equipment.
- Be cost-competitive with the baseline technology.

Demonstration Chronology and Specific Technology Demonstration Instructions

The baseline technology was demonstrated at the C Reactor north and south water pipe tunnels August 19 through 22, 1997. The improved technology was demonstrated first outdoors with uncontaminated mild steel 41-cm and 61-cm (16-in. and 24-in.) nominal-diameter pipe sections, using Model 616RBL and Model 624RBL lathes, respectively. Then the Model 616RBL lathe was used to cut contaminated 41-cm (16-in.)-diameter pipe at four locations in the gas pipe tunnel December 15 through 19. Figure 3 shows the larger lathe (Model 624RBL) cutting a 61-cm (24-in.)-diameter pipe segment on an outdoor stand. Figure 4 shows the Model 616RBL lathe being set up to cut 41-cm (16-in.)-diameter pipe in the gas pipe tunnel.

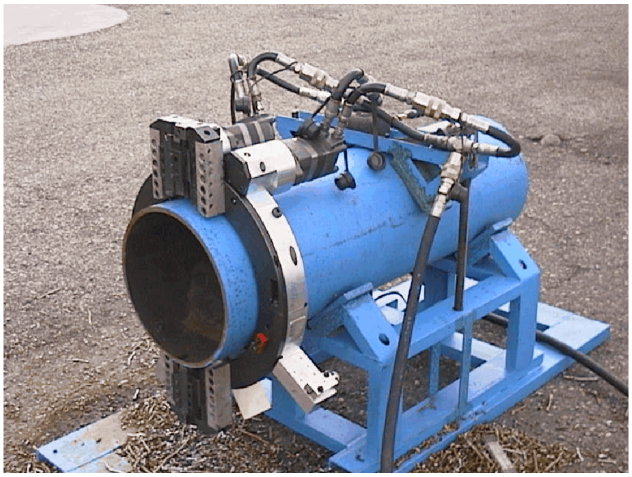

Figure 3. Cutting 61-cm (24-in.) pipe.

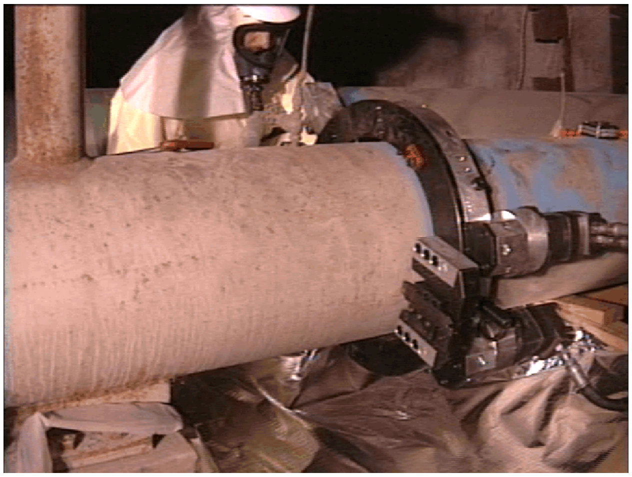

Figure 4. Setting up to cut 41-cm (16-in.) pipe.

Instructions and conditions for the demonstration included the following:

- Assess the High-Speed Clamshell Pipe Cutter technology on piping that is 41-cm and 61-cm (16-in. and 24-in.)-diameter and include some cuts of contaminated 41-cm (16-in.)-diameter pipe in the C Reactor gas pipe tunnel. This tunnel is a radiologically contaminated area and airborne radiological area.
- Pipe wall thicknesses were 3 cm (1.2 in.) for 61-cm (24-in.)-diameter pipe, and 2.6 cm (1 in.) for 41-cm (16-in.)-diameter pipe.
- Record the setup time, cut time, location, pipe size, and material type.
- Observe and record the physical condition of the cut pipe ends.
- Demonstrate the handling and cutting characteristics in tight or congested areas, i.e., in a tunnel with multiple pipes and limited clearances.
- Any contamination that was present was fixed, and the radiation field was low-level.
- Operators to be Hanford Site D&D workers.
- Pipes are located a minimum of 21 cm (8.5 in.) from the floor, walls, or adjacent pipes.
- Pipe segments required temporary supports.

■ Technology Demonstration Results

Successes

- Cutting speed for the improved technology was 7% faster than the baseline technology for 61-cm (24 in.) pipe and was 23% faster than the baseline technology for 41-cm (16-in.) pipe.
- The tool successfully cut steel pipe 41-cm and 61-cm (16-in. and 24-in.) diameter.
- Operation could be performed by individuals that are not trained welders.

The improved lathes are better than the baseline tool for achieving ALARA conditions. Except for setup, cutting may be performed remotely up to 80 m (250 ft) from the piping, which reduces operator exposure to hazardous or contaminated environments. The improved technology has less potential for spreading contamination than torches because flame-cutting generates smoke and airborne particulate. Fire hazards and ventilation requirements are much less than when using torches.

Shortfalls

- Setup time for the High-Speed Clamshell Pipe Cutter technology was approximately 5 times longer than for the baseline technology (24 min vs. less than 5 min).
- The improved technology could not be used in a portion of the pipe tunnel that had low head room due to its size and weight.
- Requires two persons or lifting gear to set up.

Meeting Performance Objectives

- The technology met all of the performance objectives listed in the Demonstration Overview section, with the exception of cost. The improved technology costs ranged from 10% to 30% more than the baseline for 10 pipe cuts (the amount of work in the baseline demonstration). The 10% increment applies if personnel using the improved cutter have prior training; the 30% increment applies if a vendor technician is dispatched to the jobsite to give instruction.
- The manufacturer’s specifications met remote operation and temperature requirements.

- Although stainless steel pipe was not included in the cutting demonstration, the manufacturer's specifications provide for stainless steel pipe cutting.

- A lathe was completely disassembled and reassembled in the field in about 1.5 hours and appeared to be easy to decontaminate. However, one pipe cut that was made had contaminated condensate in the pipe, which corroded parts of the cutter and made decontamination difficult.

■ Comparison of Improved Technology with Baseline

Table 1 compares the performance and operation of the improved technology with the baseline tool. Segmented lengths varied from 1.8 m (6 ft) to 2.7 m (9 ft).

Table 1. Comparison of improved and baseline technologies

Activity/Feature	Improved Cutter Tri Tool Inc. Cutter	Baseline Tool Oxyacetylene Torch
Setup time between cuts	24 minutes	Less than 5 minutes
Cutting time - 41-cm (16-in.) pipe	11.5 minutes	15 minutes
Cutting time - 61-cm (24-in.) pipe	15.6 minutes	16.8 minutes
Flexibility in the field	• Needs alternating current power supply • For circumferential cuts only	• Needs hot work permit • Will not cut stainless steel
Durability	High	High
Ease of operation	Two persons can readily set it up; user simple, remote controls	Manual operation requires total attention
Waste generation	Lathe cuttings	Smoke, particles
Utility requirements	240/460 VAC for hydraulic pump	None
Training	Easily taught and learned craft skill	Must be certified welder
ALARA	Better than baseline; operates remotely after setup, and does not generate airborne contamination	Poor; operator must be close to work and the cutting method generates airborne contamination
Safety	• Heavy components to move • High-pressure hydraulics • Noise levels 50 to 90 dB	• Heavy high-pressure gas bottles • Fire danger

Baseline Segmentation Tool

Oxyacetylene Torch

- Average setup time was less than 5 minutes.

- Demonstrated on 41-cm and 61-cm (16-in. and 24-in.)-diameter pipe with 2.5-cm (1-in.) and 3-cm (1.2-in.)-thick walls, respectively.

- Easy to use in congested areas.

- Requires a crew size similar to the improved technology with the addition of a firewatch.

Demonstrated Improved Technology

High-Speed Clamshell Pipe Cutter Technology (Tri Tool Inc. Models 616 RBL and 624 RBL)

- Demonstrated on 41-cm and 61-cm (16-in. and 24-in.)-diameter pipe sections.

- Cut edges were smooth and clean.

- Needs alternating current power source for hydraulic pump.
- Generates waste cuttings.
- Relatively easy to use where pipes are somewhat close together and near walls, but could not be used in a narrower part of the C Reactor gas pipe tunnel.
- Relatively easy for two persons to set up.
- Workers can learn the cutting technique quickly without having to be qualified as welders.

Skills/Training

Training of D&D workers is minimal if the trainees have a basic operational knowledge of cutting tools. Training to operate the improved tool takes less than 1hour.

Operational Concerns

- The improved lathes are powerful cutting tools. The operator must take appropriate safety precautions. Hydraulic system couplings must be properly secured and hoses protected from damage.
- If this tool is used in radiologically contaminated areas, radiological work practices and engineering controls must be used to prevent personnel and equipment contamination (except for disposable cutting bits).
- Manual handling is required for setup. (This is of special concern in high-radiation areas.)
- Pipe must be properly supported during the cutting operation.
- Clamshell pipe cutters are significantly heavier than either the oxy-gasoline torch (discussed in Section 4) or the oxyacetylene torch.

SECTION 4

TECHNOLOGY APPLICABILITY AND ALTERNATIVE TECHNOLOGIES

■ Technology Applicability

- The Tri Tool Inc. High-Speed Clamshell Pipe Cutter technology is ideally suited for D&D activities that include cutting large-bore pipe and/or conduit where reasonable access is available. Clamshell lathes are portable and especially useful for segmenting fixed pipe for size-reduction of large pipe sections.

- The cutter technology is equally well-suited for indoor and outdoor work. The technology can be applied in dusty or inert environments where flame cutting is unsafe or not useable.

- This technology is potentially valuable for any D&D project and is of particular value at sites where piping and conduit may be internally or externally contaminated because it can be operated remotely. Clamshell pipe cutting is a useful alternative in environments where open flames/smoke produced from cutting operations is not acceptable.

- The DOE, the U.S. Nuclear Regulatory Commission, and the U.S. Environmental Protection Agency all have potential for wide use of this technology at their nuclear facilities. Private-sector remediation and demolition contractors may also have applications for this technology.

■ Competing Technologies

- The High-Speed Clamshell Pipe Cutter technology is competitive with other cutting and segmentation technologies such as the baseline oxyacetylene torch used for this demonstration. Both oxyacetylene and oxy-gasoline torches are alternatives. An oxy-gasoline torch that was demonstrated previously at the Fernald Plant 1 Complex has recently been deployed at C Reactor. Cutting time for 3-cm (1.2-in.) walls and 61-cm (24-in.)-diameter pipe is approximately half that required for the high-speed clamshell lathe or the baseline oxyacetylene torch.

- The improved models tested have much higher cutting speeds than conventional clamshell pipe cutters and guillotine saws that are often used for severing large-bore pipe. Similar high-speed clamshell pipe cutters are available from PCI Energy Services (Lake Bluff, Illinois).

■ Patents/Commercialization/Sponsors

- The adjustable bearing feature is patented by Tri Tool Inc.
- The equipment is commercially available off-the-shelf.

SECTION 5

COST

■ Introduction

This section provides a cost-effectiveness analysis that compares the costs for the improved and baseline technologies used to segment large-bore pipe at the Hanford Site C Reactor. This analysis determined that the cost of the improved technology is 10% to 30% higher than the baseline for the conditions that were used during this demonstration. 30% applies if a vendor technician is dispatched to the site for training of onsite workers who operate the improved tool.

The cost analysis considers two options for the improved technology: (1) purchase and use by site labor, and, (2) rental and use by site labor. The cost-effectiveness estimate is based on eight cuts of 61-cm (24-in.) pipe and two cuts of 41-cm (16-in.)-diameter pipe located in the water tunnels below the C Reactor. The baseline costs are from direct observation of a pipe-cutting operation that used an oxyacetylene torch. The improved technology costs use production rates that were determined from the demonstration cutting of 61-cm (24-in.) pipe and 41-cm (16-in.) pipe. The cost-effectiveness analysis includes shipping (for rental of the improved technology), sleeving the hydraulic hoses, setup in the work area, installing cribbing under the pipes, performing a radiological survey of the pipe interior and exterior, cutting the pipe, and demobilizing from the work area. Costs for removing the pipe segments and disposal of the pipe are not included (the remedial action being proposed would leave this debris in place) until the tunnel roofs are removed as part of the overall demolition project.

■ Cost Data

The improved technology is available from the vendor in the forms and at the rates indicated in Table 2.

Table 2. Costs for improved technology acquisition and rental options

Acquisition Option	Item	Unit	Cost
Equipment Purchase	• 616 RBL - High-Speed Clamshell Pipe Cutter 25 cm to 41 cm (10 to 16 in.) pipe size	each	$21,800
	• 624 RBL - High-Speed Clamshell Pipe Cutter 46 cm to 61 cm (18 to 24 in.) pipe size	each	$25,300
	• Carbide insert conversion kit (per clamshell)	each	$2,215
	• Hydraulic pump and voltage kit	each	$11,550
	• Hydraulic hose, 15 m (50 ft) length	each	$875
	• Carbide insert	each	$21.60
Vendor-Provided Service	• Equipment and operator (assumes 66-cm [24-in.] clamshell pipe lathe and excludes mobilization and consumables)	day	$722
Equipment Rental	• 616 RBL - High-Speed Clamshell Pipe Cutter	mo/wk/day	$3,279/$1,093/$219
	• 624RBL - High-Speed Clamshell Pipe Cutter	mo/wk/day	$5,148/$1,716/$343
	• Carbide insert conversion kit	purchase	$2,215
	• Hydraulic hose 15-m (50-ft) length	mo/wk/day	$1,109/$370/$77
	• Hydraulic pump and voltage kit	mo/wk/day	$42/$14/$3
	• Carbide insert (must purchase)	purchase	$21.60

The price shown for the High-Speed Clamshell Pipe Cutter is for the tooling using hardened-tool, steel-cutting bits. A conversion kit (carbide insert conversion kit) is required for high-speed cutting. The improved technology was demonstrated using the carbide inserts. The maintenance for this equipment will require changing the hydraulic filter and oil every 3,000 hours (the reservoir contains 18 gallons), and performing weekly lubrication, daily cleaning (to remove metal cuttings), and periodic motor repair and new felt (applied to the mill track). Operation costs are primarily for carbide inserts and will vary depending on the type of bit (hardened tool steel or carbide insert), and number of bits used (depends on type of steel being cut, uniformity of the steel material, and the surface). Three bits are expected to last for at least four cuts. Observed unit costs and production rates for principal components of the demonstrations for both the improved technology and baseline technologies are presented in Table 3.

Table 3. Summary of production rates and unit costs

Cost Element	Improved technology		Baseline	
	Production Rate	Unit Cost	Production Rate	Unit Cost
Tool Setup Rent Purchase	24 min/cut	 $142 $119	Less than 5 min/cut	negligible
61-cm (24-in.) pipe cut Rent Purchase	15.6 min/cut	 $99/cut $83/cut	16.8 min/cut	$62/cut
40.6-cm (16-in.) pipe cut Rent Purchase	11.5 min/cut	 $89/cut $37/cut	15 min/cut	$38/cut

The unit costs and production rates shown do not include mobilization or other losses associated with non-productive portions of the work (e.g., suit-up, breaks, replacing carbide inserts, supporting the cut end of the pipe, or fire watch [in the case of the baseline]). The intention of Table 3 is to show the unit costs at their elemental level, which are free of site-specific factors (e.g., work culture or work environmental influences on productivity loss factors). Consequently, the unit costs shown in the above table are the same unit costs for the corresponding line item in Table C-1, Table C-1.1, and Table C-2 of Appendix C. Tables C-1 and C-2 can be used to compute site-specific costs by inserting quantities and adjusting the units for conditions of an individual D&D job. The production rates shown for the improved equipment are based on a pipe wall-cutting rate of 0.19 cm/min (0.08-in./min) for the 61-cm (24-in.)-diameter pipe and a cutting rate of 0.23 cm/min (0.09 in./min) for the 40.6-cm (16-in.)-diameter pipe.

Some features of this demonstration are unique to the Hanford Site and affect the cost. Consequently, specific conditions at other sites may result in different costs. The following site-specific conditions for this demonstration are the principal related factors affecting costs:

- Work area is a low-level radiation area.
- Respiratory protection must be used because of potential airborne contamination.
- No decontamination of the pipe (in the vicinity of the cut) was required.
- Pipe wall thicknesses were 3 cm (1.2 in.) for 61-cm (24-in.)-diameter pipe, and 2.6 cm (1 in.) for 41-cm (16-in.)-diameter pipe.
- The baseline crew was the same as that used for the improved technology except for using one additional D&D worker for fire watch.
- Segmented lengths varied from 1.8 m (6 ft) to 2.7 m (9 ft).

■ Cost Comparison

The improved technology has been separated into options addressing different means of equipment acquisition. One option is based on renting the improved technology equipment from the vendor, and the other option is based on purchase of the equipment. See Table 2 for vendor-supplied pricing data for both options. Refer to Appendix C of this report for detailed cost tables on each of the options shown in Figure 5 (which includes non-productive portions of the work).

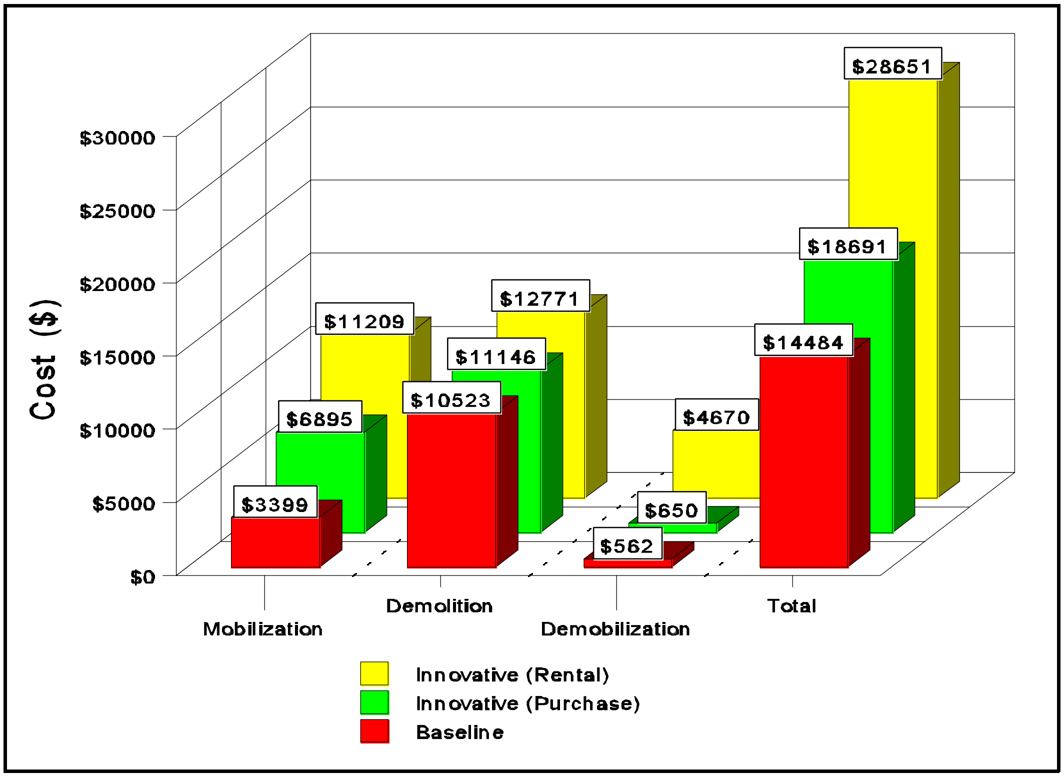

Figure 5. Cost summary (baseline vs. improved technology) for 10 pipe cuts.

■ Cost Conclusions

The improved technology has about the same productivity rates as the baseline technology. The improved technology saves the labor cost of one D&D worker; however, equipment costs are 100 times more expensive than the baseline for the rental option and 3 times more expensive for the purchase option. When the equipment cost is added to the costs for shipping (for the rental option), training (considered to be necessary for proper operation), and the time required to attach and detach from the pipe, then the improved technology is not competitive with the baseline. For this demonstration, the improved technology rental option is 100% more expensive than the baseline, and the purchase option is 30% more expensive than the baseline.

The improved technology costs include training costs (i.e., vendor travel to the site and training of the site workers), which would no longer apply after the site personnel are adequately trained. If the training costs are excluded from the cost analysis, then improved technology rental option is 78% more expensive than the baseline and the purchase option is 10% more expensive than the baseline.

The major cost drivers are training, shipping, setup, donning and doffing personal protective equipment (PPE) and the PPE costs, and lost time. The production rates for cutting the pipes play a relatively minor part in the overall costs. The time lost from productive work due to resolving issues, waiting on RCTs, dealing with unexpected conditions (e.g., condensate that had formed inside one pipe) was the largest single cost. This analysis assumes almost 3 hours lost for each day worked for the baseline tool and approximately 2.5 hours lost for the improved tool. The lost time for the baseline tool is from observed work. The assumption is made that the improved technology cost will be approximately 0.5 manhour less than the baseline because the improved technology does not require a fire watch. Significant variations in lost time could easily change the cost conclusions for the improved technology purchase option but would probably not sufficiently change the improved technology rental option to make it cost-effective. Lost time is a site-specific factor that is anticipated to vary greatly from site to site.

The tables in Appendix C allow the reader to make an estimate for a specific job by inserting site-specific quantities into the cost estimate tables.

SECTION 6

REGULATORY/POLICY ISSUES

■ Regulatory Considerations

- The improved Clamshell Pipe Cutter is a segmentation tool used for cutting pipe. No special regulatory permits are required for its operation and use.
- This system can be operated daily under the requirements of 10 CFR, Parts 20, 835, and proposed 834 for protection of workers and the environment from radiological contaminants; and 29 CFR, OSHA worker requirements.
- Although the demonstration took place at a *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) site, no CERCLA requirements apply to the segmentation work.

■ Safety, Risk, Benefits, and Community Reaction

Worker Safety

- In contrast to the baseline torch, the improved technology does not cause fire hazards, smoke, or airborne contamination.
- Radiation protection worker safety instructions in use at the facility would apply.
- The user of the technology must implement contamination control practices when cutting contaminated or potentially contaminated pipes.
- All equipment and procedures must comply with National Electrical Code Standards.
- Worker safety precautions and practices prescribed by OSHA for operation of equipment (especially cutting tools and high-pressure hydraulics) must be followed.

Community Safety

- There is no adverse safety impact on the community posed by implementation of the Clamshell Pipe Cutter tool.

■ Environmental Impact

- Use of the improved technology presents no adverse impact to the environment.

■ Socioeconomic Impacts and Community Perception

- No socioeconomic impacts are anticipated as a result of implementing the improved technology.

SECTION 7

LESSONS LEARNED

■ Implementation

- The system demonstrated is well-suited for cutting exposed pipes located more than 18 cm (7 in.) away from the wall.
- The technology can be used for interior and exterior conduits.
- Because there is no heat or smoke generation, Clamshell Pipe Cutters reduce the risk of creating airborne contamination while segmenting internally or externally contaminated pipes and conduits.

■ Technology Limitations/Needs for Future Development

- To optimize operations, future efforts should focus on reducing setup and cutting time, and increasing cutting bit life.
- The clamshell pipe cutter was too large and heavy to set up for cutting piping located in a portion of the pipe tunnel that has low head room. Also, setup time is longer for the lathes versus the torch.
- Reducing the overall weight of the system would make handling easier and would eliminate the need for two people to make some cuts.
- Clamshell lathes may be operated either dry (in this demonstration) or with coolant applied to the bits. A cost/benefit study for various pipe materials (with or without coolant) would be useful.
- Clamshell lathes can be used for circumferential cuts only, and cannot be used for longitudinal cuts or for cutting out coupons.

■ Technology Selection Considerations

- Clearance [pipe] considerations
- Personal exposure, and situations that preclude the use of applied heat or flames, and the generation of smoke/airborne material
- The technology produces smooth cut ends and bevels, which could facilitate installation of end caps or other piping as required.

APPENDIX A

REFERENCES

10 CFR Part 20, "Occupational Radiation Protection," *Code of Federal Regulations,* as amended.

Proposed 10 CFR Part 834, "Environmental Radiation Protection," *Code of Federal Regulations,* as proposed.

10 CFR Part 835, "Occupational Radiation Protection," *Code of Federal Regulations,* as amended.

29 CFR Part 1910, "General Industry Occupational Safety and Health Standards," *Code of Federal Regulations,* as amended.

29 CFR Part 1926, "Construction Occupational Safety and Health Standards," *Code of Federal Regulations,* as amended.

Means, 1997, *Means Construction Equipment Cost Data,* R.S. Means Co., Kingston, Massachusetts.

Office of Management and Budget (OMB) Circular No. A-94, *Cost Effectiveness Analysis*.

USACE, 1996, *Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary*, U.S. Army Corps of Engineers, Washington, D.C.

APPENDIX B

ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Description
ALARA	as low as reasonably achievable
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
FETC	Federal Energy Technology Center
G&A	general and administrative (costs)
HTRW	hazardous, toxic, radioactive waste
ISS	interim safe storage
LSTD	[Hanford Site] Large-Scale Technology Demonstration
OMB	Office of Management and Budget
OSHA	Occupational Safety and Health Administration
PAPR	powered air purifying respirators
PPE	personal protective equipment
RCT	radiological control technician
VAC	volts alternating current
WBS	work breakdown structure

Note: Additional acronyms and abbreviations are defined in Appendix C in footnote b for Tables C-3 and C-4 and in Table C-5.

APPENDIX C

TECHNOLOGY COST COMPARISON

The cost-effectiveness analysis computes the cost for a pipe segmentation job by using hourly rates for equipment and labor.

The selected basic activities being analyzed come from the *Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary* (HTRW RA WBS) (USACE 1996). The HTRW RA WBS, developed by an interagency group, is used in this analysis to provide consistency with the established national standards.

Some costs are omitted from this analysis to facilitate understanding and comparison with costs for the individual site. The overhead and general and administrative (G&A) markup costs for the site contractor managing the demonstration are omitted from this analysis. Overhead and G&A rates for each DOE site vary in magnitude and in the way they are applied. Decision makers seeking site-specific costs can apply their site's rates to this analysis without having to first back-out the rates used at the Hanford Site.

The following assumptions were used as the basis of the cost analysis of the improved technology:

- Oversight engineering, quality assurance, and administrative costs for the demonstration are not included. These are normally covered by another cost element, generally as an undistributed cost.
- The procurement cost of 7.5% was applied to all purchased equipment costs so the costs of administering the purchase are accounted for (this cost is included in the hourly rate).
- The equipment hourly rates for the improved technology, the government's ownership option, are based on general guidance contained in Office of Management and Budget (OMB) Circular No. A-94, *Cost Effectiveness Analysis*.
- The equipment hourly rates for the improved technology, the rental option, are based on the vendor-quoted weekly rate (divided by 40 to provide an hourly rate) and increased by 7.5% to cover costs for contract administration.
- The hourly rates for the site-owned equipment that may be used in support of the improved equipment (e.g., the site-owned truck that transports the rented improved equipment from the receiving warehouse to the C Reactor) uses standard equipment rates established at the Hanford Site.
- The equipment hourly rates for the baseline oxyacetylene torch are based on a rental rate and operation cost (Means 1997) (no standard site rates for the torch were available). The torch is actually site owned.
- The standard labor rates established by the Hanford Site for estimating D&D work are used in this analysis for the portions of the work performed by local crafts.
- The analysis uses a 10-hour work day.
- An anticipated life of 6 years and an average usage of 500 hours/year are used in the calculation of hourly rate for the improved technology purchase option.

MOBILIZATION (WBS 331.01)

Vendor Labor, Travel and Per Diem: This cost element provides for the vendor's travel to the site to provide training on use of the improved equipment. The vendor provides the training free for purchase of the equipment, but there is a charge for rental. This cost element is based on a vendor-quoted labor rate of $68.80/hour; per diem rates of $86/day; car rental of $55/day (and assumes two days); airfare for a round trip from Rancho Cordova, California, to Pasco, Washington, of $650 plus fee of 10%, for the vendor technician. The total cost is $2,033 for providing training plus 7.5% for cost of contract administration by the site (total cost of $2,185).

Worker Training: This cost item accounts for one-half day of site worker's labor for hands-on training on operation of the equipment given by a vendor technical representative.

Ship Equipment from Rancho Cordova, California to Hanford Site: The shipping cost for the improved equipment rental is based on the vendor's experience with past shipping. The total weight of the two High-Speed Clamshell Pipe Cutters, hydraulic pump, and hose is approximately 2,500 pounds. The cost for rental of the equipment is assumed to apply to the time required for shipment.

Move/Stage Equipment: For the rental option of the improved technology, this includes costs for receiving the crated equipment at the N Area warehouse/receiving, loading onto a truck, transport to the C Reactor, and unloading. This estimate assumes (not observed) 8 hours for a teamster, D&D worker, and truck, and 4 hours for an equipment operator and fork lift, for a total cost of $816, plus 8 hours of standby for the improved equipment. For the baseline and for the site ownership option for the improved technology, the effort to move the equipment from the local storage and stage it at the tunnels is based on the observed duration and crew for the baseline (assumed to be similar for site ownership of the improved technology).

Setup Area: The setup is based on the observed effort for the baseline and assumes that the improved technology would be similar. The baseline effort included installation of the high-efficiency particulate air exhauster, laying exhaust hoses into the work area, positioning the oxyacetylene torch, wrapping the torch hoses, and staging the blocks of wood used to support the cut end of the pipe. It is assumed that the improved equipment could be uncrated and moved to the work area as part of this activity and not add to the duration (observed time required to uncrate the equipment is 3 minutes per cutter).

Sleeve Hoses and Prepare Equipment: The improved equipment lathe motors are driven by a hydraulic pump. The pump is set up outside the contaminated area. The hydraulic hoses are wrapped with plastic to minimize contamination of the hoses that run into the work area. Additionally, the motor blocks are attached to the clamshell frame and some adjustment is performed in preparation of beginning work. The sleeving, hose lay-down, and the preparation is based on observed durations from the demonstration (1 hour, 0.25-hour, and 0.33-hour/clamshell, respectively).

Pre-job Meeting: The baseline work required a pre-job meeting for the workers to plan the work and review the safety requirements. The costs for the improved technology were assumed to be similar to the observed duration for the baseline.

DEMOLITION (WBS 331.17)

Safety Meeting: The baseline work required a safety meeting for each morning following the first day of work (the pre-job meeting is substantially longer than subsequent meetings). The costs for the improved technology were assumed to be similar to the observed duration for the baseline.

Don and Doff PPE: This cost item includes time for each worker to fully suit up in PPE, as well as material costs for the PPE, and includes removal of the PPE. The time spent donning and doffing each day of the baseline work was observed and the daily average is used in this cost analysis for both the improved technology and the baseline. Material costs for daily PPE for one D&D worker at the Hanford Site are shown in the table below:

Table C-1. Cost for PPE (per man/day).

Equipment	Cost Each Time Used ($)	No. Used Per Day	Cost Per Day ($)
Air purifying respirator (PAPR)	71.06	1 ea	71.06
Face shield	1.28	1 ea	1.28
Booties	0.62	2 pr	1.24
Coverall	5.00	2 ea	10.00
Double coverall (5% of the time)			0.56
Hood	2.00	2 ea	4.00
Gloves (inner)	0.14	2 pr	.28
Gloves (outer)	1.30	2 pr	2.60
Gloves (liner)	0.29	2 pr	.58
Rubber overshoe	1.38	2 pr	2.76
Total			**94.36**

Note: Based on a PAPR price of $603/each, assuming 50 uses, requires four cartridges per day at a cost of $14/each; and maintenance and inspection costs of $150 over the life of the PAPR (50 uses). The face shield price is $64/each assuming 50 uses.

Survey Exterior: The exterior adjacent to the pipe cut was surveyed for contamination prior to beginning the cut. The survey time for each of the baseline cuts was observed and the average time is used in this cost analysis for both the improved technology and the baseline. The individual observed times are 4, 4, 4, 3, 3, 4, 0, 5, 2, and 2 minutes, for an average of 3.1 minutes.

Cut Access and Exhaust Smoke: In the case of the baseline, an access hole was cut in the pipe and the smoke allowed to vent from the access hole. The purpose of this access was to allow a survey of the pipe interior prior to cutting the pipe. The average time required for cutting the access holes is used in the cost analysis for both the baseline and the improved technology. The individual observed durations for the 4-in. by 4-in. access in the 16-in. pipes are 8 and 7 minutes for an average of 7.5 minutes and the durations for the 12-in. by 12-in. access in the 24-in. pipes are 8, 12, 9, 8, 23, 23, 7, and 9 minutes, for an average of 12.4 minutes.

Survey Interior: The pipe interior, for the baseline, was surveyed and the average observed was used in the cost analysis for both the improved technology and the baseline. The individual observed durations are 2, 2, 3, 3, 3, 2, 0, 3, 3, 2, and 14, for an average of 3.4 minutes.

Attach and Detach Clamshell Pipe Cutter: The time required for attaching the cutter to the pipe (after it was previously removed from the crate for setup) was observed during the demonstration as 14 minutes. The time required to detach from the pipe was observed as 11 minutes.

Cut 16-in. Pipes: The rate for cutting with the torch is based on the average observed rate of 15 minutes. The rate for cutting with the improved tool is based on the observed cut rate of 0.005 in. per revolution with 18 revolutions per minute (0.09 in./minute). The pipe wall thickness observed for the baseline and assumed for the improved technology is 1.03 in. At a rate of 0.09 in. per minute, the improved technology method requires 11.5 minutes to cut the pipe. The observed duration for the baseline cuts was 12 and 18 minutes, for an average time of 15 minutes.

Cut 24-in. Pipes: The rate for cutting with the torch is based on the average observed rate of 16.75 minutes. The rate for cutting with the improved technology is based on the observed cut rate of 0.005 in. per revolution with 15 revolutions per minute (0.075 in./minute). The pipe wall thickness observed for the baseline and assumed for the improved technology is 1.170 in. At a rate of 0.075 in. per minute, the improved technology method requires 15.6 minutes to cut the pipe. The observed duration for the baseline cuts was 18, 17, 15, 20, 16, 10, and 21 minutes for an average of 16.75 minutes.

Replace Carbide Inserts: Replacement of broken or worn-out carbide inserts for the improved technology equipment is assumed to require 5 minutes to replace, and each insert is assumed (based on the vendor's experience) to have a life of four cuts (on average). Some limited observation during the demonstration suggests that the inserts may require replacement as often as three inserts in four cuts.

Stage to Next Cut: During the baseline cutting, some cuts were close enough that the equipment did not require significant time to move. Other cuts required moving and restaging the equipment. The observed duration required for moving and staging the baseline work was 0, 0, 0, 5, 6, 0, 2, 5, 1, and 0 minutes, for an average duration of 1.9 minutes. The improved technology method was assumed to be similar; however, the improved technology requires attaching/detaching of clamshell halves and adjusting the cutters.

Non-Productive Time: The non-productive time observed for the baseline (draining liquid from the pipe, waiting for RCTs, etc.) was recorded for each day at 74, 330, 230, 139 minutes, and the average of 3.22 hours/day is used in the cost analysis for the baseline. The improved technology method assumes the lost time is 0.5 manhour less than the baseline because the improved technology does not require a fire watch.

Wrap PAPRs: The average time observed in the baseline for wrapping powered air-purifying respirators (PAPRs) was assumed for both the improved technology and the baseline.

Support Pipe for Fall: The time assumed for both the improved technology and the baseline technologies for supporting the pipe to prevent an uncontrolled fall during the cut is based on the average time observed during the baseline. Wood cribbing was placed under the piping.

DEMOBILIZATION (WBS 331.21)

Move Equipment/Clean Area: The cost of the effort to clean up the work area and move the equipment out of the tunnels for the improved technology and the baseline is based on the observed duration for the baseline work.

Free Release: A minimal amount of time was assumed for free release of the rented equipment (for the improved technology, rental alternative).

Transport to Receiving: This activity includes costs for transporting the rented improved equipment to the N Area warehouse/receiving for shipping.

Shipping to Vendor: This activity provides for return of the rented improved equipment to the vendor and is based on the vendor's experience.

The details of the cost analysis for the two improved technology options and the baseline are summarized in Tables C-1, C-1.1, and C-2.

Table C-2. Cost summary - improved technology (rental option)

Work Breakdown Structure (WBS)	Unit	Unit Cost $	Qty	Total Cost $	Computation of Unit Cost: Production Rate	Duration (hr)	Labor & Equipment Rates: Labor Items	$/hr	Equipment Items	$/hr	Other Costs/and Comments
MOBILIZATION (WBS 331.01)		**Subtotal**		$11,210							
Vendor Labor and Travel	LS	$2185	1	$2,185							Labor, travel 3 day, air fare
Worker Training	LS	$727	1	$727		4	3 DD	$ 95.91	CP	$ 85.82	
Ship Equipment to Hanford	LS	$2280	1	$2,280		12				$ 85.82	Freight from and to vendor
Move/Stage Equipment	LS	$1503	1	$1,503		8			CP	$ 85.82	Truck trans. to C Reactor
Set Up Area	LS	$2891	1	$2,891		10.3	1 RCT+ 4 DD+1/8 SU	$184.83	RS+CT+CP	$ 95.81	
Sleeve Hose and Preparation	LS	$561	1	$561		2	same	$184.83	same	$ 95.81	
Pre-job Meeting	each	$1,063	1	$1,063		3	LT+2 RCT+ 3 DD+1/8 SU	$257.13	2 RS+CT+CP	$ 97.19	
DEMOLITION (WBS		**Subtotal**		$12,765							
Safety Meeting	day	$177	3	$531		0.5	LT+2 RCT+ 3 DD+1/8 SU	$257.13	2 RS+CT+CP	$ 97.19	
Don and Doff Personal Protective Equipment (PPE)	day	$1193	4	$4,772		1.77	same	$257.13	same	$ 97.19	PPE of $94.36/person/day added to unit cost
Survey Exterior	each	$18	10	$180		0.052	same	$257.13	same	$ 97.19	
16-in Pipe Cut Access	each	$44	2	$88		0.125	same	$257.13	same	$ 97.19	
24-in Pipe Cut Access	each	$73	8	$584		0.206	same	$257.13	same	$ 97.19	
Survey Interior	each	$20	10	$200		0.057	same	$257.13	same	$ 97.19	
Attach & Detach Cutter	each	$142	10	$1,420		0.4	same	$257.13	same	$ 97.19	
16-in Pipe Cut	each	$89	2	$178		0.25	same	$257.13	same	$ 97.19	
24-in Pipe Cut	each	$99	8	$792		0.279	same	$257.13	same	$ 97.19	
Replace Carbide Inserts	each	$50	3	$150		0.08	same	$257.13	same	$ 97.19	Carbide inserts $21.60 each and assumes 4 cuts/insert
Stage for Next Cut	each	$11	10	$110		0.032	same	$257.13	same	$ 97.19	
Lost Time	day	$875	4	$3,500		2.47	same	$257.13	same	$ 97.19	
Wrap PAPRs	day	$25	4	$100		0.5	RCT	$ 49.50			
Support Pipe for Fall	each	$16	10	$160		0.25	2 DD	$ 63.94			
DEMOBILIZATION (WBS 331.21)		**Subtotal**		$4,671							
Move Equipment/Clean Area	LS	$820	1	$820		3	4 DD+RCT	$177.38	1RS+CT+CP	$ 95.81	
Free Release	LS	$68	1	$68		0.5	RCT	$ 49.50	1RS+CP	$ 87.20	
Transport to Receiving	LS	$1503	1	$1,503							
Shipping to Vendor	LS	$2280	1	$2,280							
TOTAL				$28,646							

a Unit cost = (Labor +Equipment Rate) x Duration + Other Cost, or = (Labor +Equipment Rate) / Productivity Rate) + Other Cost
b Abbreviations for Units: LS = lump sum; FT = feet; SF = square feet; CY = cubic yards; and, hr = hour.
c Abbreviations and hourly rates for crew members and equipment are shown in table C-5.

Table C-3. Cost summary - improved technology (purchase option)

Work Breakdown Structure (WBS)	Unit	Unit Cost $	Qty	Total Cost $	Computation of Unit Cost		Labor & Equipment Rates				Other Costs/and Comments
					Production Rate	Duration (hr)	Labor Items	$/hr	Equipment Items	$/hr	
MOBILIZATION (WBS 331.01)		**Subtotal**		$6,895							
Vendor Labor and Travel	LS	$2,185	1	$2,185	2185						Labor, travel 3 days + air fare
Worker Training	LS	$501	1	$501		4	3DD	$95.91	CP	$29.26	
Move/Stage Equipment	LS	$560	1	$560		2.5	RCT+4 DD+1/8 SU	$184.83	RS+CP+CT	$39.25	
Set Up Area	LS	$2,308	1	$2,308		10.3	same	$184.83	same	$39.25	
Sleeve Hose and Preparation	LS	$448	1	$448		2	same	$184.83	same	$39.25	
Pre-job Meeting	each	$893	1	$893		3	LT+2 RCT+3 DD+ 1/8 SU	$257.13	2 RS+CT+CP	$40.63	
DEMOLITION(WBS 331.17)		**Subtotal**		$11,146							
Safety Meeting	day	$149	3	$447		.5	LT+2 RCT+3 DD+ 1/8 SU	$257.13	2 RS+CT+CP	$40.63	
Don and Doff Personal Protective Equipment (PPE)	day	$1,093	4	$4,373		1.77	same	$257.13	same	$40.63	PPE of $94.36/ person/ day added to unit cost
Survey Exterior	each	$15	10	$155		0.052	same	$257.13	same	$40.63	
16-in. Pipe Cut Access	each	$37	2	$74		0.125	same	$257.13	same	$40.63	
24-in. Pipe Cut Access	each	$61	8	$491		0.206	same	$257.13	same	$40.63	
Survey Interior	each	$17	10	$170		0.057	same	$257.13	same	$40.63	
Attach & Detach Cutter	each	$119	10	$1,191		0.4	same	$257.13	same	$40.63	
16-in Pipe Cut	each	$74	2	$149		0.25	same	$257.13	same	$40.63	
24-in Pipe Cut	each	$83	8	$665		0.279	same	$257.13	same	$40.63	
Replace Carbide Inserts	each	$45	3	$136		0.08	same	$257.13	same	$40.63	Carbide inserts $21.60 each and assumes 4 cuts/insert
Stage for Next Cut	each	$10	10	$95		0.032	same	$257.13	same	$40.63	
Lost Time	day	$735	4	$2,942		2.47	same	$257.13	same	$40.63	
Wrap PAPRs	day	$25	4	$99		0.5	RCT	$49.50			
Support Pipe for Fall	each	$16	10	$160		0.25	2DD	$63.94			
DEMOBILIZATION (WBS 331.21)		**Subtotal**		$650							
Move Equipment/Clean Area	LS	$650	1	$650		3	4DD+RCT	$177.38	1RS+CT+CP	$39.25	
TOTAL				$18,691							

a Unit cost = (Labor +Equipment Rate) x Duration + Other Cost, or =
(Labor +Equipment Rate) / Productivity Rate) + Other Cost

b Abbreviations for Units: LS = lump sum; FT = feet; SF = square feet; CY = cubic yards; and, hr = hour.

c Abbreviations and hourly rates for crew members and equipment are shown in table C-5.

Table C-4. Cost summary - baseline technology

Work Breakdown Structure (WBS)	Unit	Unit Cost $	Qty	Total Cost $	Computation of Unit Cost						Other Costs/and Comments
					Produc-tion Rate	Duration (hr)	Labor & Equipment Rates				
							Labor Items	$/hr	Equipment Items	$/hr	
MOBILIZATION (WBS 331.01)		**Subtotal**		$3,399							
Move/Stage Equipment	LS	$487	1	$487		2.5	1 RCT+4 DD+1/8 SU	$184.83	1 RS+CT	$ 9.99	
Setup Area	LS	$2,007	1	$2,007		10.3	same	$184.83	same	$ 9.99	
Prejob Meeting	LS	$906	1	$906		3	LT+2 RCT+4 DD+ 1/8 SU	$289.10	3 RS+CT	$ 12.75	
DEMOLITION (WBS 331.17)		**Subtotal**		$10,449							
Safety Meeting	day	$150	3	$449		.5	LT+2 RCT+4 DD+ 1/8 SU	$289.10	3 RS+CT	$ 9.99	
Don and Doff Personal Protective Equipment (PPE)	day	$1,096	4	$4,382		1.77	same	$289.10	same	$ 9.99	PPE of $94.36/ person/ day added to unit cost
Survey Exterior	each	$16	10	$156		.052	same	$289.10	same	$ 9.99	
16-in Pipe Cut Access	each	$37	2	$75		.125	same	$289.10	same	$ 9.99	
24-in Pipe Cut Access	each	$62	8	$493		.206	same	$289.10	same	$ 9.99	
Survey Interior	each	$17	10	$170		.057	same	$289.10	same	$ 9.99	
16-in Pipe Cut	each	$75	2	$150		.25	same	$289.10	same	$ 9.99	
24-in Pipe Cut	each	$83	8	$668		.279	same	$289.10	same	$ 9.99	
Stage for Next Cut	each	$10	10	$96		.032	same	$289.10	same	$ 9.99	
Lost Time	day	$888	4	$3,553		2.97	same	$289.10	same	$ 9.99	
Wrap PAPRs	day	$25	4	$99		.5	RCT	$ 49.50			
Support Pipe for Fall	each	$16	10	$160		.25	2DD	$ 63.94			
DEMOBILIZATION (WBS 331.21)		**Subtotal**		$562							
Move Equipment/Clean Area	LS	$562	1	$562		3	4DD+RCT	$177.38	1RS+CT	$ 9.99	
TOTAL				$14,411							

a Unit Cost = (Labor +Equipment Rate) x Duration + Other Cost, or
= (Labor +Equipment Rate) / Productivity Rate) + Other Cost

b Abbreviations for Units: LS = Lump Sum; FT=Feet; SF=Square Feet; CY=Cubic Yards; and, hr=hour.

c Abbreviations and hourly rates for crew members and equipment are shown in table C-5.

Table C-5. Hourly Rates

Abbreviation	Equipment or Crew Item	Hourly Rate ($)
CP*	16-in. and 24-in. Clamshell (rent)	85.82
CP*	16-in. and 24-in. Clamshell (buy)	29.26
CT**	Cutting Torch	8.61
DD	D&D worker	31.97
RCT	Radiological Control Technician	49.50
LT	Lead Sampling Technician	54.77
RS	Radiation Survey Equipment	1.38
SU	Field Supervisor	59.60

*Improved option only
**Baseline only