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Revision 1

April 2001

Accelerated Site Technology Deployment Integrated Decontamination and Decommissioning Project Final Cost and Performance Report

Ann Marie Phillips
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Accelerated Site Technology Deployment Integrated Decontamination and Decommissioning Project Final Cost and Performance Report

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ABSTRACT

The goal of the Accelerated Site Technology Deployment (ASTD) Integrated Decontamination and Decommissioning (ID&D) project was to encourage the widespread use of innovative, but proven commercially available technologies in D&D operations at Department of Energy (DOE) sites. The Idaho National Engineering and Environmental Laboratory (INEEL), Fernald Environmental Management Project, and Argonne National Laboratory-East teamed to complete the project. At all three DOE sites, the ASTD ID&D project assisted D&D Operations with the selection, procurement, training, and deployment of proven, innovative technologies and promoted the use of these technologies at other sites within the DOE complex. Through the ASTD ID&D Project, D&D Operations deployed 15 innovative technologies at numerous facilities at the three DOE sites from FY-98 to FY-00. This was accomplished by selecting technologies that met needs common to many D&D projects and which provided large benefits for small investments. Innovative approaches were used when performing cost-benefit analyses to minimize data collection requirements while maintaining accuracy. The cost-benefit analyses showed that the deployments saved $998K to date at all three sites, with estimated savings at the INEEL of $25.6M over the next 10 years.

SUMMARY

The overall goal of the Accelerated Site Technology Deployment (ASTD) Integrated Decontamination and Decommissioning (ID&D) project was to encourage the widespread use of innovative, but proven, commercially available technologies in decontamination and decommissioning (D&D) operations at Department of Energy (DOE) sites. The technologies were aimed at improving safety, accelerating schedules, and reducing radiation dose, waste volume, and cost. The ASTD ID&D project team consisted of three DOE sites: Idaho National Engineering and Environmental Laboratory (INEEL), Fernald Environmental Management Project (FEMP), and Argonne National Laboratory-East (ANL-E). Funding and guidance from the National Energy Technology Laboratory (NETL) through the ASTD Program enabled these deployments and was key to the success of the project.

Project Description

At all three DOE sites, the ASTD ID&D project assisted D&D Operations with the selection, procurement, training, and deployment of proven, innovative technologies. Technologies were selected carefully to be sure that they provided a large benefit for a small investment. To do this, the team chose the best technologies from the Large-Scale Demonstration and Deployment Projects (LSDDPs) that met identified D&D Operations needs. The technologies needed to provide significant improvements in cost, safety, radiation exposure, waste volume, or schedule and be widely applicable throughout the DOE complex. The ASTD ID&D project procured or assisted with procuring the technologies, often cost-sharing with D&D Operations. Where needed, they provided training for the new technologies and worked with the technology suppliers to resolve any questions that arose. Next, the team helped identify numerous deployment locations and coordinated the deployments. Since the performance of the technologies had been well-documented in the LSDDPs or in commercial applications, detailed performance data were available. Rather than collecting similar data again, the ASTD ID&D project focused on deploying as many technologies as possible, while collecting minimal data to verify performance in the new applications. Typically, the test engineer observed the technology deployments for several days to make observations and record operator comments, then continued to communicate with the operations team during the remainder of the deployment. Observations and data taken by the work crew were used to complete the data collection process. Using the information gathered during deployment tracking, they calculated cost-benefit analyses for each technology to document the cost savings and project the cost savings over the next 10 years.

To promote the use of these technologies at other sites within the DOE complex, the ID&D team published information on each technology including:

- Fact sheets
- Posters
- Articles in the INEEL star newspaper

- Summaries of how the technologies work
- Short videos
- Technology information packets for distribution
- Cost-benefit analyses
- 10-year INEEL cost savings estimates
- An ASTD ID&D internet home page (http://id.inel.gov/idd/).

The ID&D team sent out numerous packets of information both within and outside of the DOE complex, including several international locations. In addition, the ID&D engineers published papers and posters, and presented at numerous conferences, including the International Conference on Nuclear Engineering, International Decommissioning Symposium, Spectrum, Waste Management '99 and '00, Intermountain Conference on the Environment '99 and '00, and a National Academy of Sciences meeting. Additional publications were made in Pollution Engineering and Radwaste Solutions magazines. Lastly, they wrote monthly reports and a Cost and Performance Report annually to document the results of the project.

One of the keys to the success of the project was the close communication between D&D Operations and the ID&D engineers, and among the three participating DOE sites and NETL. Throughout the project, the ID&D engineers at all three sites worked very closely with the D&D Operations team. They regularly attended D&D Operations staff meetings, and D&D Operations and the ID&D engineers jointly presented papers at conferences about the project results. Communication among the three DOE sites and NETL was accomplished through regularly scheduled conference calls as well as e-mail, unscheduled calls, monthly reporting, and joint presentations and meetings held at conferences and mid-year reviews. The care taken in open, regular communication contributed to the team feeling and success of the project.

Site Descriptions

ANL-E is located on a 3,200 acre site about 25 miles southwest of Chicago's Loop. The Chicago Pile 5 (CP-5) was a nuclear research facility containing a reactor, hot cell, rod storage area, and fuel pool. After 25 years of operation coupled with 15 years of cool down, significant activation and contamination problems representative of a nuclear facility still exist. The ASTD ID&D technologies were deployed at this facility to remove the reactor bio-shield. This was a high-density concrete structure containing large metal pieces in the aggregate.

FEMP is a former uranium fabrication facility undergoing environmental remediation. The 1,050-acre site is located about 18 miles northwest of Cincinnati, Ohio. The ASTD ID&D technologies were deployed on relatively small cement blocks and steel frame structures containing small amounts of radioactive contamination.

The INEEL is an 890-mile^2 site located about 30 miles west of Idaho Falls, Idaho. At the INEEL, 52 test reactors, most of them one-of-a-kind, have been built and operated. Only three of these reactors are still in operation. In addition to the reactors, the INEEL contains facilities for applied engineering, interim waste storage, and research and development. The ASTD ID&D technologies were deployed at numerous facilities throughout the INEEL.

Technology Deployments

Through the ASTD ID&D Project, D&D Operations deployed 15 innovative technologies at numerous facilities at three DOE sites from FY-98 to FY-00. The deployments were performed on projects ranging from removal of a bio-shield on a research reactor with high radiation fields, to removal of underground concrete tanks, to demolition of a huge reactor building. The variety of structures presented numerous D&D challenges that were addressed by the improved technologies. The deployments included technologies for cutting and shearing metal, remote demolition, providing cooling for D&D workers, planning and optimizing D&D work, packaging low-level waste, scaffolding, sample collection, scabbling, and characterization. Descriptions of the technologies, deployment dates and locations, and supplier contact information are presented in Table 1, with additional details in the sections of this report.

FEMP deployed three technologies multiple times during FY-98 and FY-99. Using the Oxy-Gasoline Torch, Hand-Held Shear, and Track-Mounted Shear, they completed D&D of nine structures, removing them completely. The improved technologies allowed completion of these D&D projects over a year ahead of schedule with reduced radiation exposure, reduced cost, and increased safety. In one case, they tried to use a shear to size-reduce a large tank, but were unable to complete the task because of the large diameter and thick metal. The Oxy-Gasoline Torch cut the tank easily and quickly. The Track-Mounted Shear was used to demolish large structures quickly and efficiently. The Hand-Held shear completed jobs quickly and reduced airborne lead, improving safety.

In FY-99, ANL-E deployed the BROKK BM 250 remote demolition equipment during D&D of the CP-5 reactor bio-shield. Two BROKKs working in tandem assisted with the entire D&D process, from preparing the work area to jackhammering concrete to removing rubble and filling waste boxes. The bio-shield was made of high-density concrete and contained metal pieces that made removal difficult. The radiation fields were high, so using the BROKKs reduced radiation exposure significantly. In fact, it was hard for the engineers to imagine performing this D&D without the BROKKs, as the dose and cost would have been extremely high. In addition, the BROKKs reduced cost and schedule by working continuous shifts.

At the INEEL, 13 technologies were deployed from FY-98 to FY-00, each multiple times, in 25 different areas (buildings, structures, or outside locations). The areas cover a large range of structure types, including large concrete

Table 1. ASTD ID&D technology deployments and supplier information.

Technology	Description	Site	Date	Facility	Supplier
BROKK BM 250	A small, remote-controlled robot with a hydraulic boom extending 15 ft, to which multiple end effectors may be attached	INEEL ANL-E	5/99 to 9/99 4/9/99 to 7/2/99	STF CP-5	BROKK North American Sales, 144 Village Way, Monroe, WA 98272 Bill Barraugh, 800.621.7856, 360.794.1277, porbb@aol.com www.nasbrokk.com
DDROPS	A pre-planning tool that helps project managers optimize cutting and waste box packing	INEEL	4/99 to 5/99 4/99 to 9/15/99	STP ARMF/CFRMF	INEEL, P.O. Box 1625, MS 3710, Idaho Falls, ID 83415-3710 Dick Meservey, 208.526.1834 rhm@inel.gov
En-Vac Robotic Wall Scabbler	A remote-controlled grit-blasting scabbler that adheres to walls and sloped surfaces with vacuum suction	INEEL	3/17/00	TAN Hot Shop	En-Vac Robot Blasting Systems, (MHI Marine Engineering, Ltd.) 3003 NE 149th Ave., Portland, OR 97230 David A Cheramy, 503.256-5535, cheramy.mci@worldnet.att.net
Excel Modular System Scaffolding	Versatile OSHA approved scaffolding that snaps together so workers do not need to tighten clamps by hand or spend time leveling scaffolding	INEEL	4/99 to 5/99	STP	Excel Modular Scaffold and Leasing Corp., P.O. Box 1800 60 Industrial Park Road, Plymouth, MA 02360, James E Elkins, 800.625-7712 jimelkins@prodigy.net, www.excelscaffold.com
GammaCam™	Characterization device that imposes a visual display of radiation on a real-time black and white image of the area	INEEL	3/99 6/21/99 to 6/25/99	TAN Hot Shop U.S.S. Nimitz Not counted in deployment total because not at INEEL.	AIL Systems, 455 Commack Road, Deer Park, NY 11729 Al Henneborn, 800.944.1180 www.ail.com
Global Positioning Radiometric Scanner System (GPRS)	Radiological detection system mounted on a 4-wheel drive vehicle to rapidly survey large areas for radioactive contamination	INEEL	4/3/00 to 4/17/00 5/2/00 5/17/00 5/18/00 5/22/00 to 5/25/00 5/30/00 to 6/13/00 6/14/00 to 6/15/00 6/20/00 to 6/26/00 6/27/00 6/28/00 6/29/00 7/8/00 7//10/00 7/13/00 7/17/00 to 7/19/00 8/7/00 8/24/00 to 8/30/00 9/5/00 to 9/19/00	TAN INTEC INTEC INEEL Roads ARA I&II RWMC Road areas INTEC CFA INTEC ARA I & II TRA CFA TAN RWMC TRA TAN RWMC	TSA Systems, 1830 Boston Ave., Longmont, CO 80501 Charlie Schnurr, 303.651-6147, charlie@tsasystems.com
Hand-Held Shear	Self-powered shear for tight locations	FEMP	7/98 to 10/98	38A, 38B, 24B, 3F, 3G, 8F	Res-Q-Tek, 10405 G Baur Blvd, St. Louis, MO 63132 Andy Dzuryachko, 314.692.0065
Lead Paint Analyzer	Handheld device for real-time detection of metals in paint	INEEL	1/24/00 1/24/00 2/00 4/00	TAN Decon Shop TAN Hot Shop ETRC CPP 603 Wet and Dry Fuel Storage Facility	NITON Corporation, 900 Middlesex Turnpike, Building 8, Billerica, MA 01821 John Pesce, 800.875-1578, jpesce@niton.com, www.niton.com

Table 1. (continued).

Technology	Description	Site	Date	Facility	Supplier
			4/00	CFA Radiological Laboratory	
			5/00	MTR Canal	
Oxy-Gasoline Torch	A faster, less expensive tool for cutting carbon steel	INEEL	11/98 to 9/99	STP	Petrogen®, 103 Doolittle Drive, Suite 18, San Leandro, CA 94577 Milt Heft, 510.569-7877 www.petrogen.com
			1/99 to 9/99	STF	
			4/99 to 7/99	IET	
			6/99 to 9/30/99	ARA-I	
		FEMP	7/98 to 2/99	38A, 38B, 24B, 3F, 3G, 39C, 22A, 45B, 8F	
			7/26/99	TAN Hot Shop	
Paint Scaler	A handheld, battery-operated drill with chisel attachments for rapid sample collection	INEEL	12/15/99	TRA Gamma Building	Bosch, 120 Box Rd., Newborn, NC 28562 800.334-4151 www.boschtools.com
			2/00	ETRC	
			4/00	CPP 603 Wet and Dry Fuel Storage Facility	
Personal Ice Cooling System (PICS)	A suit with tubing through which ice-cold water is circulated by a battery-powered pump to cool workers wearing Personal Protective Equipment	INEEL	6/21/99 to 8/99	TAN PREPP	Delta Temax Inc., 320 Boundary Road, Pembroke, Ontario, Canada, K8A 6W5 Kirk Dobbs, 613.735.3996 www.dtica.com/
Soft-Sided Waste Containers	low-level waste containers that hold 3-4 times as much waste as a box and cost half as much; flexibility of the containers reduces landfill subsidence	INEEL	1/99 to 9/99	STP	Transport Plastics, Inc., P.O. Box 12, Sweetwater, TN, 37874 Al Beale, 800.603.8277
			2/99 to 9/99	ARA-I	
			2/99	NRF	
			6/99 to 8/99	STF	
Specro XEPOS XRF Analyzer (PCB Analyzer)	Bench-top characterization equipment that detects several elements in samples, including chlorine, a possible indicator of PCBs	INEEL	12/13/99	STP	ASOMA SPECTRO Analytical Instruments, 160 Authority Drive, Ftichburg, MA 01420 Meredith Daniel, 800.598-5809, mmdaniel@spectro-usa.com
			12/13/99	STP	
			12/15/99	TRA Gamma Building	
			1/26/00	IET	
			1/26/00	IET	
			2/00	ETRC	
			2/00	Old Fire Station	
			4/00	STF	
			4/00	STF	
Surveillance and Measurement System (SAMS)	A characterization device that provides real time radiation detection and isotopic information using a thallium-activated sodium iodide detector	INEEL	6/1/00 to 6/30/00	TAN	Berkeley Nucleonics Corp., 3060 Kerner Blvd., #2, San Rafael, CA 94901 John Lee, 415.453-9955, www.berkeleynucleonics.com
			7/1/00 to 7/26/00	TAN	
			7/1/00 to 7/26/00	ARA-II	
			7/26/00 to 8/2/00	ARA-II	
			8/2/00 to 8/10/00	ARA-II	
Track-Mounted Shear	Mobile demolition equipment	FEMP	7/98 to 2/99	38A, 38B, 24B, 3F, 3G	John Deere, Pemberton & Tiger Machinery Co., Inc., 11441 Mosteller Rd., Cincinnati, OH 45241 J.W. Kaperling, 513.772.3232, or Marty Prochaska, FEMP, 513.648.4089

buildings, reactor facilities, hot shops, canals, septic drain fields, and even roadsides. In total, the technologies were deployed 66 times. In some cases, one deployment consisted of using the equipment 200 times, to measure 200 samples. Characterization and sample collection technologies, including the Lead Paint Analyzer, Spectro XEPOS XRF analyzer (PCB analyzer), GammaCam™, GPRS, Paint Scaler, and Surveillance and Measurement System, provided real-time data about contaminants, avoiding long lead time and high-cost laboratory analyses. The BROKK remote demolition equipment removed overhead ducts and piping, avoiding the time-consuming, costly, and dangerous scaffolding work needed to lift the pipes down by hand. Where scaffolding was required, the Excel Modular System Scaffolding snapped together quickly and increased worker safety through the use of supplier provided ladders and platforms. Cutting carbon steel was done much more quickly and less expensively using the Oxy-Gasoline Torch. When in areas requiring Personal Protective Equipment (PPE), workers wore the Personal Ice Cooling System suits to prevent heat stress while extending stay times and increasing productivity. The DDROPS assisted with visulization and planning D&D work to optimize cutting and waste box packing and reduce radiation exposure. Lastly, the En-Vac robotic wall scabbler removed contaminants from concrete quickly and remotely, reducing exposure and cost. More details about all of the technologies are located in the individual technology sections of this report. Deploying the ID&D technologies at the INEEL resulted in significant cost savings, accelerated schedules, reduced radiation exposure, and increased safety.

New Technologies Became the Baseline

At all three sites, all but one of the improved technologies have been accepted by the D&D operations teams, and have become the new baseline. At FEMP, all three deployed technologies (Oxy-Gasoline torch, Hand-Held Shear, and Track-Mounted Shear) have become the new baseline. At ANL-E, the BROKK is now the preferred method for D&D work. At the INEEL, 12 of the technologies have become the new baseline and are now part of the D&D tool box. The En-Vac robotic wall scabbler was not purchased, but was borrowed from the supplier for the deployment, which is the only reason that it has not yet become part of the baseline at the INEEL. In becoming the baseline at the INEEL, these 12 technologies addressed and resolved (either partially or completely) 10 Site Technology Coordination Group (STCG) needs. STCG needs are documented areas where new technologies are needed to improve the way D&D work is done. The needs and the technologies that resolve these needs are presented in Table 2.

Through the information-sharing efforts of the project, six of the ASTD ID&D technologies have been deployed at other DOE sites. The further deployments are shown in Table 3. A follow-on ASTD project implemented by FEMP was responsible for many of the PICS subsequent deployments included in the table.

Table 2. INEEL STCG needs resolved by ASTD ID&D technologies.

Need Number	Need Title	Resolved	Technology
ID-7.2.03	Decontamination of Concrete Walls, Floors, Ceilings, and Corners.	Partially	BROKK
ID-7.2.06	Remote Characterization for Building Release, Large Area Surface Soil Characterization, and Characterization of Sumps, Debris, Underwater Areas, and Buried Pipes and Utilities	Partially	GammaCam™
ID-7.2.08	Robotics for D & D	Partially	BROKK
ID-7.2.15	Field Screening of Paint/Painted Surfaces to Identify Contamination such as PCBs, Lead, and other RCRA Metals in the Paint	Completely	Lead Paint Analyzer, PCB Analyzer
ID-7.2.16	Field Screening of Lead (shot, bricks, sheeting) for Radionuclide Contamination	Completely	Lead Paint Analyzer, PCB Analyzer
ID-7.2.17	Field Screening of Samples and Equipment Surfaces to Identify PCB Contamination	Completely	PCB Analyzer
ID-7.2.28	Remote Demolition of Concrete Structures	Completely	BROKK
ID-7.2.29	Remote Demolition of Machinery	Partially	Oxy-gasoline Torch
ID-7.2.30	Remote Demolition of Metal Structures	Partially	Oxy-gas Torch, BROKK
ID-7.2.31	Remote Demolition of Piping	Partially	Oxy-gas Torch, BROKK

Table 3. Subsequent deployments at other DOE sites.

Technology	Subsequent Deployment Sites
BROKK	Mound
DDROPS	Savannah River (FY-01), Rocky Flats (FY-01)
Soft-Sided Containers	Savannah River (FY-01), Rocky Flats (FY-01)
Oxy-Gasoline Torch	Portsmouth
Pipe Explorer[a]	Savannah River
Personal Ice Cooling System	Rocky Flats, Hanford, Pantex, Ashtabula, Portsmouth, Oak Ridge, Paducah, Nevada

a. Due to schedule changes, the Pipe Explorer was not deployed at the INEEL. Information was forwarded to Savannah River, which led to this deployment.

Cost Savings

The cost-benefit analyses were done using data collected during the deployments and performance information from the LSDDPs. They were done using innovative approaches to minimize data collection while maintaining high integrity data. For instance, on the Oxy-gas torch, fuel consumption was tracked and correlated to hours of use to estimate the associated cost savings, rather than keeping a log of the hours of use or number of cuts made. Scaffolding volume enclosed was used as a measure of cost savings rather than detailed tracking of which parts were used in each deployment. These innovative approaches to estimating cost savings allowed the project to focus its funding on deploying and tracking lots of technologies rather than deploying just a few with extensive data collection. In this way, the project could deploy as many technologies as possible in numerous locations with a large payback.

The cost-benefit analyses showed that the deployments resulted in significant cost reductions, saving an estimated $797K at the INEEL. Figure 1 shows how much the D&D work would have cost using the old baseline technologies, how much it cost using the ID&D technologies, and the difference, or savings to date from using the new technologies. A breakdown of the INEEL savings by technology is shown in Figure 2. Use of the improved technologies saved $201K at FEMP, and while it was difficult to quantify savings at ANL-E, because they could not imagine performing the work without the BROKKs, they believe that the savings were very significant. The cost savings, number of deployments, and number of deployment locations for each technology at the three sites are shown in Table 4. Combining the savings from the INEEL of $797K and FEMP savings of $201K, the project total savings to date is $998K. This cost savings estimate is conservative and does not include all savings such as increased safety, reduced radiation exposure, or accelerated schedule. Many of the technologies provided large benefits in these areas, but as these are difficult to quantify, the benefits were noted qualitatively. Observations about these benefits, as well as detailed cost-benefit analyses, are included in the individual technology sections of this report.

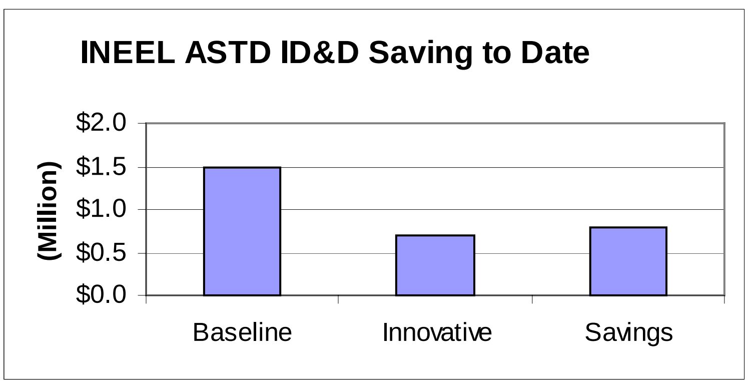

Figure 1. Total INEEL savings to date from using the ASTD ID&D technologies.

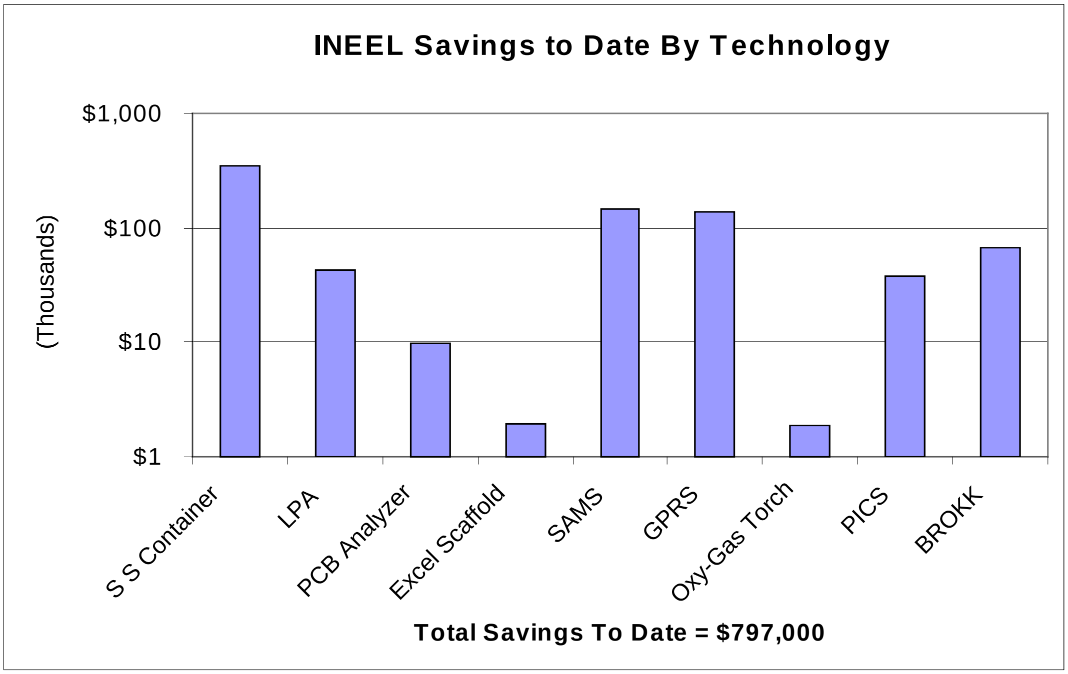

Figure 2. INEEL savings to date by technology.

Table 4. ASTD ID&D cost savings to date and estimated 10-year cost savings.

Technologies Deployed as Part of the ID&D Project	Number of Deployment Locations	Number of Deployments	Cost Savings To Date	Expected 10-Year Cost Savings
INEEL Deployments				
Soft-Sided Waste Containers	4	4	$353K	$2.1 million
Lead Paint Analyzer	6	6	$42.3K	$1.3 million
Spectro XEPOS XRF Analyzer (PCB Analyzer)	6	9	$9.8K	$490.5K
Excel Modular System Scaffolding	3	10	$2K	$672K
Paint Scaler	3	3	$0.3K	$19.9K
Surveillance and Monitoring System	2	5	$144.6K	$7.4 million
Global Positioning Radiometric Scanner	10	18	$138K	$2.1 million
En-Vac Robotic Wall Scabbler	1	1	—[a]	$205K
Oxy-Gasoline Torch	4	4	$2K	$229K
Gamma Cam™	1	2	—[b]	$90K
D&D Remediation Optimal Planning System	2	2	—[c]	$1.9 million
Personal Ice Cooling System	1	1	$38.3K	$3.8 million
BROKK BM 250	1	1	$67K	$5.3 million
TOTAL	25 different areas	66	$797.3K	$25.6 million
FEMP Deployments				
Oxy-Gasoline Torch	9	9	—[d]	—[e]

Table 4. (continued)

Technologies Deployed as Part of the ID&D Project	Number of Deployment Locations	Number of Deployments	Cost Savings To Date	Expected 10-Year Cost Savings
Hand-Held Shear	6	6	—[d]	—[e]
Track–Mounted shear	5	5	$201K	—[e]
TOTAL	9 structures	20	$201K	—[e]
<u>ANL-E Deployments</u>				
BROKK BM 250	1	1	—[f]	—[g]
TOTAL	1 structure	1	—[f]	—[g]

a. Due to the limited surface area of the deployment, the En-Vac did not show a significant cost savings during the deployment.

b. Due to the increased number of people involved in the Gamma Cam deployment, no cost savings was seen.

c. During the DDROPS deployment, DDROPS was used to compare manual planning and waste box packing (which was actually done) to DDROPS optimization, so the savings were theoretical, and not included in the cost savings totals.

d. Cost savings were not broken-down by technology at FEMP. The $201K includes savings from all three technologies.

e. D&D work at FEMP will be completed by 2006, so 10-year estimates are not possible.

f. The ANL-E team was unable to estimate the costs of doing the work without the BROKK, as the high radiation fields and high density concrete with embedded metal would have made the task prohibitive.

g. The BROKKs used at ANL-E were on loan, and have been returned, so continued use and 10-year estimates are not possible.

The team estimated the cost savings from using the improved technologies over the next 10 years at the INEEL. Use of the 13 ID&D technologies is expected to save $25.6M when performing D&D work at the INEEL over the next 10 years. Figure 3 shows how much the D&D work would have cost using the old baseline technologies, the estimated cost of doing the D&D work using the ID&D technologies, and the savings. The estimated 10-year cost savings are shown in Table 4 for each of the technologies deployed. Details of the 10-year estimated cost savings are included in the technology sections of this report.

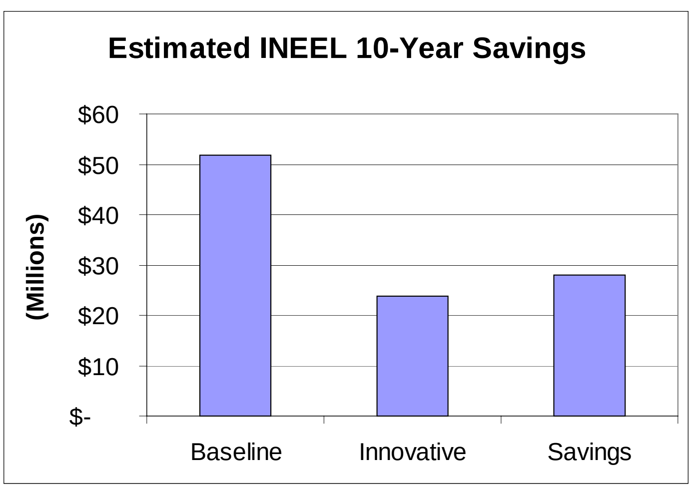

Figure 3. Estimated savings at the INEEL over the next 10 years from using the ASTD ID&D technologies.

About this Report

This cost and performance report was prepared using guidance provided by the Department of Energy Office of Environmental Management standard DOE/EM - 0302, “Documenting Cost and Performance for Environmental Remediation Projects,” dated August 8, 1996. The foundation for this guide was provided by the Federal Remediation Technologies Roundtable in their publication, Guide to Documenting Cost and Performance for Remediation Projects, EPA-542-B-95-002. Member agencies of the Roundtable include the U.S. Environmental Protection Agency (EPA), the U.S. Department of Defense, the U.S. DOE, and the U.S. Department of Interior.

The last section of this report discusses in detail the technologies deployed as part of this project. The technology sections are organized in a similar format to that of an Environmental Remediation Project Cost and Performance Report covering the following subjects:

Technology Description
Performance
Cost-benefit Analysis
Regulatory and Policy Issues
Observations and Lessons Learned
References

Fact sheets on each technology are contained in Appendix A, and fact sheets on the overall project are presented in Appendix B. These sheets are also located on the ASTD ID&D home page (http://id.inel.gov/idd/).

ACKNOWLEDGMENTS AND CONTACTS

We would like to extend our sincere thanks to Harold Shoemaker and Chelsea Hubbard for their significant programmatic guidance and support throughout this project. In addition, we would like to thank all of the team members at Fernald Environmental Management Project, Argonne National Laboratory – East, and the Idaho National Engineering and Environmental Laboratory who, through their contributions, made this project such a success.

ASTD ID&D contacts.

Location	Contact Name	Phone	E-Mail
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DOE-ID	Chelsea Hubbard	208.526.0645	hubbarcd@inel.gov
INEEL	Dick Meservey	208.526.1834	rhm@inel.gov
	Ann Marie Phillips	208.526.6877	aqs@inel.gov
	Julia Tripp	208.526.3876	jtri@inel.gov
FEMP	Larry Stebbins	513.648.4785	lawrence.stebbins@fernald.gov
	Marty Prochaska	513.648.4089	marty.prochaska@fernald.gov
ANL-E	Ed Wiese	630.252.7983	ewiese@anl.gov

The Internet addresses of the participants are listed below:

- ANL-E http://www.anl.gov
- INEEL http://www.inel.gov
- FEMP http://www.fernald.gov
- NETL http://www.netl.doe.gov

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FIGURES

TABLES

ACRONYMS

ALARA	As Low As Reasonably Achievable
ANL-E	Argonne National Laboratory-East
ARA	Auxiliary Reactor Area
ARMF	Advanced Reactivity Measurement Facility
ASTD	Accelerated Site Technology Deployment
CFA	Central Facilities Area
CFR	Code of Federal Regulations
CFRMF	Coupled Fast Reactivity Measurement Facility
CP-5	Chicago Pile 5
CPP	Chemical Processing Plant
DDROPS	Decontamination, Decommissioning, and Remediation Optimal Planning System
DOE	Department of Energy
D&D	decontamination and decommissioning
EC	estimated cost
EMIP	Environmental Management Integrated Plan
EPA	Environmental Protection Agency
ETRC	Engineering Test Reactor Complex
FEMP	Fernald Environmental Management Project
G&A	General and Administrative
GPRS	Global Positioning Radiometric Scanner
ID&D	Integrated Decontamination and Decommissioning
IET	Initial Engine Test (Facility)
IHSO	Industrial Hygiene/Safety Officer
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center

ITSR	Innovative Technology Summary Report
JSS	Job Site Supervisor
LLW	Low-Level Waste
LSDDP	Large-Scale Demonstration and Deployment Project
MTR	Materials Test Reactor
NEPA	National Environmental Protection Act
NETL	National Energy Technology Laboratory
NRF	Naval Reactors Facility
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
PICS	Personal Ice Cooling System
PIF	Performance Indicator Factor
PPE	personal protective equipment
PREPP	Process Experimental Pilot Plant
RCT	radiation control technician
RWMC	Radioactive Waste Management Complex
SAMS	Surveillance and Measurement System
STF	Security Training Facility
STP	Sewage Treatment Plant
TAN	Test Area North
TC	total cost
TMI	Three Mile Island
TRA	Test Reactor Area
XRF	X-ray fluorescence

Accelerated Site Technology Deployment Integrated Decontamination and Decommissioning Final Cost and Performance Report

The overall goal of the Accelerated Site Technology Deployment (ASTD) Integrated Decontamination and Decommissioning (ID&D) project was to encourage the widespread use of innovative, but proven, commercially available technologies in D&D operations at Department of Energy (DOE) sites. The technologies were aimed at improving safety, accelerating schedules, and reducing radiation dose, waste volume, and cost. The ASTD ID&D project team consisted of three DOE sites: Idaho National Engineering and Environmental Laboratory (INEEL), Fernald Environmental Management Project (FEMP), and Argonne National Laboratory-East (ANL-E). Funding and guidance from the National Energy Technology Laboratory (NETL) through the ASTD Program enabled these deployments and was key to the success of the project.

At all three DOE sites, the ASTD ID&D project assisted D&D Operations with the selection, procurement, training, and deployment of proven, innovative technologies. Technologies were selected carefully to be sure that they provided a large benefit for a small investment. To do this, the team chose the best technologies from the Large-Scale Demonstration and Deployment Projects (LSDDPs) that met identified D&D Operations needs. The technologies needed to provide significant improvements in cost, safety, radiation exposure, waste volume, or schedule and be widely applicable throughout the DOE complex.

TECHNOLOGY DESCRIPTIONS, PERFORMANCE, COST ISSUES AND LESSONS LEARNED

This section of this report discusses in detail the technologies deployed as part of this project. The technology sections are organized in a similar format to that of an Environmental Remediation Project Cost and Performance Report covering the following subjects:

- Technology Description
- Performance
- Cost-benefit Analysis
- Regulatory and Policy Issues
- Observations and Lessons Learned
- References.

Fact sheets on each technology are contained in Appendix A, and fact sheets on the overall project are presented in Appendix B. These sheets are also located on the ASTD ID&D home page (http://id.inel.gov/idd/).

BROKK BM250—Remote Demolition Equipment

Technology Description

D&D Projects typically encounter a significant amount of process piping and miscellaneous steel on the interior of contaminated facilities during dismantlement operations. The DOE baseline technologies to dismantle this process piping and miscellaneous steel are hand-held power tools (reciprocating saws, band saws, etc.) and personnel access and support systems (ladders, scaffolding, man-lifts, etc.).

The BROKK BM250, developed by Holmhed Systems AB in Skelleftea, Sweden, is a remote-controlled concrete demolition system that replaces hand-held equipment like jackhammers (Figure 1). It consists of a revolving table, capable of continuous rotation, mounted on a tractor-like base. Extending from the table is a three-part hydraulic arm, to which a variety of end effectors can be attached. The INEEL owns a La Bounty Shear, BROKK Hammer, Rammer Shear/Crusher, BROKK Rotating Grapple, BROKK Loader Bucket, McDonnell Scabbler, and Pentek Squirrel II Scabbler. The Pentek Scabbler, which contains a vacuum for dust control, was designed for manual use, but has been adapted by the INEEL to fit the BROKK. Solid rubber wheels mobilize the robot, and hydraulic outriggers extend beyond the tires to add stability during operation.

The BROKK BM250 can be manipulated from as far away as 200 ft using a tether remote control system, or 400 ft using a radio remote control system. The control unit is strapped around the operator's waist. On its face are a variety of buttons and dials and two levers that control operation of the robot.

Figure 1. BROKK BM250 Remote-Controlled Concrete Demolition System was deployed with a variety of attachments.

The BROKK BM250 Technical Data includes:

- Weight – 6,750 lb
- Min. Width – 47.6 in.
- Min. Height – 69.3 in
- Motor Output – 22 kW
- Max. Attachment Weight – 660 lb
- Arm Length – 15 ft

The BROKK BM250 has many advantages over baseline technologies because the remote control system removes the worker from the potentially hazardous dismantlement field conditions typically encountered during D&D operations. Some of the main advantages are as follows:

- It is operated by remote control, allowing the operator to be positioned at a safe distance from high radiation areas and other hazardous conditions.

- It is powered by a 440-volt, 3-phase motor, eliminating problems of exhaust fumes in containment areas.

- It is useful for a wide range of tasks in various work conditions from breaking, removing, and loading concrete debris to removing radioactive waste from high radiation areas.

- Working time is less than half that of most manual tools, significantly reducing cost, schedule, and worker radiation exposure.

- Cost savings are achieved through increased rate of work, longer work shifts, reduced radiation exposure, reduced personal protective equipment (PPE) costs, and mortgage reduction from accelerated schedules.

Performance

D&D Operations can use the BROKK BM250 equipment for numerous work tasks, ranging from demolishing concrete to cutting piping to scabbling concrete. By using a variety of end effectors, the BROKK BM250 has the flexibility to perform a large variety of work tasks. Possible end effectors for the BROKK BM250 equipment and their work task applications are listed in Table 1.

Table 1. BROKK BM250 end effectors and their use.

End Effector	Description	Use
Hammer	Hydraulic Impact Hammer	Concrete Demolition – Fractures concrete matrix
Shear	Hydraulic Shear	Steel Demolition – Cuts and shears metal (piping, miscellaneous steel)
Crusher	Hydraulic Crusher	Concrete/Steel Demolition – Non-cutting jaws smash/crush concrete/steel/metal
Grapple	Hydraulic Grapple – Opposing jaws	General – Grapple for material handling operations
Bucket	Hydraulic Bucket	General – Bucket for material handling operations
Scabbler	Hydraulic Impact Scabbler	Concrete Decontamination – Removes contaminated areas of concrete surface

The BROKK BM250 also offers the additional safety afforded by the operator being removed from the immediate work area, thus avoiding potential hazards from the demolition dust and debris as well as reduction in dose rates due to distance. In D&D Operations that are in higher radiation field areas, it is important to keep worker dose rates “As Low As Reasonably Achievable” (ALARA). Additionally, the BROKK BM250 helps reduce worker fatigue, heat stress, and exposure while performing demolition work tasks in a radiologically contaminated area.

The commercial demolition and commercial nuclear industry are using the BROKK equipment with the impact hammer as the main end effector for concrete demolition (mainly BROKK BM250s and BM330s). The BROKK BM250 was used on the Janus Reactor D&D Project in 1997, the Washington Public Power Service D&D Project from 1997 to 1999, and numerous other D&D projects in the United

States. As the BROKK remote demolition equipment gains acceptance in the demolition and nuclear industry as a baseline technology, the D&D Operations personnel find more uses and applications for the BROKK equipment and end effectors.

Performance at the INEEL ASTD. The BROKK BM250 was deployed at the INEEL's Security Training Facility (STF) in June and July of 1999. Piping covering an entire wall in the building was cut with a La Bounty MSD-7R Shear attachment that was purchased by the D&D Operations Department (Figure 2). In addition, the BROKK Hammer made two holes through cast iron and concrete plates in the facility's basement that workers could not have made with a jackhammer or cutting torch. The INEEL expects a wide variety of other deployments on its upcoming D&D projects. Cost savings for the BROKK BM250 are being calculated on a per-job basis, because of the variety of its capabilities. In just 2 months, the BROKK BM250 saved approximately $67K at STF.

Before deployment, the INEEL's BROKK BM250 was sent to the BROKK North American Sales maintenance shop to be retrofitted. The retrofit included fixing the brake problem identified by BROKK manufacturing and installing the new radio remote control system (the first radio remote control system for a BROKK in the United States). Through the ASTD ID&D, two INEEL maintenance personnel traveled to the BROKK shop to observe the modifications and obtain training for maintaining the BROKK.

BROKK obtained Federal Communication Committee approval for their radio remote control in February 1999. The cost of the retrofit, including conversion of the unit from an analog to a digital control system, was included in the cost of the radio remote control ($7,500).

In addition, through the ASTD ID&D, BROKK personnel provided operator training at the INEEL before the deployment.

Figure 2. The BROKK BM250 was used to cut piping at the INEEL STF.

Performance at ANL-E ASTD. Crews used two BROKK BM250s during D&D of the Chicago Pile 5 (CP-5) reactor (Figure 3). This working arrangement was unique in that this was a joint effort by ANL-E and a subcontractor, NSC Energy Services/Duke Engineering, which was hired to perform the D&D work scope. The ANL-E project used a U.S. Government-owned BROKK BM250 and the subcontractor purchased the other BROKK BM250. At the end of this deployment, the U.S. Government-owned BROKK BM250 was decontaminated. The subcontractor will decontaminate their BROKK BM250 and move it to another D&D Project, probably the K-1420 D&D Project at the East Tennessee Technology Park, formally known as the K-25 Site located just west of Oak Ridge, Tennessee.

The BROKK BM250s operated with two types of attachments—a hydraulic hammer and a bucket. Operators used the hammer to break the high-density concrete bio-shield of the research reactor and the bucket to load debris into waste containers. The walls of the bio-shield, constructed of high-density concrete with metal stampings as the main aggregate component, were 4–5 ft thick and 15 ft high. Numerous pipes and passages ran through the concrete into the reactor. Radiation levels around the reactor reached 7 rem/hour, and the bio-shield material had readings up to 25 rem/hour on contact. Ed Wiese, project engineer at ANL-E, indicated that with these radiation levels, doing the work without the BROKK BM250s would have resulted in large personnel dose rates.

Figure 3. BROKK BM250s were used to remove the CP-5 bioshield at ANL-E.

ANL-E workers used a remote control with a multi-wire tether to control each BROKK BM250. The two machines worked in tandem on continuous shifts. A typical operator position was to the side and back of the machine, approximately 8 to 10 ft from the point of work. The BROKK BM250s were successful in accelerating the schedule and reducing the cost of this D&D work.

Cost-benefit

The BROKK BM250 remote demolition equipment was used with two attachments at the INEEL's STF. The hammer was used to break two 2- to 3-ft holes in the floor to create negative airflow during asbestos removal in the sub-basement. The floor was concrete with an unexpected cast iron plate in it. It took only 15 minutes to set up the hammer and 1 hour for two operators to make the required hole. It is difficult to compare this activity with a baseline as the workers were not sure how they would have been able to make the hole through the cast iron plate, since a handheld jackhammer and torch would not have been able to do it.

The shear was used to remove piping from the walls and drop it on the floor to clear the way for an asbestos-covered duct above the piping. A crew of two people worked for 3 days at this activity. In addition, it was used for one day to remove some ventilation system ducting. During baseline operations, a crew of at least four people would have used hand tools to cut and lower the pipe and ducting to the floor. Scaffolding would have been needed for the job also. The Job Site Supervisor (JSS) indicated that the job went at least 10 times faster using the BROKK shear. It also greatly increased worker safety, as personnel did not have to be in areas where pipes fell during removal.

This cost-benefit analysis is based only on the INEEL shear deployment.

Innovative Technology Assumptions

- The INEEL purchased a BROKK BM250 and impact hammer for $118,372 ($104,750 robot & hammer + $7,500 radio control + $900 cable + $3,722 spares + $1,500 shipping).
- A La Bounty MSD-7R shear was purchased for attachment to the BROKK BM250 for $18,000.
- 27% General and Administrative (G&A), 5.3% Material Handling and 4.5% Performance Indicator Factor (PIF) are added to all base equipment costs.
- Service Life 15 years (N), used 1,000 hours per year (based on manufacturer's recommendation and D&D Project Manager's estimates).
- 5.8% interest rate (I).
- Vendor quoted maintenance cost of $10/hr.
- Labor rates include all adders. Labor times gathered by ASTD project personnel from the D&D workers.

Innovative Equipment Cost

The overall purchase cost (P) is $ (118,372 + 18,000)* 1.27 * 1.053 * 1.045 = $190,578

X $/yr = $P (\{1-(1+I)/[1-(1+I)^{N}]\} + I)$

X = $190,578 $\{(1-1.058)/[1-(1.058)^{15}] + 0.058\}$

X = $190,578* 0.102

X = $19,367/year or ($19,367/yr)/1,000 hr/yr = $19.37/hour

EC = $(setup time + work time)* $19.37 + maintenance costs

EC = $(60 hrs training + 40 hrs work)*$19.37 + $10/hr (40 hrs work)

EC = $2,337

Innovative Labor Cost

Time to set up shear – and locate it – 1.5 hours – 2 operators @ $45.50/hr = $137

Training – 2 operators for 60 hrs @ $45.50/hr = $5,460

One JSS for 4 days for 1 hr/day for briefings ($65.44/hr) = $262

Two operators @ $45.50/hr for 4 days including job briefings = $364

Total Innovative Deployment Cost

Total Costs	=	EC + training cost + setup cost + work cost
TC	=	$2,337 + $137 + $5,460 + $262 + $364
TC	=	$8,560

Baseline Assumptions

- Labor rates include all adders.
- Set up time is minimal.
- Job performance is 10 times longer than that of the BROKK BM250 with four operators based on JSS's comments.

Baseline Equipment Costs

Baseline is to use shears or cut-off saws (chop-saws, band saws and other hand-held tools) and scaffolding. Assume the cost of equipment use is negligible.

Baseline Labor Costs

Job will take estimated 40 days with a crew of 4 people at $45.50/hr

JSS for 40 days at 1 hr/day for briefings @ $65.44/hr

Baseline Total Costs

Total Costs	=	EC + (4 people*40 days*10 hrs/day * $45.50/hr) + (40 hrs * $65.44/hr)
TC	=	0 + $72,800 + $2,618
TC	=	**$75,418**

Cost Saving Of INEEL STF Deployment

Savings = $75,418 - $8,560 = **$66,858**

The production rates and unit costs are based upon the piping quantities involved in the demolition efforts. Assuming 12 runs of 80-foot long 4 in. (or less) diameter piping for a wall area of 960 linear ft (lf) yields the following unit rates and production rates which are summarized in Table 2.

BROKK Unit Rate	==> $ 8,560/960 lf =		$ 8.92/lf
BROKK UR w/o Training	==> $ 3,100/960 lf =		$ 3.23/lf
Manual Unit Rate	==> $75,418/960 lf =		$78.56/lf
BROKK Production Rate	==> 960 lf/ 207 hrs	=	4.638 lf/hr
BROKK PR w/o Training	==> 960 lf/ 87 hrs	=	11.034 lf/hr
Manual Production Rate	==> 960 lf/1,640 hrs	=	0.585 lf/hr

Table 2. BROKK BM250 with hydraulic shear unit rates vs. baseline technology.

Innovative Technology			Baseline Technology		
Cost Element	Unit Cost	Production Rate	Cost Element	Unit Cost	Production Rate
BROKK	\$3.23/lf	11.034 lf/hr	Manual	\$78.56/lf	0.585 lf/hr

These Unit Costs and Production Rates are comparable to those found during the use of the BROKK BM250 with impact hammer during the CP-5 LSDDP work in Building 202 for the demolition of the concrete reactor pedestal and shield walls in August/September 1997. Table 3 is taken from Section 5 of the Innovative Technology Summary Report (ITSR) on the BROKK. This work scope was performed by Afftrex, Inc. According to the Afftrex job-site superintendent, Thomas Curry, the BROKK BM250 remote demolition equipment saved the job for Afftrex since the concrete was so hard that conventional jackhammers would not break up the concrete and the BROKK BM250 was the only equipment small enough to fit through the access portals.

Table 3. Summary of BROKK and manual unit costs and production rates observed during LSDDP.

Innovative Technology			Baseline Technology		
Cost Element	Unit Cost	Production Rate	Cost Element	Unit Cost	Production Rate
Remote Demolition	\$17.10/ft^3	11.4 ft^3/hr	Manual Demolition	\$254.87/ft^3.	0.63 ft^3/hr

Approximately 50 facilities and 13 other structures are scheduled for D&D at the INEEL over the next 10 years, with an estimated cost of over \$113 million. The INEEL Inactive Sites Department recently used a study of the recent 5-year period of actual costs to come up with percentages typical for D&D projects. The 5-year period study indicated that 49% of D&D Project cost were related to physical work. It is assumed that only 10% of the D&D physical work would use the BROKK BM250 for deployment activities such as removal of piping, cable trays, process equipment, miscellaneous steel, and other interior architectural items. The cost-benefit analysis indicated a unit cost saving for the BROKK BM250 is \$3.23/lf vs. \$78.56/lf of piping removed or 95.9% cost savings. When applied to the 10% of physical work the projected cost savings would be \$5,313,000.

- \$113,110,000 × 0.49 = \$55,410,000 physical work to be performed
- \$55,410,000 × 0.10 = \$5,541,000 baseline cost of work to be performed with BROKK
- (78.56 – 3.23) / 78.56 = 0.958
- \$5,541,000 × 0.958 = **\$5,313,000 (BROKK Estimated 10-year Savings)**

Regulatory and Policy Issues

Proper training for the equipment operators is a must to ensure the correct use of the equipment and safety of the operators and co-workers. The remote control system takes some practice to get used to due to its inherent sensitivity and the response time of the electro-hydraulic equipment. Proper maintenance and servicing are also necessary to keep the BROKK equipment operating at peak performance. Operator and maintenance training should be provided by BROKK certified training representatives.

There are no known regulatory restrictions associated with use of the BROKK remote controlled demolition equipment other than the standard federal regulations on worker protection and equipment safety found in the Occupational Safety and Health Administration (OSHA) Code of Federal Regulations (CFR). These specific OSHA regulations are listed below:

OSHA 29 CFR 1926		OSHA 29 CFR 1910	
1926.300-.307	Tools – Hand and Power	1910.211-.219	Machinery & Machine Guarding
1926.400-.449	Electrical – Definitions	1910.241-.244	Hand & Portable Power Tools
1926.28	Personal Protective Equipment	1910.301-.399	Electrical Definitions
1926.52	Occupational Noise Exposure	1910.95	Occupational Noise Exposure
1926.102	Eye and Face Protection	1910.132	General Requirements (PPE)
1926.103	Respiratory Protection	1910.133	Eye and Face Protection

Observations and Lessons Learned

- Operator feedback on the BROKK BM250 has been extremely positive. Operators like the increased productivity, the increased safety that results from being further from the work area, and the power available to such a compact electro-hydraulic unit.

- Cable management must be considered whenever the BROKK BM250 is used. Even when operating with the radio remote control, the equipment is connected to its power cord, which must be managed to prevent damage to the cable.

- One interesting method for removing cabling was to grasp the end of the cable, then rotate the end effector continuously, wrapping the cable around the arm as it is removed. The end result is a neat pile of cable and a quick removal.

- When changing end effectors, it is necessary to place the end effectors up off the ground to facilitate re-connecting them to the BROKK. This is required to allow the quick coupling device to engage.

- Oak Ridge National Laboratory and the INEEL Robotics Cross-Cutting Group developed and installed a Universal Control console and cameras for remote operation on the BROKK BM250 in FY-00.

References

Innovative Technology Summary Report, April 1998, *Remote Control Concrete Demolition System*, Chicago Pile 5 (CP-5) Research Reactor, LSDDP.

Innovative Technology Summary Report, August 2000, *Modified BROKK Demolition Machine with Remote Console*, Idaho National Engineering and Environmental Laboratory, LSDDP.

Decontamination, Decommissioning, and Remediation Optimal Planning System

Technology Description

The baseline technology used for the packaging of low-level waste (LLW) into specified waste containers has been manual labor and personnel packing capabilities. Since this operation depends upon individual packing capabilities (space, dimensional, and configuration capabilities), the packing results are as varied as are the individuals performing the task. Specifically, unless the personnel have many years of experience in packaging LLW and the various waste types (piping, structural steel, miscellaneous steel, concrete debris, and miscellaneous building debris) waste container void volumes will be unacceptably high. The main goal for waste packaging is void volume minimization (i.e., bury less air and more waste). This is especially true for hard-sided LLW containers made of steel or wood. These shapes are not conducive to void volume reduction and retain their shape no matter what is placed inside. In addition, the radiation fields when packing LLW sometimes result in faster packing, without as much consideration for void space.

To efficiently cut and package contaminated waste generated from dismantling a facility, engineers and programmers at the INEEL have developed a special computer interface known as the Decontamination, Decommissioning, and Remediation Optimal Planning System (DDROPS) (Figure 4). DDROPS provides an optimized size reduction and packaging plan for tanks, piping, and other dismantled equipment. From facility drawings, photographs, and video images, engineers create a three-dimensional model using ProEngineer, a commercial software. This 3-D model can be made to visualize the area with colors representing different characteristics for individual components within the structure, such as the level of radiation or the material composition. Next, the optimal number and location of cuts (with respect to length, mass properties, and radiation) is determined using an optimization program. This system also shows how to package segmented items into waste containers and provides a detailed inventory of the waste box contents (materials and waste stream identification). Modeling, cutting, and packaging can all be videotaped for later viewing. The INEEL has been awarded a patent on the DDROPS system.

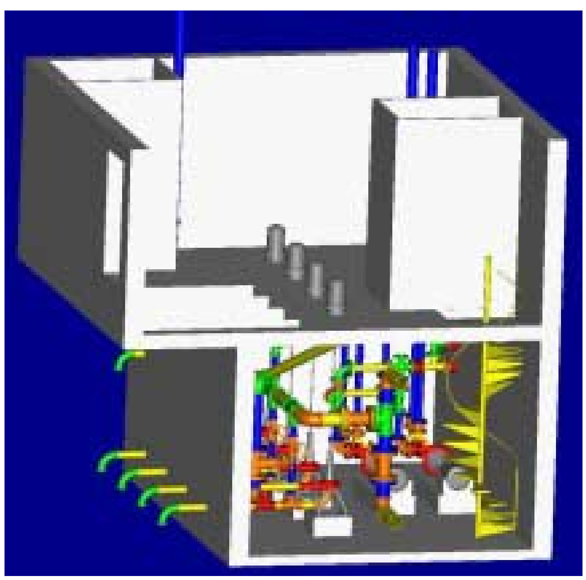

Figure 4. DDROPS creates a 3-D model of a facility, then optimizes cutting and waste packaging operations.

DDROPS helps train operators by providing a preview of their job so they can better plan and perform D&D work. It determines packaging routines, resulting in improved packing densities and reduced waste volumes (Figure 5). As a result, disposal costs are reduced and less storage space is filled. This tool can also reduce the risk of radiation exposure to workers. By knowing where to cut before entering the job site and where the "hot spots" are, workers don't have to estimate or guess where to cut, minimizing the cuts made and reducing time spent in the contaminated area. Having a detailed inventory of the waste containers' contents is also a great benefit to the waste disposal site.

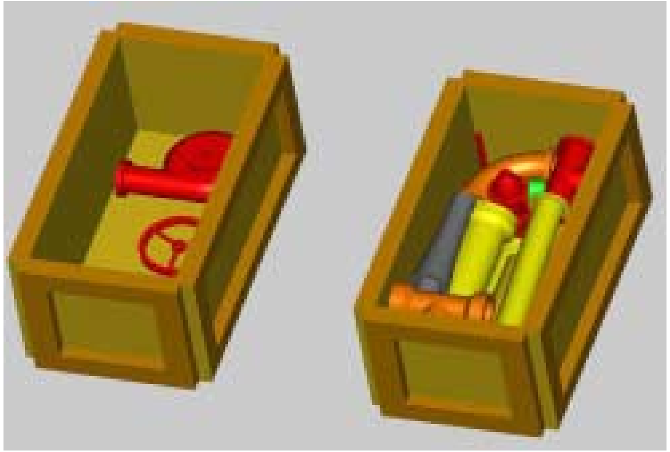

Figure 5. DDROPS can be used to reduce the number of waste boxes required by eliminating void volumes.

Performance

Workers have deployed DDROPS at the Test Reactor Area (TRA) 660 Advanced Reactivity Measurement Facility/Coupled Fast Reactivity Measurement Facility (ARMF/CFRMF). With the model created by DDROPS, operators determined a better procedure for removing a reactor inside this facility (Figure 6). Instead of cutting up the reactor while it's under water, they will remove it whole before segmenting. From the model, engineers calculated the location of the center of gravity and the best place to attach lifting brackets required for reactor removal. The program provides animation showing removal so workers can easily visualize cutting and packaging. D&D managers plan to use DDROPS for subsequent D&D projects.

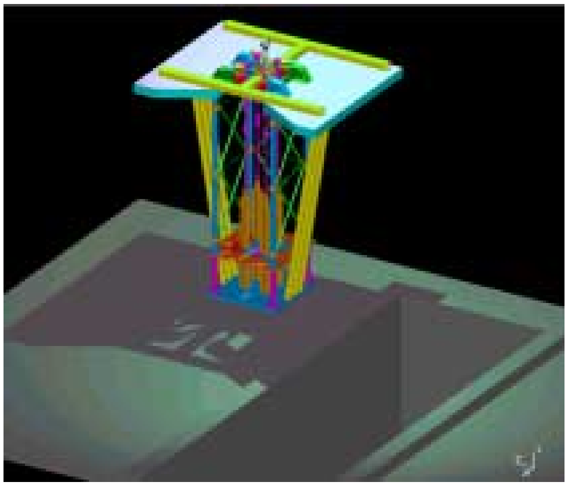

Figure 6. DDROPS was used to model the ARMF to determine lifting and cutting procedures.

The DDROPS was also used at the Sewage Treatment Plant (STP) D&D Project. It optimized the segmentation of process piping located in the basement and packaging the waste into the LLW containers (INEEL baseline technology is $4 \times 4 \times 8$-ft wooden or metal boxes that are certified as being "Strong-Tight"). The INEEL STP D&D Project workers performed this segmentation and waste packaging as they normally would under baseline conditions. The final result of their packaging efforts was compared to those that were projected/calculated by the DDROPS. DDROPS projections indicated that about 1.6 waste boxes would be required to hold the material removed from this room. Six boxes were actually used to hold this waste. This shows the tremendous potential for waste volume reduction through the use of the DDROPS.

The DDROPS has many potential applications in the field of D&D. It could be applied in any packaging operation involving workers trying to maximize waste container utilization and reduce void volumes. It would be especially applicable in projects where radiation fields are significant. A secondary application would be the 3-D imaging of an existing facility configuration during the characterization phase of a D&D project. The National Environmental Protection Act (NEPA) requires use of the National Historical Preservation Act and includes a review of the facility and its history before alteration and/or demolition. This determines if the facility is a "National Historically Significant Facility" and should be preserved and/or properly documented before demolition. The 3-D imaging system could be used to develop a 3-D model of the entire facility in its operational configuration to provide for historical preservation information. Once this is completed, the facility could be demolished or the contaminated facility could be decontaminated to allow public access, thus reducing costs to the DOE.

Cost-benefit

The cost-benefit analysis for the DDROPS is based upon the cost savings associated with LLW volume reduction that could have been achieved at the STP D&D Project (projected/calculated LLW containers vs. actual quantities of LLW containers). DDROPS was used to create a 3-D model of building CF-691. The model was created in Pro-Engineer using blueprints of the facility. It shows all of the piping, pumps, valves, tanks, and other possibly contaminated materials in the facility. The DDROPS cutting optimization program was then used to determine the optimal cutting/segmentation locations in the existing piping. The resulting "cut pieces" were then virtually packaged into waste boxes. Between one and two $4 \times 4 \times 8$-ft virtual waste boxes (144 ft^3) were required to contain the material in CF-691. The CF-691 facility was dismantled with normal D&D operational techniques (without the benefit of the optimal cutting locations). The dismantlement resulted in filling between five and six $4 \times 4 \times 8$ ft waste boxes (700 ft^3). This indicates potential savings of four to five waste boxes (556 ft^3) at a cost of approximately $700 each for a $3,500 saving. In addition, although at the INEEL the cost of LLW disposal is not charged to the D&D projects, at commercial sites the cost ranges from \$100/ft^3 to \$700/ft^3. The potential savings for a 556/ft^3 waste reduction is between $56K and $389K.

The 10-year INEEL Environmental Management Integrated Plan (EMIP) D&D Parametric Model projected the waste streams for Radioactive Waste Management Complex (RWMC) LLW at approximately 337,000 ft^3. It was initially assumed that 20% of this RWMC LLW would use the DDROPS for deployment activities. This initial engineering estimate was revised to reflect the lower use of B25 containers and higher use of specialized packaging for this waste stream. Therefore, the volume of RWMC LLW where DDROPS is estimated to apply is 7% of the total, or 23,590 ft^3. The cost-benefit analysis indicated that using DDROPS resulted in filling three boxes, rather than eight boxes using the baseline method, or a volume reduction of 5/8. With a unit disposal cost of \$129.26/ft^3, the baseline cost to dispose of 23,950 ft^3 would be $3,049,000. A volume reduction of 5/8 based on using the DDROPS would result in a projected cost savings of $1,906,000.

- $337{,}000 \times 0.07 = 23{,}590 \text{ ft}^3$
- $23{,}590 \times \$129.26 = \$3{,}049{,}000$ (baseline cost)
- $\$3{,}049{,}000 \times 5/8 = \$1{,}906{,}000$ (DDROPS estimated 10-year savings)

Regulatory and Policy Issues

There are no known regulatory issues associated with a computerized 3-D modeling and data system, specifically the INEEL DDROPS.

Observations and Lessons Learned

During the ASTD ID&D project, the 3-D models of the facilities were created based on 2-D drawings and photographs of the facilities. This process was fairly time-consuming, increasing costs and delaying the usefulness of the planning tool. In the future, using an automated system such as photogrammetry to create the 3-D model of the facility is recommended. With a system such as this, where still and/or video photography is processed by a computer to create a 3-D model, model input time would be reduced, increasing the cost-effectiveness of the DDROPS system.

References

INEEL, 1999, Environmental Management Integrated Plan (EMIP) D&D Parametric Model, Excel spreadsheet of the D&D Operations Department.

En-Vac Robotic Wall Scabbler

Technology Description

Most of the facilities at the INEEL scheduled for D&D contain concrete structures: walls, floors, pools, reactor shielding, etc. Some of the concrete surfaces are contaminated with hazardous constituents or radioactive materials. Workers must remove such contamination before they can demolish a structure. They typically use hand-held scabbling devices for this purpose.

A remote method of scabbling improves worker safety by reducing exposure to the dangers of radiation and/or hazardous chemicals. The En-Vac decontamination robot uses the power of vacuum suction to adhere to a surface as it moves across, scabbling contaminated concrete or metal by means of abrasive steel grit blasting (Figure 7). Also included in the En-Vac system is a filter that removes contaminated debris and a recycling unit that circulates grit back through the system. The robotic unit is able to remove 1/8 in. of the surface with each pass. Curved surfaces, floors, and slopes can also be scabbled by the En-Vac robotic system. Corners and other obstructed areas, however, require additional tools.

Advantages of the En-Vac Robot include:

- Speed—the En-Vac is up to 5 times faster than hand scabblers
- Less worker exposure
- Less contamination spread
- Collection and containment of scabbled debris.
- Improve worker safety by removing them from the hands-on repetitive/vibrating task of scabbling.

Figure 7. En-Vac Robotic Wall Scabbler.

Performance

The En-Vac Robot was demonstrated through the LSDDP in March 2000 at the INEEL. The En-Vac was used at Test Area North (TAN) to remove polychlorinated biphenyls (PCBs), lead, and radioactively contaminated paint and concrete from the walls of the TAN-607 Decontamination (Decon) Shop (Figure 8).

Immediately following this demonstration, workers deployed the En-Vac at the same location. The robot made one pass on a painted concrete floor measuring 1,984 ft^2, a job that took 5.7 hours to complete. Overall, the innovative technology is up to five times faster than the baseline methods of hand scabbling. The En-Vac Robot significantly reduces airborne contamination, improves worker safety by lessening exposure, and accelerates schedules.

Figure 8. Robotic Wall Scabbler on the TAN Decon Shop wall.

Cost-benefit

This cost-benefit calculation is based on the deployment of the En-Vac at TAN-607. Cost savings information is based on calculations in the ITSR.

Due to the high cost of the innovative equipment and its mobilization and demobilization, the baseline method is actually more cost effective for small jobs. Since the deployment of En-Vac at the INEEL involved only 1,984 ft^2, no savings were realized. The En-Vac begins saving expense for scabbling jobs of 10,000 ft^2 or more, with an average wall size of 600 ft^2. For jobs of 1,500 ft^2—with average walls sizes between 60 and 600 ft^2—the cost of the En-Vac and the baseline are approximately equal. On 10,000-square-foot jobs, the cost of using the innovative technology becomes about $51,207 less than that of using hand scabblers, which equates to $5.12 per square foot. Despite being significantly more expensive than the baseline, the En-Vac operates at a much higher production rate—23 ft^2/hr versus

15 ft^2/hr for obstructed areas, and 146 ft^2/hr versus 45 ft^2/hr in unobstructed areas. The expense comes in equipment rates, mobilization, demobilization, and moving from area to area; thus, if enough area is scabbled, the savings from the speed of the En-Vac begin to outweigh the cost of the expensive equipment factors.

Regulatory and Policy Issues

There were no regulatory issues with the innovative technology during this deployment.

Observations and Lessons Learned

The En-Vac performed well during its deployment, removing workers from the dangers of contaminated areas.

Items that should be considered include:

- Any area within 8 in. of a corner or other obstruction must be decontaminated using a hand scabbler or other alternative device.

References

Innovative Technology Summary Report, September 2000, *The En-Vac Robotic Wall Scabbler*, Idaho National Engineering and Environmental Laboratory, LSDDP.

Excel Modular System Scaffold

Technology Description

The baseline technology for scaffolding applications in normal D&D Operations has long been tube and clamp type scaffolding. This name comes from the tubular framing sections and the interlocking clamp used to allow many variable configurations of individual tubular framing sections. This type of scaffolding also has tubular cross-bracing that locks into position with pins and clips to provide rigidity to the scaffolding. It requires extensive leveling efforts with blocking and screw jack systems. Carpenter craft personnel are typically assigned to perform this work, but D&D laborers have also been trained to perform this work in asbestos abatement activities.

The innovative technology is an automatic locking scaffolding system that uses vertical frames with support cups and interlocking horizontal bearer (Figure 9). This system is easy to install with no special tools and requires fewer parts than the tube and clamp baseline technology. The Excel Modular System Scaffold manufactured by Excel Modular Scaffold and Leasing Corporation in Plymouth, Massachusetts, was designed for speedy assembly and disassembly and has proven to be an improvement over tube and clamp scaffolding. Carpenters place vertical supports with cups 5-¾ in. apart in adjustable square bases and attach horizontal bearers, which snap onto the cups by means of a spring-loaded, positive locking trigger mechanism (Figure 10). Excel scaffolding is leveled on the first layer only, whereas tube and clamp scaffolding must be leveled at each layer. To build a working platform, Excel users lay planks across the horizontal bearers. These planks are similar to those used with conventional scaffolding, but they are narrower so the Excel scaffolding fits into smaller spaces.

Figure 9. The Excel Modular Scaffold System is easier and faster to assemble than tube and clamp scaffolding.

Excel also manufactures ladders, trusses, swing gates, cantilevers, floor hatches, and other attachments that enhance safety by eliminating the dangers associated with climbing on scaffolding. In addition, Excel is the only scaffolding approved for fall protection anchorage. The main advantages to the Excel Modular System Scaffold are:

- 40–45% reduction in number of necessary parts (based on LSDDP).
- 60–70% reduction in labor costs and worker radiation/hazard exposure.
- Minimal use of hand tools (socket and ratchet) reduces repetitive motion injury.
- Ladders, swing gates, floor hatches, and other similar attachments prevent climbing on scaffolding, decreasing worker danger.

Figure 10. The Excel Modular System Scaffold uses an automatic locking clamp to "snap together".

Performance

Excel Modular System Scaffold has been used at the INEEL's Process Experimental Pilot Plant (PREPP), STP, and STF. The carpenter who completed these deployments said Excel scaffolding was much easier and faster to install than tube and clamp scaffolding. In some instances, the spacing of the cups makes the new scaffolding slightly less versatile, and it is slightly more difficult to decontaminate after use in asbestos areas because fibers settle in the cups. However, these inconveniences do not significantly affect the exceptional performance in reducing labor costs for setting up and tearing down. The Excel Modular System Scaffold has been well received on D&D projects and is preferred by personnel. In fact, the deployment at the STP was carried out spontaneously by workers on their own initiative because they had seen the positive implications of using the new scaffolding at other locations.

Cost-benefit

This scaffolding was deployed in FY-99 at the INEEL's STF, STP, and PREPP facilities. To date, seven scaffolding setups of various sizes have been done at STF to complete asbestos removal activities. In addition, one at STP and two at PREPP have been used to complete pipe demolition. The ITSR cost-benefit analysis was used as the basis for this cost analysis. The deployment was divided into mobilization, work, and demobilization.

The ITSR tracked actual setup, usage and takedown times for both the Excel and the tube and clamp system. It was not possible to track to that level during the ASTD deployments. Therefore, information on the quantity, footprints (area) and heights of the various setups was collected from the D&D carpenter setting up the scaffolding on the various site projects (Table 4, Column A). The carpenter also indicated the approximate length of time the setups were in place (Table 4, Column B).

As in the ITSR, the cost of using the Excel scaffolding was based on its amortized purchase price. The ITSR calculated $0.53/hour for use but this did not include overhead costs of 31.5%. When these are added in and the purchase price amortized over 10 years at 5.8% interest for 1,000 hours of use per year, the calculated rate is $0.71/hour of use. Since this is based on the parts needed to construct a 420-ft^3 scaffold, it was ratioed with the volume of the various setups to get an appropriate cost of equipment use (Table 4, Column C). This rate was multiplied by the number of hours the scaffolding was left in place (Table 4, Column D). The cost of using tube and clamp scaffolding was similarly calculated to be $0.35/hour of use (Table 4, Column I).

The cost of mobilization of the Excel scaffolding included staging the scaffolding, which according to the ITSR takes 15 minutes with one carpenter ($45.50/hr) and one laborer ($41.07/hr) and an equipment rate of $0.71/hr for a total of $21.82. The labor rates used in the ITSR did not include all overhead costs that are included in this analysis. Mobilization included a 30-minute pre-job briefing for the carpenter, laborer and job supervisor ($65.44/hr) and the equipment rate of $0.71/hr for a total of $68.08. Mobilization also included the scaffolding setup at a production rate of 540 ft^3/hr by one laborer and one carpenter and included the equipment rate of $0.71/hr for this time. The cost of setting up the Excel scaffolding calculated out to $0.16/$ft^3$, which is multiplied by the volume of the setup (Table 4, Column E). Staging the tube and clamp scaffolding took 40 minutes with one equipment operator ($47.12/hr) with an hourly cost of the tube and clamp scaffolding ($0.35/hr) and forklift ($3.30/hr) for a total of $33.81. Mobilization included a 30-minute pre-job briefing for the carpenter, laborer, and job supervisor and the scaffolding equipment rate of $0.35/hr for a total of $76.20. The tube and clamp scaffolding setup production rate was 300 ft^3/hr by one laborer and one carpenter and included the scaffolding equipment rate of $0.35/hr and miscellaneous small tools rate of $0.17/hr. The cost of setting up the scaffolding calculated out to $0.29/$ft^3$, which is multiplied by the volume of the setup (Table 4, Column H).

The cost of Excel demobilization included storing the scaffolding, which takes 15 minutes with one carpenter ($45.50/hr) and one laborer ($41.07/hr) and the equipment rate of $0.71/hr for this time for a total of $21.82. It also included the Excel scaffolding teardown at a production rate of 1,800 ft^3/hr by one laborer and one carpenter and included the equipment rate of $0.71/hr. The cost of tearing down the Excel scaffolding calculated out to $0.05/$ft^3$, which is multiplied by the volume of the setup (Table 4, Column F). Storing the tube and clamp scaffolding took 40 minutes with two equipment operators with a scaffolding rate of $0.35/hr plus the forklift rate of $3.30/hr for a total of $33.18. It also included the scaffolding teardown at a production rate of 402 ft^3/hr by one laborer and one carpenter and included the scaffolding rate of $0.35/hr and miscellaneous tools rate of $0.17/hr for this time. The cost of tearing down the tube and clamp scaffolding calculated out to $0.22/$ft^3$, which is multiplied by the volume of the setup (Table 4, Column J).

Adding together the mobilization, use and demobilization costs showed that use of the Excel scaffolding saved $1,950 in FY-99 (Table 4, Columns G&K). Despite the seemingly low savings, the scaffolding was seen as a big improvement over the tube and clamp by the D&D carpenter. In almost all instances, he preferred to work with the new scaffolding and felt it reduced the chances of injury due to the ease of setup. In higher radiation areas, the ease of construction would also lead to significant reduction in personnel exposure.

Table 4. Scaffolding cost-benefit analysis.

A Setup Vol. ft^3	B Job Time hrs	C Excel Use Rate $/hr	D Excel Work $	E Excel Mobilize $	F Excel Demob $	G Excel Total $	H T&C Mobilize $	I T&C Work $	J T&C Demob $	K T&C Total $	L Cost Difference $
6×10×15=900	80	1.52	121.71	233.9	66.82	422.43	371.01	60	231.81	662.82	240.39
6×10×15=900	80	1.52	121.71	233.9	66.82	422.43	371.01	60	231.81	662.82	240.39
8×12×10=960	80	1.62	129.83	243.5	69.82	443.15	388.41	64	245.01	697.42	254.27
8×12×10=960	80	1.62	129.83	243.5	69.82	443.15	388.41	64	245.01	697.42	254.27
3×6×13=234	80	0.40	31.65	127.34	33.52	192.51	177.87	15.6	85.29	278.76	86.25
5×7×12=420	80	0.71	56.80	157.1	42.82	256.72	231.81	28	126.21	386.02	129.3
1,354	80	2.29	183.1	306.54	89.52	579.17	502.67	90.27	331.69	924.63	345.46
7×8×6=336	80	0.57	45.60	143.70	38.62	227.92	207.45	22.40	107.73	337.58	109.66
5×7×14=490	80	0.83	66.40	168.30	46.32	281.02	252.11	32.67	141.61	426.39	145.37
5×7×14=490	80	0.83	66.40	168.30	46.32	281.02	252.11	32.67	141.61	426.39	145.37
											1,950.73

C=(A/420)*0.71 – ratio of setup vol times amortized equipment cost
D=B*C - hours worked times amortized equip. cost
E=21.82 staging + 68.08 briefing + (0.16*A) equip setup
F=21.82 staging + (0.05*A) equip teardown
G= D+E+F - total cost
H=33.81 staging + 76.20 briefing + (0.29*A) equip setup
I=B*[0.35*(A/420)] added G&A and PIF to equipment cost (not in ITSR)
J=(0.22*A) + 33.81 added G&A to labor costs (27%) (not in ITSR)
K=H+I+J
L=K-G

Approximately 50 facilities and 13 other structures are scheduled for D&D at the INEEL over the next 10 years, with an estimated cost of over $113 million. The INEEL Inactive Sites Department recently used a study of the recent 5-year period of actual costs to come up with percentages typical for D&D projects. The 5-year period study indicated that 49% of D&D Project cost were related to physical work. It is assumed that only 7% of the Physical D&D projects would use the Excel Modular System Scaffold for deployment to support such activities requiring personnel access. Conversation with the D&D personnel indicated that scaffolding use varies dramatically from project to project, making average use very difficult to project. The cost-benefit analysis indicated an average unit cost saving for the Excel Modular System Scaffold is approximately 34.6%. When applied to the 3.5% of physical work, the projected cost savings would be $672,000.

- $113,110,000 × 0.49 = $55,410,000
- $55,410,000 × 0.035 = $1,939,350 (baseline cost)
- $1,939,350 × 0.346 = **$672,000 (Excel Modular System Scaffold Estimated 10-year savings)**

Regulatory and Policy Issues

There are no known regulations or policy issues that affect use of this modular scaffolding system.

Observations and Lessons Learned

The Excel Modular System Scaffolding works well in standard scaffolding configurations, and fits better into small spaces than tube and clamp scaffolding. For some special and/or uniquely shaped scaffolding configurations, tube and clamp scaffolding may be preferred.

References

Innovative Technology Summary Report, August 1999, *The Automatic Locking Scaffolding System*, Idaho National Engineering and Environmental Laboratory, LSDDP.

GammaCam™

Technology Description

The baseline technology for the performance of radiological surveys has been the radiation control technician (RCT) and hand-held instrumentation. The RCTs provide coverage during characterization, deactivation, and D&D operations. This is standard throughout the DOE complex and commercial nuclear industry, although in recent years the commercial nuclear industry is turning more to newer remote surveying systems for facility characterization. Use of personnel to perform radiological surveys leads to worker exposures that could be avoided if remote surveying systems were used.

The GammaCam™, manufactured by AIL Systems, Inc., can be used to provide qualitative information (i.e., provides graphical information showing radioactive hot spots, but not field strength or isotope identity) about radioactive hot spots remotely, thus reducing exposure of personnel during initial entries into these facilities (Figure 11). Once the location of radioactive hot spots is known, steps can be taken to reduce worker exposure to radiation during D&D activities. The GammaCam™ identifies primary sources of radiation by providing a two-dimensional color image of gamma radiation fields placed over a corresponding visual black and white video image of the area being scanned. Different colors represent the different radiation levels, red representing the highest and blue the lowest. The GammaCam™ provides relative field strength instead of quantified data, and can be a great supplemental tool for manual probe searches.

Figure 11. GammaCam™ provides information on radioactive hot spots to reduce worker exposures.

During deployment, the GammaCam™ sensor head is placed at least 10 ft from the area to be inspected and controlled remotely from a notebook computer (Figure 12). The computer can be as far as 100 ft from the GammaCam™ head. A remote pan and tilt feature added to the GammaCam™ by INEEL Remote Systems engineers allows complete control from outside the contaminated area. The INEEL team also designed and built an enclosure to protect the sensor head from contamination. The enclosure has forced airflow for cooling, high-efficiency particulate air filters for the air coming in, and a positive pressure inside the enclosure to keep contaminants out. The GammaCam™ sensor head weighs about 60 pounds; the GammaCam™ and enclosure weigh about 120 lb.

Figure 12. A notebook computer controls the GammaCam™.

The main advantages of the GammaCam™ system are:

- Radiation sources can be located from a distance, improving worker safety.
- Hot spots can be located so RCTs can measure and shield those areas.
- Large areas can be surveyed in a short period of time, thus reducing cost over manual surveying.

Performance

The INEEL Remote Systems Engineering Department purchased the GammaCam™ from AIL Systems in 1996 with EM-40 funds. In 1998, the ASTD ID&D project funded construction of the enclosure protecting the head. The GammaCam™ and enclosure were used to survey the equipment used to dry containers containing Three Mile Island (TMI) materials at the TAN Hot Shop in March of 1999 (Figure 13). This initial scan identified one hot spot that was then shielded before processing of the TMI materials began. In July 1999, engineers again surveyed the area to see if fuel-processing activities had caused any changes in radiation levels. The GammaCam™ showed that processing the TMI materials had not significantly changed the radiation levels in the TAN Hot Shop.

The applications for this type of system are most prevalent during characterization of contaminated facilities. This system can be used to identify radiological hot spots within the contaminated facility and/or process system, equipment, etc., and thereby give the RCTs a better understanding of overall contamination and exposure concerns. It should be noted that this system does not lend itself to “Release Surveys” since the GammaCam™ is not sensitive enough to read radiological energy levels at release levels unless it is set up very close to the surface and allowed to count for extended periods of time.

Figure 13. The GammaCam™ in a specially built enclosure was used at the INEEL hot shop.

Cost-benefit

During FY- 1999, the GammaCam™ was used to gain "before and after" information on the equipment used for the TMI fuel in the INEEL TAN hot shop. As stated in the ITSR, the GammaCam™ is not a replacement for manual surveying as it does not give quantitative information. Therefore, this analysis focuses on the costs of deploying the GammaCam™ and the benefits it provided. It will not compare it to manual surveying.

This technology was used twice; once before handling the TMI fuel, and again after handling the TMI fuel. The Remote Systems Engineering group at the INEEL purchased a GammaCam for $184,900 and a special enclosure was built to provide contamination control for $9,600. Using a service life of 20 years and assuming the equipment is used 40 hours per year, gives an equipment usage cost of $583/hour.

For each deployment, a statement of work took ½-1 day to complete (one RCT for 5 hours at $55/hr and one robotics engineer for 5 hours at $52/hr). During each setup, it took two robotics engineers 3 hours to prepare the equipment and cover the cables with plastic to prevent contamination. The labor during the 2-hour period the GammaCam was taking readings is summarized below:

- One JSS for 2 hours during activities @ $65.44/hr = $131 * 2 deployments = $262.
- Two robotics engineers to run camera and do cable management for 2 hours while taking readings @ $52.24/hr = $209 * 2 deployments = $418.
- One RCT to provide in-cell communication and to line up the 7 shots for 2 hours @ $27.49/hr = $55 * 2 deployments = $110.
- One operator to move camera positions for 2 hours while taking readings @ $45.50/hr = $91 * 2 deployments = $182.

After the readings were complete, it took two robotics engineers 2 hours to decontaminate the equipment, obtain data printouts and transport the GammaCam back to storage @ $52.24/hr = $209 * 2 deployments = $418. One RCT was also needed to verify the equipment was decontaminated for 15 minutes @ $27.49/hr = $7 * 2 deployments = $14.

Using a total 14-hour usage time for the equipment costs gives an overall deployment cost of $19.7K. The majority of the cost of deploying the GammaCam was in the equipment cost – primarily because this equipment is expensive and is only used once or twice a year at the INEEL. The labor costs totaled approximately $3,400.

The GammaCam has been used to reduce radiation exposure to personnel by identifying the hot spots without extensive hand metering – this can target the areas needing decontamination or shielding. The potential for cost savings in reduced radiation exposure levels is significantly higher than the cost of deployment considering that each man-rem saved is worth approximately $6,500.

Approximately 50 facilities and 13 other structures are scheduled for D&D at the INEEL over the next 10 years, with an estimated cost of over $113 million. The INEEL Inactive Sites Department recently used a study of the recent 5-year period of actual costs to come up with percentages typical for D&D projects. The 5-year period study indicated that approximately 10.6% of the D&D Project activities are related to characterization work. It is assumed that only 25% of these characterization work tasks are applicable to radiological surveys that would use the GammaCam System. The cost-benefit analysis indicated an average unit cost savings for the GammaCam was not conclusive enough due to lack of number of deployments. It is further assumed that the cost savings utilizing the GammaCam over conventional radiological survey methods utilizing hand-held instrument is approximately 3%. When applied to the 25% of characterization work the projected cost savings would be $90,000.

- $113,110,000 × 0.106 = $12,032,300
- $12,032,300 × 0.25 = $3,008,100 (baseline cost)
- $3,008,100 × 0.03 = $90,000 (Gamma Cam Estimated 10-year savings)

Regulatory and Policy Issues

The only known regulatory issues associated with radiological energy recording and data storage systems, specifically the GammaCam™, is the radiological source within the shielded interior. This radiological source must be controlled according to current federal regulations related to the control of radiological sources.

Observations and Lessons Learned

It should be noted that the GammaCam™ technology provides qualitative, not quantitative data. Alternative systems that provide specific isotope and energy level information are commercially available.

References

Innovative Technology Summary Report, January 1998, *GammaCam™ Radiation Imaging System*, Chicago Pile 5 (CP-5) Research Reactor Large-Scale Demonstration Project.

Global Positioning Radiometric Scanner System

Technology Description

Before decontaminating and decommissioning a surplus facility and/or surrounding area, D&D project crews must survey the site to obtain radiological contamination information. Project managers need the results of this characterization to set work objectives. In the past, surveyors marked off a statistical grid and scanned the area with handheld instruments. The process was labor intensive and costly.

The Global Positioning Radiometric Scanner (GPRS) System makes characterization faster, less expensive, and more accurate. The technology includes a radiological detection system, portable computer, differential global positioning system, and four-wheel drive vehicle (Figure 14). Two $4 \times 26 \times 1.5$-in. plastic scintillators in an $8 \times 8 \times 72$-in. white enamel steel box compose the detection system. 1/8-in. lead shielding on the top and sides of each detector allows only data directly below the system to be measured. Detectors are mounted 3 ft high on the front of the four-wheel drive vehicle for transportation over the characterization area. Geosoft, a software program, graphically represents data to visually identify radioactive contamination.

This visual representation of data is a major benefit of the system (Figure 15). Using the GPRS system also increases the number of data points surveyed, resulting in more accurate and reproducible data. Another benefit of GPRS is that in situ detection of radiation is done in real time. The combination of real-time analysis and the four-wheel drive system reduces the number of surveying labor hours by 77%.

Advantages of the GPRS include:

- Visual representation of data
- Ability to survey more data points
- More accurate and reproducible data
- Real-time, in situ detection
- 77% reduction in number of surveying hours.

Figure 14. Global Positioning Radiometric Scanner System (GPRS).

Performance

The GPRS System was demonstrated as part of the INEEL LSDDP project in September 1999. Engineers wrote a test plan and the technical procedure requirement (TPR-EM-ESP-5.4, "Surface Radiation Surveys Using the GPRS") to define the use of the system under the INEEL LSDDP.

Additional funding in the ID&D ASTD made it possible to track the deployments of this technology from April 2000 through August 2000. The GPRS was used three times at TAN and twice at Auxiliary Reactor Area (ARA). It was also used for routine surveys four times at the Idaho Nuclear Technology and Engineering Center (INTEC) and three times at RWMC. In addition, TRA used it in Waste Area Group 2 surveys twice and Central Facilities Area (CFA) used it on the drainfields twice. The GPRS was also used twice to survey INEEL roadsides. This is a total of 18 deployments, and from the survey logs the total GPRS survey time was about 630 hours.

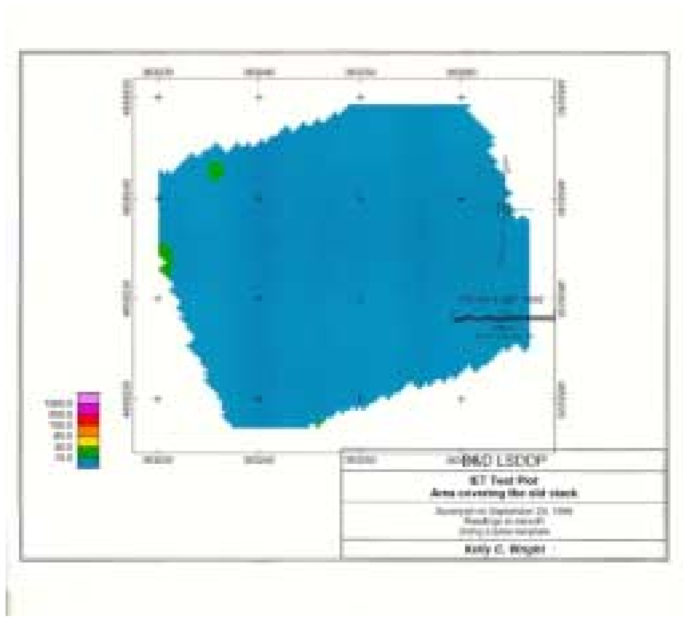

Figure 15. GPRS plot.

Cost-benefit

Cost-benefit calculations are based upon 18 surveys, which took about 630 hours. Since the GPRS can survey 32,000 ft^2 per hour, 630 hours equates to 20 million ft^2. The cost-benefit information in the ITSR (see references) was used to complete this analysis.

The ITSR records the purchase and installation cost of the detection system as $57,800 and the purchase price of the 4-wheel drive vehicle as $63,604. The INEEL also anticipates annual calibration/maintenance costs of approximately $1,500 and a yearly cost for a differential correction signal subscription of about $900. The ITSR estimated a service life of 10 years for the equipment and a usage of 960 hours per year.

Based on equipment price and labor hours, the U.S. Army Corps of Engineers calculated the costs of both baseline and innovative technology for the Demonstration. GPRS cost $127.94 to survey 8,000 ft^2, and the baseline technology cost $169.34 for the same area. These numbers did not include the INEEL General and Administrative (G&A) costs (27%) or PIF cost (4.5%). These adders were included in this report, as they add 33% (1.27*1.045) to equipment and labor hour costs. GPRS amount becomes \$127.94*1.33 = \$170.27 for 8,000 ft^2; baseline becomes \$169.34*1.33 = \$225.22 for 8,000 ft^2.

Dividing each of these costs by 8,000 ft^2 yields the cost per square foot. The innovative system costs \$170.16/8,000 ft^2 = \$.02127/ft^2. The baseline cost is \$225.22/8,000 ft^2 = \$.02815/ft^2. Savings per square foot is the difference: \$.02815/ft^2-\$.02127/ft^2 = \$.00688/ft^2. To recover the cost of the GPRS equipment would require \$121,404/\$.00688/ft^2 = 17,645,930 ft^2 of surveying. The GPRS system can survey approximately 32,000 ft^2/hr, and it is estimated that it will be used 960 hr/yr, so it can survey about 32,000*960 = 30,720,000 ft^2/yr. The recovery time will be 17,645,930 ft^2/30,720,000 ft^2/yr = .57 yr.

So far, using the GPRS at the INEEL has saved \$138K (20 million ft^2*\$.00688/ft^2). Based on an estimated use per year of 960 hours, which equates to 30,720,000 ft^2, **the GPRS will save \$2.1 million over the next 10 years** (\$.00688/ft^2*30,720,000 ft^2/yr = \$211K/yr).

Regulatory and Policy Issues

GPRS meets the requirements for 10 CFR, Chapter 111, Department of Energy, Part 835 and "Occupational Radiation Protection." In addition, it meets requirements defined in DOE-STD-1098-99, "Radiological Control," dated July 1999.

The major safety issue to consider involves driving. But the risks of driving hazards are reduced when two people are present in the vehicle. A passenger watches for potential hazards on his/her side of the vehicle and verifies that information is acquired properly so the driver can focus on driving.

Observations and Lessons Learned

The GPRS System is a mature technology, and it performed well in the demonstration and the deployment. Operation of the survey unit requires no special skills, but an ability to use the Geosoft software is essential. Following training, users find the system user-friendly, and they are able to generate higher quality data than with the baseline produces.

Items that should be considered include:

- Surveyors should conduct daily response check on the plastic scintillators before surveying
- The GPRS needs annual preventative maintenance
- Optimal speed for collecting accurate measurements is 5 mph
- The detector unit should be stored indoors for protection during winter months
- Historical information about the survey area needs to include possible radiological constituents—GPRS detects only gamma radiation
- Weather and soil conditions may affect survey results
- Before entering a survey area, users should determine background radiation and trigger limits from an adjacent, "clean" area with similar soil chemistry.

References

Innovative Technology Summary Report, March 2000, *Global Positioning Radiometric Scanner System*, Idaho National Engineering and Environmental Laboratory, LSDDP.

Hand-Held Shear

Technology Description

The baseline technology for cutting small piping and miscellaneous steel is the use of electrical-powered hand-held reciprocating saws and/or band saws. The sawing operation has potential problems with the generation of airborne contamination such as lead paint particles.

The innovative technology is a hand-held shear (Figure 16). The hand-held shears used during the LSDDP at the Fernald site were Lukas Rescue Team shears which are capable of shearing up to 2-½ in. diameter piping. These shears are portable and require no hydraulic or electrical power lines to operate, so they provide easier access to remote areas. The shear's cutting blade configuration allows cutting operations on process piping that is still attached to the wall.

During the ASTD ID&D project at Fernald, different commercially proven shears were selected for deployment. The Res-Q-Tek shears operate from a hydraulic source, and provide increased cutting capacity. These hand-held shears are operated using 100-Vac electrical power units that drive a hydraulic pump rated at 10,000 psi that can operate at 5,000 psi for extended life. The end effectors included two oval blade cutters and one straight blade cutters for the cutting of various piping diameters and flat stock respectively. It also includes an articulating head mini-cutter for cutting materials in difficult to access areas.

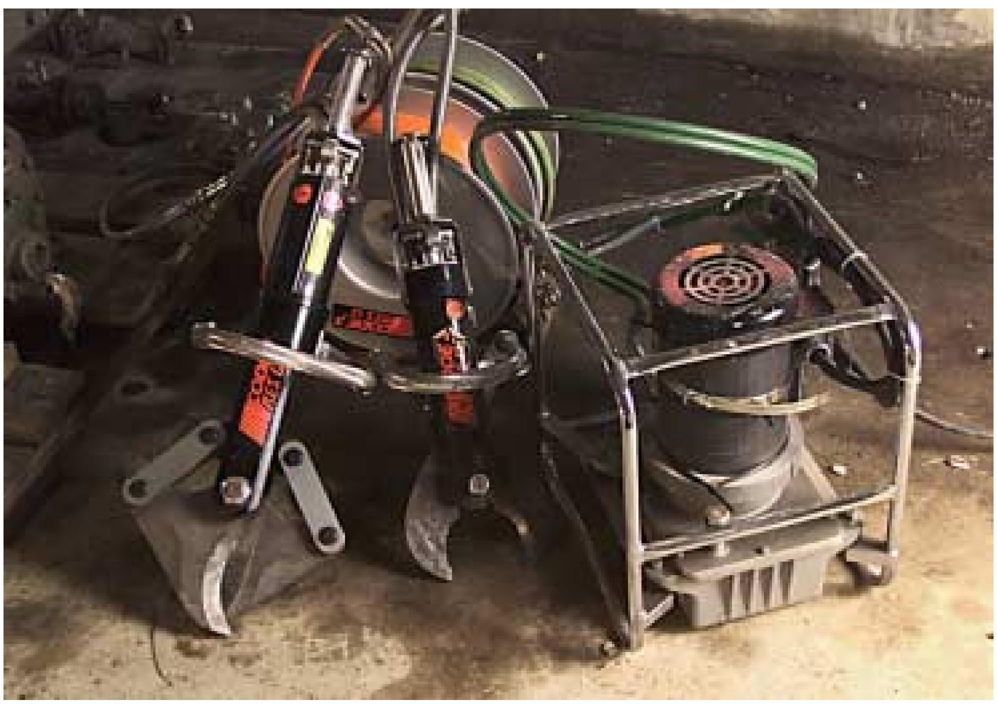

Figure 16. The hand-held shears were provided by FEMP under the ASTD ID&D program.

Benefits of using the hand-held shear include:

- Eliminating the generation of airborne lead paint particles and allow increased worker productivity during demolition operations.

- Providing a crimping effect on process piping, which controls to some degree the spread of internal contamination from the pipe.

Performance

The hand-held shears used by the ASTD project were procured with EM-40 funds and first used to segment small-diameter (less than or equal to 3 in.) piping and conduit in Fernald facilities 38A and 38B (Figure 17). Small diameter piping and conduit was also segmented in Fernald facility 24B (Railroad Engine House) with the hand-held shears. Operators of the hand-held shears like the ability to quickly segment conduit in tight areas next to walls, components and other obstructions. However, when segmenting up to 3 in.-diameter pipe with the larger model of hand-held shears operators complained of fatigue if they had to hold the shears for a very long period of time, particularly if above chest height.

The hand-held hydraulic shear was very effective for light-duty (2-in. diameter or less) pipe cutting. This shear unit reached into corners that other cutting tools have difficulty accessing. Overall, the hand-held hydraulic shear cuts approximately 20% faster than other cutting techniques for light-duty cutting. The hand-held hydraulic shear also minimizes the amount of paint chips and minimizes airborne lead exposure to the workers. This technology has many applications in typical D&D projects since there are many small steel items such as process piping and conduit to be demolished.

Figure 17. FEMP used the hand-held shears to cut metal and reduce airborne contaminants.

Cost-benefit

See Cost Information on the Track Mounted Shear.

Regulatory and Policy Issues

There are no other known regulatory restrictions associated with the use of the hand-held shear equipment other than the standard federal regulations on worker protection and equipment safety found in the OSHA regulations. These specific OSHA regulations are listed below:

OSHA 29 CFR 1926		OSHA 29 CFR 1910	
1926.300-.307	Tools–Hand and Power	1910.211-.219	Machinery & Machine Guarding
1926.400-.449	Electrical–Definitions	1910.241-.244	Hand & Portable Power Tools
1926.28	Personal Protective Equipment	1910.301-.399	Electrical Definitions
1926.52	Occupational Noise Exposure	1910.95	Occupational Noise Exposure
1926.102	Eye and Face Protection	1910.132	General Requirements (PPE)
1926.103	Respiratory Protection	1910.133	Eye and Face Protection
1910.149	Control of Hazardous Energy		

Observations and Lessons Learned

The following observations were made during this ASTD project:

The weight of the hand-held shear must be considered when being deployed in the field (approximately 50–60 lb) and operator fatigue must be expected. This must be considered vs. the conventional lighter-weight reciprocating saw or band saw (about 20–25 lb). This hand-held shear is a good tool if some additional support can be afforded the operator, e.g., resting the shear on the man-lift handrail, etc.

- It is important to properly size the electric motor to drive the hydraulic pump that powers the shears. When the shears were first being used, the D&D laborers using them complained about the slow cycle time between segmenting pieces of pipe/conduit and the relatively long period of time that it took. A call was placed to Res-Q-Tek, and a technical representative recommended changing to a different electric motor for the hydraulic pump. After this change was made the shears functioned well.

- It is important to keep the blades on the shears adjusted properly to the correct tolerances to facilitate cutting operations.

Niton 700 Series Multi-Element Spectrum Analyzer
(Lead Paint Analyzer)

Technology Description

Before performing any decontamination or dismantlement work, D&D project crews must characterize the site. The results of the characterization are needed to set work objectives. Currently, D&D project managers rely on contract laboratories to provide results on environmental sampling for lead, cadmium, chromium, and other metals in paint. Large samples of paint are hand-scraped off the surface and collected in sample bottles. Once the samples have been collected and sent to the laboratory, it may take as long as 90 days to receive the results.

The Niton 700 Series Multi-Element Analyzer is a hand-held, battery-operated instrument that uses X-ray fluorescence (XRF) spectrum analysis to identify and quantify metals and elements in paint (Figure 18). All eight RCRA metals and up to 17 other elements can be characterized within seconds. The analyzer uses two radioactive sources to complete the analysis and stores up to 3,000 data points and sample locations. A laptop computer controls the Niton in the field, and data can be downloaded to a personal computer (Figure 19).

To use the analyzer, the trained operator simply sets it against the painted surface. Readings are available within 20 seconds. Separate paint layers can be measured by moving the analyzer to a location where underneath paint layers are showing. This can aid in determining which paint layer contains lead or other hazardous material.

Advantages of the Niton analyzer include:

- Reduction in sampling time and time to receive analysis results (20 seconds compared to 1-3 months).
- Capability of determining contents of different paint layers not available through scraped samples.
- Data closely matches laboratory analyses and may more accurately represent actual paint composition in some locations, as rust and other debris are contained in the scraped samples.
- Lower unit operating costs.
- Very easy to use.

Figure 18. Niton Lead Paint Analyzer.

Figure 19. A portable laptop controls the Niton.

Performance

The Niton 700 Series Multi-element Analyzer was demonstrated as part of the INEEL LSDDP project in February 1999. The deployments of this technology were tracked between December 1999 and April 2000. Through the ASTD ID&D project, a standard procedure (technical specification requirements) was written to aid in the ease of these deployments. This allows the user to reference this procedure when creating the work packages instead of repeating the procedure in each work package.

Although winter is normally a time that D&D work slows down at the INEEL, a total of 6 deployments (34 samples) were completed. Paint was tested at two locations at TAN (the Decon Shop and TAN 607) with two spots in each location in January 2000. Confirming laboratory analyses were sent on these samples. In February 2000, 20 spots were tested in the TRA-654. Lead was found in the bottom paint layers. Two samples were sent to the laboratory in this case. Six more spots were tested in April at the INTEC building CPP-603. Four of these were in areas where it was not possible to take scraped samples for laboratory analyses due to airborne radiation concerns. One composite sample was sent to the laboratory. Also in April, paint was tested at four spots at CFA building 690. In addition, the analyzer was used to determine the amount of lead in paint on concrete on one sample at the TRA Materials Test Reactor. This is a total of 35 samples, with 7 confirming samples sent to the laboratory for further analysis.

Cost-benefit

This cost-benefit calculation is based on the deployment of the Niton Lead Paint Analyzer at six locations. 35 samples were analyzed with 7 sent for a confirming laboratory analysis, resulting in a reduction of 28 laboratory samples. The cost-benefit information in the ITSR (The Niton 700 Series Multi-Element Spectrum Analyzer (Lead Paint Analyzer) was used to complete this analysis.

In the ITSR, the amortized purchase price of the equipment was $11.24/hour based on an equipment cost of $25,000, a maintenance cost of $2,600 every 24 months, a service life of 10 years and 500 hours/year usage. These numbers did not include the INEEL G&A costs of 27% and the PIF of 4.5%. Since these costs add 33% (1.27*1.045) to the equipment cost, they were included in these calculations. The cost of using the analyzer in the ITSR was noted to be $11.24/hr. An increase of 33% is calculated to be $11.24/hr *1.33 = $14.95/hr.

The costs for mobilization, demobilization, and disposal of the innovative and baseline techniques were the same for both applications. Therefore, only the characterization costs were included in the following calculations. The INEEL G&A costs were also added to the labor for both cases. This resulted in an innovative cost of $46.44/sample and a baseline cost of $1,562.90/sample. This is a savings of

$1,516.46/sample. Therefore, during the 6-month deployment period in which 28 samples were completed using only the analyzer, **a savings of $42,460 was realized**. The payback period for this equipment is less than 6 months.

Figure 20. The Niton is hand-held for easy field use.

As the site personnel become more familiar with this equipment, its use will increase, even beyond D&D use. It is conservatively estimated that it will reduce laboratory analyses by at least 85 samples per year. At a savings of $1,516/sample, this is $129K/year or **$1.29 million over the next 10 years.**

Regulatory and Policy Issues

The Niton 700 Series Multi-element Analyzer meets the Department of Transportation requirements for 49 CFR 173.421 excepted packages for limited quantities of Class 7 (radioactive) materials. At the INEEL, the analyzer must be controlled and accounted for at all times (requiring a custodian to check out this equipment).

Observations and Lessons Learned

The analyzer performed well during these deployments and it is being used by a number of personnel at the INEEL. The analyzer is easy to use and requires no special skills. During normal use, the analyzer must be returned to the manufacturer every 4 years to replace the source and upgrade software.

References

Innovative Technology Summary Report, July 1999, *The Niton 700 Series Multi-Element Spectrum Analyzer (Lead Paint Analyzer)*, Idaho National Engineering and Environmental Laboratory, LSDDP.

Oxy-Gasoline Torch

Technology Description

D&D Project operations typically use the oxy-acetylene torch or oxy-propane (Chem-o-lene) torch to perform most of the steel cutting that cannot be accomplished using heavy-duty hydraulic shears mounted on a trackhoe. The oxy-acetylene torch is a cumbersome setup that includes oxygen and acetylene bottles in a cart with regulators, hoses, and the torch itself. Acetylene was replaced with Chem-o-lene at the INEEL several years ago for environmental reasons.

The Oxy-Gasoline torch, manufactured by Petrogen® Inc., is a tool for cutting carbon steel (Figure 21). Fueled by gasoline, it can be used as a direct replacement for the standard oxy-acetylene torch. The Oxy-Gasoline torch consists of a two-and-a-half gallon fuel tank with safety valves, a durable gasoline supply hose, and a cutting torch head. A built-in hand pump or an external source of compressed air pressurizes the gas tank. About 10–20 psi is required to deliver the gas to the head of the torch, where it mixes with oxygen in the tip.

Safety was a primary consideration in the torch's design. Since liquid gasoline cannot burn without oxygen and the fuel is a liquid all the way to the cutting tip, there is no chance of backflash in the fuel line. The design also includes several safety valves. A fast-flow check valve in the tank shuts off the fuel in case the hose ruptures. The tank comes equipped with a pressure relief valve that opens at 35 lb per square inch and check valves under the pressure gauge and inside the outlet valve that prevent fuel from escaping if the gauge or valve is accidentally broken off. In contrast to acetylene, gasoline is less volatile. Acetylene can actually explode without an oxygen source.

The Oxy-Gasoline torch cuts faster than conventional torches. The Oxy-Gasoline torch relies on 100% oxidation rather than melting to cut through the metal. The torch oxidizes steel to a granular slag that is blown out of the cut by the force of the flame. The force and momentum of the gasoline vapor (about four times denser than acetylene) drive the fuel deep into the cut face where it continues to burn and oxidize metal. This enables the Oxy-Gasoline torch to cut through thicker metal easier and faster

Figure 21. Petrogen's® Oxy-Gasoline torch cuts steel faster and less expensively than the acetylene torch.

than other oxy-fuel torches and produces a clean cut with minimal kerf (slot left behind in the metal after cutting). The granular slag is also less likely to clog the tip of the torch during cutting, unlike the molten metal produced by other torches.

The oxy-acetylene torch depends on a combination of oxidation (70%) and melting (30%) to cut metal and is slower because some of the molten metal re-solidifies and has to be re-cut. This produces cuts with considerable kerf and rough edges.

The Oxy-Gasoline torch has many advantages over the oxy-acetylene torch including:

- Faster and cleaner cuts with less slag.
- Less expensive fuel (equivalent cuts can be made with $3 of gasoline versus $50 of acetylene) that is easy to obtain and store.
- Increased portability (gasoline fuel tank weighs 30 lb compared with the 250-lb acetylene tank).
- Reduces cost, accelerates schedule, and reduces radiation exposure.
- Gasoline vaporization at the tip is an endothermic process that helps prevent the tip of the torch from overheating, and extends its life.
- Can be used to cut steel that is in direct contact with concrete without the risk of the concrete shattering and causing a projectile hazard (Figure 22).

Figure 22. The Oxy-Gasoline torch was used to cut rebar at the INEEL STP.

Performance

The Oxy-Gasoline torch can be applied in any situation where an oxy-acetylene torch would normally be used. The main applications for the Oxy-Gasoline torch in D&D Operations is cutting steel such as concrete reinforcing steel, steel tanks, larger process equipment, and larger steel shapes and plate.

Performance at the INEEL ASTD

The Oxy-Gasoline torches purchased under the ASTD ID&D project were first deployed at the INEEL in July 1998. The deployment was at CFA-691, where the torches were used to cut up reinforcing steel (rebar) during the dismantlement of a concrete digester tank (Figure 22). Throughout the summer of 1999, the torches were used at a number of facilities. These facilities include the STF, STP, Initial Engine Test (IET) facility, and ARA. The torches work extremely well. Operators commented that they are easier to move around and cut more quickly than an acetylene torch, especially with thick metal such as railroad track. The operators liked the torches so much that they used them at different areas on their own initiative. The Oxy-Gasoline torch is fast becoming the baseline at the INEEL for D&D metal cutting operations.

Performance at the FEMP ASTD

The Oxy-Gasoline torches were purchased for use ($5K) by the ASTD project and used at FEMP during FY 1998 and FY 1999 with very successful results. The Petrogen® torch cut 65% faster than the baseline oxy-acetylene torch and the gasoline is significantly cheaper than the acetylene torch. It is considered safer due to less generation of slag than conventional torches and because the fuel stays in the liquid phase longer. The net result is a safety improvement with performance, cost, and schedule savings.

In one case, a large tank needed to be reduced in size for disposal. Operators tried to reduce the size of the tank using shears, but found that the tank was too thick, and the shears would not cut it. The Oxy-Gasoline torch was deployed to cut the tank, with great success. The Oxy-Gasoline torch was used on numerous buildings at FEMP, and is quickly becoming the baseline cutting tool there.

Cost-benefit

This cost-benefit calculation is based on the deployment of the Oxy-Gasoline torch at several INEEL facilities for a variety of materials (pipes, plate, rebar, etc.). It was not possible to track actual time used or inches of cuts made to do a cost-benefit analysis as was done in the ITSR. The only reasonable way to determine the deployment cost savings was to note the number of gallons of gasoline used and equate that to the number of inches cut and cost savings using the data obtained from the FEMP Oxy-Gasoline torch ITSR.

The ITSR compared the oxy-acetylene torch cutting to the Oxy-Gasoline torch cutting for metal thicknesses of 0.5 in. to over 4.5 in. Length of cuts and unit cost ($/in.) are summarized in Table 5.

The ITSR also states that accurate fuel consumption data could not be collected during only those times when the torches were being demonstrated, therefore "since the total demonstration time for each torch was approximately one work day, fuel consumption was estimated to be a typical work day's usage which… is 2.5 gallons of gasoline…." This indicates 1 gallon of gas was used to cut 148 in. (369 in. per tank/2.5 gallons per tank) with the Oxy-Gasoline torch.

At STF, the Oxy-Gasoline torch was used to cut 14- to 16-in.-diameter water pipe about 3/8- to 1-in. thick using 4 gallons of gasoline. This equates to 592 in. of metal cut (148 in./gal * 4 gal) at a cost of $533 (592 in. * $0.90/in.). To cut 592 in. of metal with the oxy-acetylene torch would cost $704 (592 in. * $1.19/in.). Therefore, $112 was saved at this facility by using the oxy-gas torch. If the costs for cutting 2-in.-thick metal were used (i.e., a 50% savings), the savings would be on the order of $300.

Personnel at IET used the Oxy-Gasoline torch to cut 1- to 2-in. plate and railroad track. The operator indicated he thought it worked 3 to 4 times faster than the baseline torch. Approximately three tanks of gas (2.5 gallons/tank) were used which equates to 1,100 in. cut at a cost of $704 [if using the 2 in. cutting costs from the above table ($0.64/in)]. To cut the same amount with the baseline torch would cost $1,232. Therefore, the Oxy-Gasoline torch has saved $528 (if only 2 times as fast). If it actually cut 4 times faster, the savings would be more on the order of $1,500.

Table 5. Summary of ITSR information on oxy-gas and oxy-acetylene torches.

Thickness	≤ 0.5 in.	1.0 in.	1.75 in.	2.0 in.	4.5 in.	Overall
Oxy-gas Length (in.)	166.5	35	43	120	4.5	369
Oxygas Unit Cost ($/in.)	$0.62	$0.92	$1.01	$0.64	$2.53	$0.90
Oxy-acetylene Length (in.)	166.5	35	43	108	4.5	357
Oxy-acetylene Unit Cost ($/in.)	$0.63	$1.05	$1.18	$1.12	$7.75	$1.19

At the STP, the Oxy-Gasoline torch was used to cut ½- to 1-in.-thick rebar. Approximately one tank of gas was used, saving around $100. At ARA, approximately 2 tanks of gas were used, saving around $200. Thus, using the oxy-gas torch at the INEEL during FY-99 provides **overall cost savings of $900-$2,100**.

Although actual savings are minimal, the perception by the workers is it cuts 2 to 4 times faster and is much easier to use. Feedback from the field on the Oxy-Gasoline torch was very positive. It is lighter and easier to handle than the oxy-acetylene torch, the thicker metal cuts do not have to be preheated first, and it reduces worker fatigue. One operator indicated, "the more I use it the more I like it." The savings are not as apparent in the dollars saved because actual "cutting time" is so small. More of the time is used to actually set-up the cuts versus doing the cutting. To save $10,000, the Oxy-Gasoline torch would have to be operated enough to use 25 to 50 tanks of gas. In general, the sites at which the torch is used need it only for occasional cutting and do not have it in constant operation day after day. The Oxy-Gasoline torch is considered safer because it produces less metal slag and will not explode the concrete as acetylene torches can.

Approximately 50 facilities and 13 other structures are scheduled for D&D at the INEEL over the next 10 years, with an estimated cost of over $113 million. The INEEL Inactive Sites Department recently used a study of the recent 5-year period of actual costs to come up with percentages typical for D&D projects. The 5-year period study indicated that 49% of D&D Project cost were related to physical work. It is assumed that only 2.5% of the D&D physical work would use the Oxy-Gasoline Torch System for deployment activities such as cutting of piping, reinforcing steel in concrete, process equipment anchoring systems, miscellaneous steel, and other interior architectural items. Conversation with the D&D personnel indicated the Oxy-Gas Torch was only used for 2 weeks per year making the use per year 1.9%. If the initial engineering estimate of 2.5% is averaged with this 1.9%, the resulting value is 2.2%. The INEEL ASTD ID&D FY-99 Cost and Performance Report indicated a unit cost saving for the Oxy-Gasoline is $0.90/in. vs. $1.19/in. of steel being cut or 24.4% cost savings. When applied to the 2.2% of physical work the projected cost savings would be $299,000.

- $113,110,000 × 0.49 = $55,410,000
- $55,410,000 × 0.022 = $1,225,413 (baseline cost)
- (1.19 – 0.90) / 1.19 = 0.244

- $1,225,413 × 0.244 = **$229,000 (Oxy-Gasoline Torch Estimated 10-year savings)**

Regulatory and Policy Issues

Proper training for the equipment operators is a must to ensure the correct use of the equipment and safety of the operators and co-workers. Petrogen® certified training representatives should provide operator training. Proper maintenance and servicing are also necessary to keep the Petrogen® equipment at peak performance. Petrogen® provides a detailed operation and maintenance video that should be watched as part of standard training for the Oxy-Gasoline torch.

There are no known regulatory restrictions associated with the using of the Petrogen® Oxy-Gasoline torch other than the standard federal regulations on worker protection and equipment safety found in the OSHA regulations. These specific OSHA regulations are:

OSHA 29 CFR 1926		OSHA 29 CFR 1910	
1926.300-.307	Tools – Hand and Power	1910.211-.219	Machinery & Machine Guarding
1926.400-.449	Electrical – Definitions	1910.241-.244	Hand & Portable Power Tools
1926.28	Personal Protective Equipment	1910.301-.399	Electrical Definitions
1926.102	Eye and Face Protection	1910.132	General Requirements (PPE)
1926.103	Respiratory Protection	1910.133	Eye and Face Protection

Observations and Lessons Learned

- Feedback from the field on the Oxy-Gasoline torch was very positive. It is lighter and easier to handle than the oxy-acetylene torch, the thicker metal cuts do not have to be preheated first, and it reduces worker fatigue.

- At the INEEL, one of the leather pump cups that allows the tank to pressurize during hand pumping failed, possibly from a defective part or from the dry climate. Petrogen® replaced the pump cup at no charge.

- INEEL welders also observed that the torch lighting procedures must be carefully observed. Specifically, if the oxygen pre-heat is not blowing hard enough, the oxygen will not mist, and will drip, rather than flowing properly.

- During FY- 1999, there was a problem with back flash up the oxygen line on an Oxy-Gasoline torch in use at the Hanford site. This problem was not specific to the Oxy-Gasoline torch—any oxygen based cutting tool has the risk of backflash up the oxygen line. Proper purging of the oxygen line before lighting the torch is necessary to prevent this from occurring. In the Hanford incident, the preliminary findings determined that operator error caused the backflash. Petrogen's® investigation of manufacturer's recommendations for numerous oxygen-based cutting torches showed that all of them stress the need to purge the oxygen line before use. In response to the Hanford incident, Petrogen® sent free oxygen backflash preventors to all of its customers, and made these preventors part of their standard equipment.

- Cleanliness of the fuel is paramount to proper performance of the Oxy-Gasoline torch. Even very small amounts of residual oil (such as using a gas can that had been used with oil previously) have been known to cause a slight drip of gasoline.

- Optimal placement of the torch tip relative to the material being cut is required to avoid clogging, overheating, and excessive wearing of the tips.

- Establishing the correct pressure in the gasoline tank to compensate for the difference in altitude between the tank and the torch is required.

- Neither the oxy-acetylene nor the Oxy-Gasoline torch will readily cut stainless steel due to its resistance to oxidation, and neither torch is able to cut cast iron.

References

Innovative Technology Summary Report, July 1998, *Oxy-Gasoline Torch Technology*, Fernald Environmental Management Project – Building 1A and 66, LSDDP.

Innovative Technology Summary Report, December 1998, *Oxy-Gasoline Torch*, Deactivation and Decommissioning Focus Area, DOE/EM-0401.

Paint Scaler

Technology Description

Before performing any decontamination or dismantlement work, D&D project crews must characterize the site. The results of the characterization are needed to set work objectives. Currently, D&D project managers rely on contract laboratories to provide results on environmental sampling. For these analyses, large samples of paint are scraped off the surface by hand using tools such as paint scrapers, putty knives, chisels and hammers. This is a time-consuming and physically demanding task for the sample collectors.

The Bosch 11225VSRH is a 24-volt, battery-operated, ¾-in. hammer drill that can replace hand-held scraping tools (Figure 23). When the Bosch paint scaler is used with an optional chipping adapter or other available bits, it can remove paint from either concrete or metal surfaces. It is ultra-compact and lightweight, and it has an ergonomically balanced grip.

Advantages of using the Bosch paint scaler include:

- Sampling is 2 to 5 times faster than with hand-held tools, reducing worker exposure and worker fatigue.
- Removes hard, thick coatings much easier than hand scraping.
- Reduces the amount of substrate collected with the coating sample because it is easier to control.
- Reduces the possibility of personal injury associated with the use of hand tools.
- Cost reductions and accelerated schedules are possible because more samples can be taken in a shorter period of time.

Figure 23. Battery operated Paint Scaler.

Performance

The Bosch Paint Scaler was demonstrated as part of the INEEL LSDDP in September 1999 (Figure 24). It has been deployed three times in the last 6 months to obtain paint samples. It was used in December 1999 at the TRA 641 to obtain three paint samples. In February 2000, it was used at TRA 654 to take two paint samples, and in April 2000, it was used at INTEC building CPP-603 to obtain two paint samples. This is a total of seven samples.

Figure 24. The Paint Scaler removes samples quickly and inexpensively.

Cost-benefit

This cost-benefit calculation is based on the deployment of the Bosch Paint Scaler at three locations in which seven samples were taken. The cost-benefit information in the Paint Scaler ITSR was used to complete this analysis.

In the ITSR, the amortized equipment cost was $0.82/hour. This number did not include the INEEL G&A costs of 27% and the PIF of 4.5%. Since these costs add 33% to the equipment cost, they were included in these calculations. The cost of using the paint scaler at the INEEL is then calculated to be $0.82/hr *1.33 = $1.09/hr. The baseline equipment use rate was also adjusted from $0.60/hr to $0.80/hr for the same reason.

The costs for mobilization, demobilization, and disposal of the innovative and baseline techniques were the same for both applications; therefore, only the characterization costs were included in the following calculations. The INEEL G&A costs were also added to the labor for both cases. This resulted in an innovative cost of $249.57/sample and a baseline cost of $299.28/sample. This is a savings of $49.71/sample. Therefore, **$348 was saved during the 6-month deployment period** in which seven samples were completed.

As the site personnel become more familiar with this equipment, its use will increase, even beyond D&D use. It is conservatively estimated that it will be used to gather at least 40 samples per year. At a savings of $49.71/sample this is $1,988/year or **$19,880 over the next 10 years**.

Regulatory and Policy Issues

There are no known regulatory or policy issues with this technology.

Observations and Lessons Learned

The paint scaler performed well during these deployments, and it is being used by a number of personnel at the INEEL. Because it performs faster than hand scraping, there is a reduction in worker exposure to chemicals, extreme temperatures, radiation, and asbestos. Items that should be considered include:

- An extra battery will ensure minimal downtime during sampling activities.
- A variety of chisel bits are available to aid in gathering samples from a variety of materials.

References

Innovative Technology Summary Report, March 2000, *Paint Scaler*, Idaho National Engineering and Environmental Laboratory, LSDDP.

Personal Ice Cooling System – Cool Suit

Technology Description

D&D Projects typically encounter high-temperature conditions due to weather, humidity, and air restrictions during D&D operations. These high ambient temperatures, and the PPE requirements imposed for radiological and/or chemical safety of the workers, shorten the time workers can spend in an area performing physical labor work tasks due to physical exhaustion and water loss. The baseline technology is to limit stay times to ensure workers are not overheated and core body temperatures do not exceed limits imposed by the Industrial Hygiene/Safety Officer (IHSO). In one area of the INEEL, workers saw an extreme need for a personal cooling system, and created their own by piping breathing air into their PPE to provide cooling by convection. Although this system was helpful, it was not used beyond the original job. The INEEL working conditions are typically warmer in the summer months, but even in winter the PPE requirements and lack of ventilation often result in the need to limit stay times to control heat stress. In addition, recent incidents indicate that if workers do overheat, the contaminants can be wicked through the PPE, resulting in a potential contamination of workers.

The Personal Ice Cooling System (PICS) is a self-contained cooling system that uses the cooling effects of ice bottles and a recirculating water pumping system to keep personnel body temperatures cooler (Figure 25). The PICS is worn under the worker's PPE and allows normal freedom of movement. This allows the personnel wearing the required PPE to perform demolition work during hot weather with fewer breaks and less fatigue, thus improving productivity and reducing project labor costs.

The PICS is manufactured by Delta Temax, Inc., of Canada, and consists of a full body suit similar to long underwear with tubing sewn into the garment. A full suit includes pants, a shirt or vest, and a hood. The INEEL purchased only vests and shirts, because data from LSDDPs showed that cooling the torso is effective enough for most applications. The suit comes equipped with a tough insulated pouch attached to a harness that can be worn on the back, chest, or waist. Ice bottles made of high-density polyethylene can be filled with ice cubes or frozen solid in a standard freezer. The ice bottles are carried in the insulated pouch that can be worn underneath or on top of PPE. A small battery-powered pump circulates chilled water from the ice bottle through the tubing in the suit. The cold water absorbs body heat, and then returns to the ice bottle to be re-chilled. The user can adjust the cooling rate, based on the work load and temperature conditions, using a two-speed flow control. With the pump and 2 liters of water, the suit weighs only 12 lb. The PICS is portable, easy to use, and totally self- contained.

Figure 25. Personal Ice Cool Suits are worn under PPE to keep workers cool and avoid heat stress.

The main advantages of the PICS suits include:

- Increases stay times (more than 4 times with temperatures above 100° F).
- Increases worker well-being and comfort.
- Ensures safer body temperature.
- Saves money as a result of longer stay times, fewer work stoppages, and a decreased need for PPE use.

Performance

The PICS was originally used during the LSDDP at the Fernald Site, Building 68, in September 1997 which indicated stay times that were 4 times longer and 30% better work efficiency. Although the PICS have been used additionally at FEMP, this use was not done under the ASTD ID&D project, as ambient conditions in the buildings that were decontaminated and decommissioned under the ASTD ID&D did not warrant use of the suits. FEMP performed another ASTD project aimed at increasing the use of PICS throughout the DOE complex, which resulted in many subsequent deployments.

Performance at the INEEL ASTD. The PICS purchased by the ASTD project were deployed at the INEEL's PREPP in late June of 1999 (Figure 26).

Figure 26. INEEL workers used the PICS vests to increase stay times during work in full PPE.

In hot conditions, workers wore full PPE and performed heavy work that included removing hazardous heavy metals such as lead, arsenic, and mercury. The cool suit vests were deployed and all workers were very positive about using them. They commented that the suits made a big difference and rendered immediate cooling in otherwise uncomfortable conditions. These suits allowed workers to remain in the area for twice as long as they normally would have, under supervision of their IHSO. Fewer cool-down breaks meant that there were fewer changes into and out of PPE. Having longer stay times and using less PPE has already resulted in a cost saving of about $38K. It is anticipated that using the suits on future projects at the INEEL will continue to increase productivity, worker comfort, and stay times, thus saving even more.

One of the non-D&D workers at TAN said that they liked the PICS so well that they wished they could use it on their jobs, so TAN Operations purchased some for non-D&D work. Following the ASTD ID&D deployment, the D&D PICS were borrowed from the D&D group by the TRA Maintenance team, who used them during the winter months for reactor maintenance.

Cost-benefit

This cost analysis was completed on the PICS deployment at the TAN PREPP facility. Workers were in full PPE including respirators. Use of the PICS cooling vests allowed the workers to more than double their stay times doing heavy work at an average room temperature of 90^{o}F.

Although 10-hour shifts are worked at the facility, with pre-job briefings, scheduled breaks and work cleanup, approximately 6.5 hours per day are actually worked in PPE as per the job site IHSO. The training time for the PICS was negligible (only about 10 minutes). Using information from the PICS Innovative Technology Summary Report (ITSR), the following work cycle times were determined for both with and without the PICS when using full PPE (Table 6).

Therefore, for a baseline (without PICS) work period of 6.5 hours, a total of 3.8 productive hours per day (6.5 hours * 90 min/155 min) can be completed. This is 38 % efficient (3.8 hours/10 hours). For a PICS work period of 6.5 hours, a total of 5.5 productive hours per day (6.5 hours *180 min/213 min) can be completed for an efficiency of 55 % (5.5 hours/10 hours).

The PICS were used on this job for a total of 19 days (190 hours) by a crew of six people for a total of 1,140 hours (6 people*190 hours/person). The loaded labor rate is approximately $45/hour for a cost of $51,300. For the baseline, the same amount of work would have taken 1,650 hours (1,140 hours *(0.55/0.38)). At a labor rate of $45/hr, this is $74,250. Therefore, the PICS saved about $22,950 in labor costs for this job.

In addition, PPE costs were also saved. In the ITSR analysis, the PPE used was very similar to that being worn at the INEEL facility. The ITSR calculated cost for baseline PPE was $14.93/hr, which would cost $24,635 for the estimated baseline hours. The ITSR calculated cost for innovative PPE was $8.12/hr, which would cost $9,257 for the estimated innovative hours. This is a saving of $15,378.

The PICS deployment was highly successful in reducing costs during the INEEL deployment, realizing savings of **$38,328**. This would equate to a unit cost savings of approximately **$33.62/hr** ($38,328/1,140 hrs).

Table 6. Work cycle times with full PPE.

Work Task	Baseline Work Cycle (min)	PICS Work Cycle (min)
Stay time	90	180
PPE don	10	20
PPE doff	10	13
Rest time	45	0
Total Work Cycle	155	213

Approximately 50 facilities and 13 other structures are scheduled for D&D at the INEEL over the next 10 years, with an estimated cost of over $113 million. The INEEL Inactive Sites Department recently used a study of the recent 5-year period of actual costs to come up with percentages typical for D&D projects. This value for physical work was 49% of the total budget. The 5-year period study indicated that of the physical work, approximately 66.9% was labor related and that the average labor rate was approximately $51.79 per hour. It is assumed that 20% of these physical tasks would require the PICS to reduce heat stress to personnel deployed in confined work areas and/or areas of high temperatures. Conversation with the D&D personnel indicated that PICs were used for over 80% of the summer months (4 months) making the use per year 26.7%. If the initial engineering estimate of 20% is averaged with this 26.7%, the resulting value is 23.3%, or 167,067 man-hours. The cost-benefit analysis indicated a labor savings of 31% over the baseline unit labor cost of $51.79 when using the PICS. When applied to the averaged 23.3% of physical work, the projected labor cost savings would be $2,682,000. In addition, the usage of PPE is reduced with the PICS, adding another cost savings. The ASTD ID&D FY-99 Cost and Performance Report indicated that the average cost of PPE per hour of PICS usage was reduced from $14.93 to $8.12, or a savings of $6.81 per hour. When applied to the 167,067 hours of projected use, the PPE savings is $1,138,000. Combining the labor savings and PPE savings, the projected cost savings from using the PICS is $3,820,000.

- $113,110,000 × 0.49 = $55,410,000
- $55,410,000 × 0.669 / $51.79 man-hours = 716,000 man-hours
- 716,000 man-hr × 0.233 = 167,067 man-hours for estimated PICS use
- 167,067man-hr × $51.79/man-hr x .31 = $2,682,000 (labor savings) using PICS
- 167,067 × $6.81 = $1,138,000 (PPE savings) using PICS
- $2,682,000 + $1,138,000 = **$3,820,000 (Total PICS Estimated 10-year savings)**

Regulatory and Policy Issues

Monitoring by an industrial hygienist should always be provided while working in hot temperatures, even if the PICS suits are used. The INEEL has a procedure (MCP-2704) which requires oversight in any heat stress situation, even when using cooling suits. It is important to recognize that each worker’s susceptibility to heat stress is varied due to individual physical characteristics (weight, age, health, heart and respiratory conditions, etc.), acclimatization, and medication (diuretics, sedatives, tranquilizers, blood pressure medication, etc.).

There are no known regulatory restrictions associated with the use of the PICS other than the standard federal regulations on worker protection and equipment safety found in the OSHA regulations. This specific OSHA regulations is:

OSHA 29 CFR 1926		OSHA 29 CFR 1910	
1926.28	Personal Protective Equipment	1910.132	General Requirements (PPE)

Observations and Lessons Learned

- In general, the workers used the packs as a hip pack instead of a shoulder pack. The packs were worn under the PPE and on top of lightweight modesty clothing.

- To change the ice bottles (3-4 times per day per person) the PPE was cut open, the ice bottle changed and the PPE re-taped.

- The workers washed the vests daily when they showered. In future, a structured laundering plan for the PICS could be set up.

- Care must be taken to set up a cycling system so that the ice bottles are completely frozen before each use. If the water is not completely frozen, the cooling power is limited, defeating the purpose of the PICS.

- Methods to change out the ice bottles may vary depending on the location conditions. At the INEEL, the PPE was slit open, the ice bottle replaced, and the PPE retaped. However, in areas of high levels of contamination, cutting the PPE open to replace the ice bottle may not be acceptable. Radiation Control should always review plans to use the PICS, and provide guidance about where the PICS should be worn (under or over PPE), and how ice bottles should be changed out. Another option would be to use PPE that has flaps for protecting removable equipment.

References

Innovative Technology Summary Report, June 1998, *Personal Ice Cooling System (PICS)*, Fernald Environmental Management Project – Building 68, LSDDP.

Soft-Sided Waste Containers

Technology Description

The baseline technology supporting D&D Operations for LLW disposal has been hardsided containers (occasionally ¾ in. plywood, but currently 20-gauge metal B12s and B25s). One of the major problems with these containers is the void volume due to packing configuration and weight restrictions.

Transport Plastics, Inc. has developed the Lift-Liner™ bags for safe storage, transport, and disposal of LLW (Figure 27). This pliable/flexible waste container is larger in size and weight capacity than the baseline containers. The bags are made of woven and coated 25-mil (0.025-in.) polypropylene and are lined with two layers of 40-mil (0.040-in.) high-density polyethylene. Four flaps fold across the top of a full bag and are secured by 20 1-in. straps of polyester webbing. The system also includes a loading frame and lifting frame. The loading frame supports a container as it is being filled. A crane suspends the lifting frame while the 2-in. polyester straps on the outer shell of a full container are connected to it, and then the crane places the bag onto a transport vehicle. These bags allow loading of larger waste debris and minimize void volumes due to weight capacity limits of the container. This container-size increase requires less sizing of D&D debris and thereby reduces D&D costs. In addition, their flexibility reduces void volumes within the container and allows for denser filling of the waste disposal site, reducing cost and subsidence. The container itself is less expensive than conventional waste containers which also reduces D&D costs for waste containers.

The main advantages of the soft-sided waste containers include:

- Lower cost than metal containers ($365 compared with $735, resulting in a savings of $1,800 per bag—1 bag versus 3 or 4 boxes).
- Lighter and more compact—empty bags can be moved by hand.
- Hold three times as much as a metal box.
- Easier to load.
- Hold larger debris, so less waste processing is necessary.
- Reduce void space and landfill subsidence.

Figure 27. Transport Plastics Lift-Liner™ holds more volume and costs less than standard metal boxes.

Performance

Soft-sided containers have been deployed at the INEEL's STP, STF, ARA, and Naval Reactors Facility (NRF). At the STF, the soft-sided containers were used for asbestos waste. The asbestos was double-bagged, per standard procedure, and the soft-sided containers were used to transport the bagged asbestos to the INEEL landfill. Using the soft-sided containers in this application provided an efficient way to package the asbestos waste and saved multiple trips to the landfill. In the other areas, the bags were used for miscellaneous low-level waste like concrete and debris (Figure 28). The use of the bags decreased the waste processing time required to size the pieces of waste. Users have been so impressed with the Lift-Liner™ bags that they have become the baseline technology for LLW disposal at the INEEL. The only exception is in cases where puncture is a risk, because rebar and other items can make holes in the soft-sided containers. Even in such cases, soft-sided containers can be used if protruding rebar is cut before loading or if sharp objects are loaded on top of other waste in the container.

The soft-sided containers are limited to LLW disposal and asbestos disposal at the INEEL. They are not currently used for Mixed Low-Level Waste and/or Hazardous Waste since there are specific requirements for handling, packaging, transporting and storing these types of wastes.

Figure 28. The soft-sided containers were filled with debris and soil at the INEEL STP.

Cost-benefit

The ITSR for the soft-sided waste container compared costs for packaging 260 ft^3 of soil in a soft-sided container versus metal boxes. One soft-sided container holds up to 260 ft^3 and costs $365. The metal boxes hold up to 96 ft^3 and cost $735 each. Therefore, approximately three metal boxes are required for each bag used. Table 7 outlines the costs summarized in Figure 11, Section 5 of the soft-sided waste container ITSR.

Table 7. Cost summary from ITSR for soft-sided containers.

Activity	Soft-sided Container Costs (based on one bag for 260 ft^3)	Metal Box Costs (based on 3 boxes for 260 ft^3)
Mobilize (container costs are major contributor)	$500	$2,355
Containerize	$301	$ 464
Demobilize	$ 94	$ 92
Total Cost	$895	$2,911

Total Cost per container	$895	$ 970
Unit Cost $/cubic foot	$3.44	$11.20

Unit Cost Savings ==> $11.20 - $3.44 = $7.76/cubic foot of waste

Since their demonstration, soft-sided containers have been used at several INEEL locations. The primary location of their use is the CFA STP decommissioning project. To date, 67 soft-sided bags of waste have been shipped to the RWMC for disposal. Up to 60 more bags may be required to complete the project. In addition, the ARA has filled 27 bags and plans to use one more this year. The NRF has also used two of these bags and the STF has used 18. Thus a total of 114 bags have been used at four INEEL locations at a cost of $102,030 (114 * $895). Up to 61 additional bags were planned to be filled during FY 1999, at a cost of $54,595.

For each of the bags filled, three metal boxes would have been needed. Thus 342 boxes would have been used at a cost of $331,740 (342 * $970) with another 183 needed the rest of the fiscal year at a cost of $177,510. Table 8 summarizes these costs.

Table 8. Comparison of low-level waste container costs.

	Current Usage		Additional FY- 1999 Usage Estimate	
Container Type	Number	Cost	Number	Cost
Soft- sided	114	$102K	61	$55K
Metal	342	$332K	183	$178K
Savings	$230K		$123K	

The estimated overall savings for soft-sided container use at the INEEL in FY- 1999 is $353,000. If the unit cost savings of $7.76 per cubic foot is applied to the projected INEEL LLW volumes for D&D Projects (RWMC LLW ==> 4,834,000 ft3 based upon the EMIP 1996 Parametric Model) the potential cost savings would be approximately ==> $7.76 $\times$ 4,834,000 = **$37,512,000.**

The 10-year INEEL EMIP D&D Parametric Model projected the waste streams for RWMC LLW at approximately 337,000 ft^3. It is assumed that 80% of this RWMC LLW would use the Soft-Sided Containers for waste packaging. The cost-benefit analysis indicated a baseline unit cost of $11.20/$ft^3$, and a Soft-Sided Container unit cost of $3.44/$ft^3$. This results in a unit cost saving for the Soft-Sided Containers of $7.76/$ft^3$. When applied to the 80% of RWMC LLW, the projected cost savings would be $2,092,000.

- 337,000 $ft^3 \times 0.80$ = 269,600 ft^3
- 269,900 $ft^3 \times$ $7.76 ft^3 = **$2,092,000 (Soft-Sided Containers estimated 10-year savings)**

Regulatory and Policy Issues

The Lift-Liner™ soft-sided containers meet U.S. Department of Transportation (DOT) requirements for transport of low specific activity contaminated objects (strong tight rule). The soft-sided containers are approved for disposal at the INEEL’s RWMC.

INEEL D&D and RWMC Operations personnel have been properly trained in the setup, packaging, handling, loading and unloading of the soft-sided containers. It is important that associated personnel receive proper training before working with these containers.

Observations and Lessons Learned

The following Lessons Learned are from both the ASTD deployment and the ITSR:

- Smaller debris and rubble should be placed on the bottom of the container to provide a base and pad for the larger debris. This prevents penetrations of the Soft-Sided container.
- Use of the manufacturer's hinged loading frame saved 65% of setup time.
- The soft-sided container top tie-down straps were originally too short for effective use by workers. The manufacturer lengthened these top tie-down straps to allow easy access.
- The soft-sided container had problems with stitching failure of the outside loading straps. The manufacturer solved this problem by sewing the lifting straps lower on the container walls.
- The polypropylene will degrade in approximately 1,200 hours based upon average sunlight and ultra-violet light degradation rates. If the soft-sided containers are to be stored outside for a significant length of time it is recommended that they be covered with a tarp.
- Soft-sided containers that were stored outside were susceptible to rodent damage since the polypropylene material can be readily chewed. The damaged soft-sided containers can be taped closed and/or be re-bagged. Directly depositing the containers in the RWMC, rather than storing them at the job site, will prevent this problem.

References

Innovative Technology Summary Report, April 1999, *The Soft-Sided Waste Container System*, Idaho National Engineering and Environmental Laboratory, LSDDP.

1996 EMIP Parametric Model for EM40 D&D Operations, Projected Waste Stream Data.

SPECTRO XEPOS XRF Analyzer

Technology Description

Before performing any decontamination or dismantlement work, D&D project crews must characterize the site. The results of the characterization are needed to set work objectives. Currently, D&D project managers rely on contract laboratories to provide results on environmental sampling for RCRA metals, volatile organics, and PCBs. Once the samples have been collected and sent to the laboratory, it may take as long as 90 days to receive the results.

The SPECTRO XEPOS X-ray Fluorescence (XRF) analyzer, is a technology that uses polarized XRF spectrometry to detect elements from sodium to uranium (Figure 29). The XEPOS also detects the presence of PCBs by using the presence of chlorine (Cl-) as an indicator of the possible presence of PCBs. If chlorine is present, PCBs may be present and samples must be sent to a laboratory for further testing. If no chlorine is present, no PCBs are present. Small samples are taken in the field and transported to an on-site location for analysis. Before analysis, sample material is ground up and mixed uniformly to ensure accurate results. However, no digestion process is needed, eliminating the possibility of procedural error associated with sample preparation. A technician can easily be trained to grind and mix the sample material in minutes, while digestion procedures require much more training to ensure samples are properly prepared. At the INEEL, the samples are ground and mixed using a special mill. A binding agent is then added to the powder and the substance is pressed into a pellet, which is analyzed.

The XEPOS provides simultaneous determination of the elements present in a sample. The system can be set up with multiple internal standards that are matrix matched for various media such as soils, water, coatings, biological materials, etc. In addition, the sample analysis can be completed the same day the samples are collected, providing a near real-time output for the user.

Specific advantages of the SPECTRO XEPOS include:

- A much faster turnaround on the sample results, resulting in acceleration of D&D schedules and cost savings.
- Smaller samples required (4 grams versus hundreds of grams) so samplers are exposed to hazards for a much shorter duration.
- No digestion process required on samples.
- Data quality equivalent to laboratory analysis.

Figure 29. The Spectro XEPOS XRF Analyzer is a bench-top field deployable unit.

Performance

Performance at the INEEL ASTD

The SPECTRO XEPOS XRF Analyzer was demonstrated as part of the INEEL LSDDP in November 1999. It has been deployed regularly since the demonstration. Although the winter is normally a time that the D&D work slows down at the INEEL, a total of nine deployments at six different locations were completed between December 1999 and April 2000.

The first deployments were in December 1999 at the CFA STP. A water sample was screened for chlorine, and none was detected, indicating it was PCB-free. No laboratory analysis was completed. In addition, two oil samples were screened, and chlorine was present. These samples were then sent to a contract laboratory, which did not find PCBs. A third deployment occurred in December 1999 at TRA 641. Two paint samples were screened and found to contain chlorine. These samples were sent to the laboratory to confirm the presence of PCBs.

The next two deployments were on samples from the Initial Engine Test Facility. Two oil samples were screened, and chlorine was found. In this case, no laboratory analysis was completed, and the oil was treated as PCB waste. In addition, six soil samples, some with oil contamination, were screened. The soil samples contaminated with oil were found to contain chlorine, and this soil was treated as PCB waste. The other soil samples were not found to contain chlorine. In this case, no confirming laboratory analysis was completed.

During February 2000, two paint samples from TRA 654 and two paint samples from the old fire station were screened, and chlorine was detected. Paint samples from these locations were then sent to the laboratory. During April 2000, one soil sample was tested from the STF. No chlorine was detected, and no laboratory analysis was completed. An oil spill was also tested at this facility in April. A small chlorine peak was indicated, and a confirming sample was sent to the laboratory.

This totals 19 samples completed on a variety of materials with nine of these samples being sent to the laboratory for a confirming analysis. Figure 30 shows how samples are placed in the Analyzer.

Figure 30. Samples are placed in the Spectro XEPOS XRF Analyzer.

Cost-benefit

This cost-benefit calculation is based on the deployment of the XEPOS SPECTRO XRF Analyzer at 6 different locations for 9 separate deployments. Nineteen samples were analyzed with nine being sent for a confirming laboratory analysis, resulting in a reduction of 10 laboratory samples. The cost-benefit information in the draft ITSR (XRF Analysis of PCBs and Inorganics) was used to complete this analysis.

Assumptions are as follows:

In the ITSR, the amortized purchase price of the SPECTRO XEPOS Analyzer was $70.09/hr including $24.19/hr for annual costs for repair/maintenance/calibration (not for labor during work) based on an equipment cost of $63,072. The amortized cost does not include the INEEL General and Administrative costs (27%), material handling costs (5.3%) and PIF costs (4.5%). Since this can be a significant amount on a large purchase, the additional cost due to these adders was figured. A 20-year service life and 124 hr/yr usage rate was assumed.

The overall purchase cost (P) is $63,072*1.27*1.053*1.045 = $88,142

$$X \ \$/yr = P(\{1-(1+I)/[1-(1+I)^{N}]\} + I)$$

$$X = \$88,142\{(1-1.058)/[1-1.058^{20}] + 0.058\}$$

$$X = \$88,142 * 0.0858$$

$$X = \$7,560/year \text{ or } (\$7,560/yr)/124 \text{ hr/yr} = \$60.96/hr$$

When the maintenance labor cost is added, the usage cost of the analyzer is:

$60.96/hr + $24.19/hr = $85.16/hr

The costs for mobilization, demobilization and disposal of the innovative and baseline techniques were the same for these applications; therefore, only the characterization portion was calculated. Using an analyzer usage rate of $85.16/hr and increasing the labor rates by the G&A costs yields a cost of $48.98/sample for characterization with the XEPOS. The adjusted baseline cost (with G&A added to labor) was $1,030.38/sample. The savings per sample is then $1,030.38 - $48.98 = $981.40/sample.

Although 19 samples were analyzed with the innovative technique, laboratory analyses were still required on 9 of them. Therefore, the savings will be based on the 10 samples not sent for laboratory analysis.

$981.40/sample * 10 samples = $9814 savings during the 6-month deployment period.

In addition, using this field screening technique resulted in less quantifiable advantages, such as a shortened schedule and reduced radiation exposure.

As the site personnel become more familiar with this equipment its use will increase, even beyond D&D use. It is conservatively estimated that it will reduce laboratory analyses by at least 50 samples per year. At a savings of $981/sample this is a savings of $49,050 per year or $490,500 over a 10-year period. This makes the payback period for the equipment (plus adders) approximately 1.8 years.

Regulatory and Policy Issues

Federal regulations associated with a radiation-generating device must be followed. At the INEEL, the owner must comply with procedures relating to the control and registration of radiation-generating devices. These procedures detail the necessary training required for operators and the postings necessary for the area. In addition, proper training for the sampling and analysis technicians is required to ensure accurate sample results and safety.

Observations and Lessons Learned

The SPECTRO XEPOS performed well during these deployments. The lessons learned were the same as are noted in the ITSR. Besides those already mentioned on the system advantages, the following were noted:

- It is recommended that paint or coating samples be ground up into a powder before analysis to obtain consistent results.

- A simpler method of exporting the data generated by the SPECTRO XEPOS would aid the user in being able to quickly incorporate data into spreadsheets and documents.

References

Innovative Technology Summary Report, September 2000, *XRF Analysis of PCBs and Inorganics*, Idaho National Engineering and Environmental Laboratory, LSDDP.

Surveillance and Measurement System

Technology Description

Before performing any decontamination or dismantlement work, D&D project crews must characterize the site. The results of the characterization are needed to set work objectives. Currently, D&D project managers rely on handheld detectors to identify radioactive contamination in hazardous environments. These detectors do not provide isotopic characterization. For isotopic analysis, samples must be sent to a contract laboratory. Laboratory analysis typically costs about $150 per sample and results may not be available for weeks or even months.

The Surveillance and Measurement System (SAMS) produced by Berkeley Nucleonics identifies isotopes with a thallium-activated sodium iodide detector (Figure 31). Combined with a time-slicing, data compression technique, the detector facilitates shorter acquisition times, accurate identification, and spectroscopic capabilities. SAMS can identify multiple isotopes in one-second intervals because of a data compression technique it uses called Quadratic Compression Conversion. The instrument alone detects up to 70 different radionuclides and can detect up to 95 with the addition of a neutron detector.

The standard model 935, which costs $7,500, includes a 1.5-in. × 2-in. thallium-activated sodium iodide crystal. Two other crystal sizes are available: 2 × 2-in. and 3 × 3-in. Operators at the INEEL use the 3 × 3-in. version, which costs about $10,000.

Advantages of the SAMS 935 include:

- Instant results
- Number of required lab samples lessened by a factor of 5 or 6
- Significant reduction in worker exposure
- Provides isotopic information unavailable with other handheld detectors
- Portability and decreased weight allow more measurements in a shorter time period
- Significant savings.

Figure 31. Surveillance and Measurement System (SAMS) Model 935.

Performance

Performance at the INEEL ASTD

The Surveillance and Measurement System was demonstrated as part of the INEEL LSDDP project in April 2000. ASTD project personnel began tracking deployments in June 2000 and continued through August 2000.

Workers used the SAMS full-time during the months of June, July, and August, completing a total of 557 samples (Figure 32). During June, workers performed 44 scoping surveys at TAN using the SAMS. They then calibrated the instrument to do quantitative surveys, and analyzed 36 more samples, which were also sent to a laboratory to confirm results. In July, personnel continued to use the SAMS at TAN to characterize 125 more samples, 55–60 of which were sent to a lab. They also characterized approximately 80 samples at the INEEL's ARA-II. Between July 26 and August 10, workers analyzed 272 additional samples at ARA-II. The SAMS deployments at the ARA-II are in an area where an old sewer line/system was being excavated. They used the SAMS to determine the location, distribution and depth of Cs-137 contamination in the pipe trench soil after the sewer line had been removed (the SAMS was deployed using an ANDROS robot to ensure personnel safety). They completed 1,000 ft of trench and only found contamination in one spot, which is believed to have come from surface soil contamination falling into the trench. Laboratory analysis sampling was done inside the lines and septic tank. Plans are in place to use SAMS again on a hot line to the ARA-16 tank later in the D&D work.

Cost-benefit

This cost-benefit calculation is based on the deployment of the Surveillance and Measurement System at two locations. Of the 80 samples characterized in June, 36 were also sent to a laboratory; 44 were not. In July, personnel sent 55–60 of the 125 samples tested at TAN to the laboratory. The number of samples from ARA sent to a contract laboratory for further analysis was not available; however, operators estimated that the number of lab samples was reduced by a factor of 5 or 6. So, of the 80 samples tested in July at ARA, it is conservatively assumed that 1/5, or 20%, (.2*80 = 16 samples) of the samples were also sent to a lab. In addition, 20% of the 272 August samples (.2*272 = 54.4 = 54 samples) were also analyzed in a lab. The cost-benefit information in the ITSR (*Surveillance and Measurement System (SAMS)*) was used to complete this analysis.

Figure 32. SAMS 935 in Operation.

The total cost of hand sampling and laboratory analysis for 18 samples was calculated to be $6,277. SAMS total cost was figured as $1196. These costs do not include the General and Administrative (G&A) tax or the PIF, which are added at the INEEL. G&A is 27%, and PIF is 4.5%; together, these costs add an additional 33% (cost*1.27*1.045 = cost*1.33) to the price of equipment and to the cost for labor, so 33% is added to each of the figures calculated for the 18 samples completed in the Large-Scale Demonstration. Baseline cost for 18 samples now becomes $6277*1.33 = $8,248. SAMS cost for 18 samples is $1,196*1.33 = $1,591. Dividing each of the costs by 18 yields cost per sample; for the baseline: $8,248/18 samples = $458.22/sample, and for SAMS: $1591/18 samples = $88.39/sample. The difference between the per sample costs is the savings per sample from using the SAMS. Using the SAMS 935 saves $458.22-$88.39 = $369.83 per sample.

Adding the number of samples from June, July, and August at TAN and ARA yields a total of 80+125+80+272 = 557 samples. The number also sent to the laboratory is subtracted to calculate the number of samples analyzed only by the SAMS 935. The total number of samples sent for lab analysis is 36+55 to 60+16+54 = 161 to 166. The larger number will be used in order to provide a more conservative savings estimate. 557-166 = 391 samples were analyzed using the innovative technology. Based on this information, the **total savings from June to August 2000 becomes $144,603.53** ($369.83/sample*391 samples).

The ITSR included an estimated use per year of 800 hours. Analyzing a sample using the SAMS 935 takes about 10 min, which equates to 6 samples per hour. 800 hours*6 samples/hour = 4800 samples. During three months of use at the INEEL, the SAMS was used for 557 samples. Using the SAMS throughout the year at this level would result in approximately 2500 samples taken. This more conservative number will be used to estimate the 10 year cost savings. Estimating that 20% will be sent to the lab yields a total of 2500 (1-0.2) = 2000 samples analyzed only by SAMS. At a rate of $369.83/sample, this is a saving of $740K per year or **$7.4 million over the next 10 years.**

Regulatory and Policy Issues

There are no known risks associated with using the SAMS 935 unit; however, D&D Project managers using the SAMS must access CERCLA sites and radiation areas. To enter CERCLA sites or radiation areas at the INEEL, workers are required to have Radiation Worker I or Radiation Worker II training, in addition to 40-hour OSHA training. If the SAMS is to be used for regulatory purposes, it must be calibrated on a regular basis, according to company policy.

Observations and Lessons Learned

The SAMS costs about $10,000, whereas lab samples cost $150 each. Based on these numbers only, the cost of the SAMS is recovered after 66 samples. However, other factors make the cost recovery even more rapid. These factors are the time and costs saved by the instant sample results SAMS provides, and the elimination of shipping costs associated with sending samples to a lab.

Other items to consider include:

- The device is capable of internally storing characterization results, but it needs user-friendly software to easily download results to a personal computer
- Baseline technologies are preferable where alpha and beta radiation emitters are present
- Because SAMS is extremely sensitive, it is necessary to either take background radiation levels into account or to have portable shielding to block background radiation from measurements.

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Track-Mounted Shear

Technology Description

The baseline technology for dismantling pipe and wall fixtures is workers standing on scaffolding and operating hand-held cutting tools like torches, hand-held shears, and saws. The materials being removed must be rigged to prevent falling, and slowly lowered to the ground.

The track-mounted shear is operated from the cab, which is located at a distance from the work surface, removing operators from the immediate demolition area. The shear used a John Deere 450 LC track-mounted excavator with a Pemberton PES-II 700R shear (Figure 33). Other equipment specifications include:

- Excavator powered by 6101-A John Deere turbo-charged/after-cooled diesel engine developing 285 SAE net horsepower.
- Base unit weight 95,700 lb (with secondary 3,500 lb. auxiliary counter weight).
- 12-ft, 10-in. arm weighing 5,425 lb.
- 2.63 yd^3 bucket weighing 4,460 lb.
- Jaw opening of shear is 35.5 in.
- Jaw depth of shear is 37.5 in.
- Shear rotation is 360 degrees.
- Shear weight is 15,100 lb.
- Shear machine rating of 83,000 to 105,000 lb.

Figure 33. The track-mounted shear was used for D&D activities at FEMP.

Benefits of this technology include:

- Increased worker safety.
- Reduction of personnel radiation exposure.

Performance

The Track-Mounted Shear, procured by the FEMP via the ASTD ID&D project, was first deployed for heavy steel and component segmentation during the D&D of the Cylinder Filling Station (38B) and Cylinder Filling Station (38A). Following the completion of the D&D of these two facilities, the track-mounted shear was instrumental in the D&D of the Fernald Sewage Treatment Plant Complex. By using this ASTD- procured piece of equipment, the Sewage Treatment Plant Complex D&D project was able to avert $97K in equipment rental costs. The Track-Mounted shear was subsequently used for heavy steel and component segmentation on four more Fernald facilities that were D&D'd under this ASTD project. The field manager for this ASTD project and the operator of the Track-Mounted shear had very positive feedback on the new technology. Both commented on how easily the shear was able to segment, remove and place heavy steel members and elements directly into waste containers safely and efficiently. The long reach of the shear allowed the operator to remain safely out of harms way during operation. The overall D&D work was completed much more safely and efficiently compared to the other, baseline method.

This technology could have applications in areas of very high risk for demolition operations, (e.g., the potential for collapse of the facility onto the equipment is high). Another use of this equipment is where the radiation fields are high enough to warrant removal of the personnel from the immediate area due to ALARA concerns and the potential for higher than desired operator dose rates.

Cost-benefit

Fernald ASTD Deployment Costs included the following:

Buildings	Actual Cost
38A, 38B	$127,092
24B, 3F, 3G	$157,186
22A, 8F, 39C, 45B	$ 67,738
Total Actual Costs	$352,016

Fernald 1996 Engineering Cost Estimates:

Description	Estimated Cost
3F, 3G, 39C	$227,168
24A, 38A, 38B	$295,801
8F	$ 7,280
22A, 45B	$ 23,155
Total Estimated Costs	$553,404

Therefore, this shows **cost savings for all Fernald ASTD deployments of 36.4% or $201,388.** This cost analysis reflected the cost savings of the Track-Mounted shear, Oxy-Gasoline torch, and the Hand Held shear at FEMP. There was no delineation of breakdown according to technology available from the Fernald Site. The deployments were accomplished in a significantly shorter period of time than originally planned. This was due in large part to the effectiveness of the deployed ASTD technologies.

To determine the unit cost savings, the following estimate was then completed.

Equipment Cost:

$340,000 John Deere 450 LC track-mounted excavator
$111,000 Pemberton PES-II 700R shear (purchased by EM-40).

$451,000

Assuming a 10-year life of the equipment, since heavy use wears the equipment relatively quickly, the Equipment Depreciation/Equipment Cost per Hour was calculated as follows:

$$X\ \$/yr = P\left(\{1-(1+I)/[1-(1+I)^{N}]\} + I\right)$$

$$X = \$451{,}000\ \{(1-1.058)/[1-(1.058)^{10}] + 0.058\}$$

$$X = \$\ 451{,}000 * 0.083$$

$$X = \$37{,}433/\text{year or } (\$37{,}433/\text{yr})/1{,}000\ \text{hr/yr} = \$37.43/\text{hour}$$

Assuming that the project lasted approximately 3 months or approximately 420 hours, the cost of the equipment would be:

$37.43/hour × 520 hours = $19,464

The Revised/Adjusted Cost Savings would be $201,338 - $19,464 = $181,924

Therefore the Hourly Unit Cost Savings would be $181,924/1,000 hours = $181.92/hr.

Regulatory and Policy Issues

There are no other known regulatory restrictions associated with the use of the remote controlled demolition equipment other than the standard federal regulations on worker protection and equipment safety found in the OSHA regulations. These specific OSHA regulations are listed below:

OSHA 29 CFR 1926		OSHA 29 CFR 1910	
1926.300-.307	Tools–Hand and Power	1910.211-.219	Machinery & Machine Guarding
1926.400-.449	Electrical–Definitions	1910.241-.244	Hand & Portable Power Tools
1926.28	Personal Protective Equipment	1910.301-.399	Electrical Definitions
1926.52	Occupational Noise Exposure	1910.95	Occupational Noise Exposure
1926.102	Eye and Face Protection	1910.132	General Requirements (PPE)
1926.103	Respiratory Protection	1910.133	Eye and Face Protection
1910.149	Control of Hazardous Energy		

Observations and Lessons Learned

The following observations were made during the Track-Mounted shear deployment:

- The Track-Mounted shear is a large powerful piece of equipment that is not well suited to working in confined quarters. It must have room to rotate about its axis as it performs D&D work.

- The blades of the shear must be kept in the proper adjustment to prevent small pieces of steel and debris from becoming lodged between the blades.

- To prevent a release of hydraulic oil during the first 100 hours of operation, the hydraulic hose fillings on the shears need to be periodically checked to ensure they are not working themselves loose.

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Appendix A

ASTD ID&D—Technology Fact Sheets

Appendix B

ASTD ID&D Project Overall Fact Sheet