INNOVATIVE TECHNOLOGY
Summary Report

DOE/EM-0534

E-Perm® Alpha Surface Monitor

Deactivation and Decommissioning
Focus Area

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

May 2000

INNOVATIVE TECHNOLOGY
Summary Report

E-PERM® Alpha Surface Monitor

OST/TMS ID 2315

Deactivation and Decommissioning
Focus Area

Demonstrated at
321-M Fuel Fabrication Facility
Large-Scale Demonstration and Deployment Project
Savannah River Site
Aiken, South Carolina

INNOVATIVE TECHNOLOGY
Summary Report

Purpose of this document

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

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

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

All published Innovative Technology Summary Reports are available on the OST Web site at http://ost.em.doe.gov under "Publications."

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SECTION 1

SUMMARY

The E-PERM® Alpha Surface Monitor is an integrating electret ion chamber used to measure alpha radiation on all types of surfaces. The technology is best suited for use on surfaces with low contamination levels such as areas with potential for free release, but can also be used in areas with higher levels of contamination. Measurement accuracy and production of the E-PERM® Alpha Surface Monitor compared favorably with the baseline technology, i.e., hand probe and smear, during its demonstration at the Savannah River Site's 321-M Fuel Fabrication Facility. As demonstrated, the productivity of the improved technology is about 35% higher than the baseline, but costs slightly more. The average unit cost per reading for the electrets is $2.45 vs. $2.01 for the baseline surveying method. However, the E-PERM® Alpha Surface Monitor can offer the following advantages: ALARA considerations, reduction of operator error, use in limited access areas, and lower detection levels. Technology selection officials; therefore, should consider deploying the electret ion chambers as part of an overall characterization strategy.

■ Technology Summary

The E-PERM® Alpha Surface Monitor is a small, stand alone, integrating electret ion chamber (EIC) used to measure alpha radiation on surfaces of materials. The system is composed of a small ion chamber with a mylar window to contain the ions produced by the interaction of alpha radiation with air and a sensor to collect and measure the ions produced. A separate microprocessor provides the hardware to measure and process data.

Problem

Many Department of Energy sites have a need to quickly and cheaply characterize surfaces for uranium, plutonium, and other alpha emitting radionuclides. A method that minimizes waste, reduces personnel exposure, and reduces costs is needed to efficiently characterize excess facilities.

How It Works

When ionizing alpha radiation from a contaminated surface enters an electret ion chamber, the radiation causes ionization by stripping electrons from atoms of air in the chamber. The ejected electrons are attracted to a positively charged piece of Teflon®, called the electret, mounted inside a chamber. The electrons collect on the surface of the electret and neutralize its charge. After the designated exposure time has elapsed, the electret is removed from the chamber. Using a portable charge reader, the electret's final voltage is read. The difference in the electret's initial and final voltages is a function of exposure time and the alpha contamination level to which the unit has been exposed. After the charge reader measures the change in the electret's voltage, the data are used to calculate the contamination level. Data can be downloaded to a personal computer to provide databases and aid in reporting.

Potential Markets

In addition to SRS, Oak Ridge National Laboratory, Rocky Flats, Fernald, the Nevada Test Site, Hanford, and the Tonopah Test Range have the need to characterize surfaces with alpha producing radionuclides.

Figure 1. SPER2 Microprocessor, electret, and 180 cm^2 ion chamber.

Advantages Over the Baseline

At the Savannah River Site, the baseline technology is the hand probe and smear method. The advantages of the E-PERM® Alpha Surface Monitor are:

- Simple to use and analyze. Semiskilled technician sufficient.
- Small size and weight. Units can be easily located in difficult-to-reach areas. Units can be placed on floors, walls, and ceilings.
- Minimizes personnel exposure. Units can be set in position and left until exposure time is complete. Technician does not stay in radiation area during survey.
- Eliminates operator error and fatigue.
- Microprocessor collects, stores, and analyzes data to make reporting easier and quicker.
- Robust technology. The electrets are unaffected by shock, humidity, and temperature.
- Capable of measuring very low contamination levels (<10 dpm/100cm^2)

Limitations of Technology

Surfaces where the EIC's are placed should be relatively flat and smooth to form an enclosed space within the EIC. Gaps between the EIC and surface being monitored may cause erroneous readings.

Demonstration Summary

The E-PERM® Alpha Surface Monitor demonstration was held in the 321-M Fuel Fabrication Facility located at the Savannah River Site (SRS) during the period June 16, 1999 to August 24, 1999. The 321-M facility was used to manufacture fuel and target assemblies for irradiation in the site's production reactors. The facility was deinventoried in 1995, leaving the process area a high contamination area, contaminated with highly enriched uranium. Other parts of the building remain posted radiological areas with lower levels of contamination. Some overhead areas have low level contamination. During deactivation of the facility, surveys are necessary to establish the contamination levels in the facility.

Key Results

The key results of the innovative technology demonstration are:

- Measurements with the EIC's showed satisfactory agreement with the baseline technology and NIST traceable standards.
- Productivity was higher than the baseline.
- The cost of performing characterization work with the EIC's is slightly higher on average than the baseline; however, the unit cost of the EIC's should decrease for projects with large numbers of readings.
- In addition to those advantages listed above, there is no radioactive waste produced and measurement accuracy can be improved with longer exposure times if necessary.
- The EIC's are most efficient in areas where access with the baseline technology is difficult or limited (e.g., overheads, gloveboxes) and for final surveys using the MARSSIM guidelines.
- The EIC's are capable of measuring contamination levels below the practical range of the baseline.

Regulatory/Policy Issues

None

Availability

The E-PERM® Alpha Surface Monitor is available from Rad Elec Inc.

Future Plans

The E-PERM® Alpha Surface Monitor technology will become an alternative to the hand probe and smear method of characterization at SRS. The technology may be used when technology capabilities meet job requirements and objectives.

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Licensing Information

No licensing or permitting activities were required to support this demonstration.

Web Site

The 321-M LSDDP Internet address is **http://www.srs.gov/general/srtech/lstd/index.htm**
The Deactivation and Decommissioning Focus Area Internet address is **http://www.netl.doe.gov/dd**

Other

All published Innovative Technology Summary Reports are available online at http://em-50.em.doe.gov. The Technology Management System, also available through the EM50 Web site, provides information about OST programs, technologies, and problems. The OST Reference # for the E-PERM® Alpha Surface Monitor technology is 2315.

SECTION 2

TECHNOLOGY DESCRIPTION

Overall Process Definition

The E-PERM® alpha monitor is a small, stand alone, integrating electret ionization chamber (EIC). The E-PERM® alpha monitor consists of:

- An electret
- The ion chamber housing
- A portable electret voltage reader.

When ionizing alpha radiation from a contaminated surface enters the ion chamber through a thin aluminized mylar window, the radiation causes ionization by stripping electrons from atoms of air in the chamber. The ejected electrons are attracted to the electret mounted inside the ion chamber. The electrons collect on the surface of the electret and over time partially neutralizes the initial charge.

After the exposure time has elapsed, the electret is removed from the chamber and it's final voltage measured using an electret charge reader. The difference in the electret's initial and final voltages is a function of the alpha contamination level it has been exposed to and the time of the exposure. The voltage drop and exposure time are converted to contamination levels by either a hand-held computer or a microprocessor reader that can provide immediate contamination levels in dpm/100 cm^2.

Electret

The electret is a positively charged Teflon® disc that serves as both the source of an electrostatic field and a sensor. The electrets are very stable and are unaffected by shock, humidity, temperature, and will hold charges for long period of times if not exposed to ionizing radiation. The electret is available in the following thicknesses and sensitivities:

- 0.127 mm (long-term exposure, low sensitivity)
- 1.524 mm (standard sensitivity)
- 4.572 mm (short-term exposure, high sensitivity).

The vendor is available to assist in selection of the electret most appropriate for a given application.

Each electret can be used for multiple measurements. The number of measurements depends on the voltage drop for each measurement. Each electret has an initial charge of approximately 700 volts and can be used down to approximately 200 volts. Acceptable readings can be made with a minimum drop of 15-20 volts. During the demonstration, a 30 volt drop gave accurate measurements. In general, the higher the voltage drop, the better the accuracy. Once the electret has been fully discharged, it cannot be recharged and must be discarded.

Ion Chamber

The ion chamber provides a holder for the electret and a chamber for containing the ions produced by the alpha radiation. Ion chambers are available in two sizes: 1) 48 cm^2, and 2) 180 cm^2. The chambers are made of electrically conducting plastic and have windows covered with a thin aluminized mylar film to protect the electret from dust and other particles. Other materials may be used as window covers for background measurements and measurements of other radionuclides.

Electret Voltage Reader

There are two electret voltage readers available. A hand held reader, called the SPER1 is suitable for relatively small numbers of electret measurements. It is easily protected from contamination in contaminated areas. The voltage readings, electret serial numbers, locations, deployment times, and contamination levels must be manually recorded and calculated.

The SPER2 Microprocessor Electret Reader is designed to manage data associated with large numbers of measurements. The reader is combined with a barcode reader and computer hardware that stores measurement data. The data can be downloaded to a personal computer (PC) to calculate contamination levels and create databases and reports. The unit is packaged in a rugged case and can be used in the field for onsite measurement. It is recommended that the unit not be taken into highly contaminated areas.

Figure 2. SPER2 Microprocessor, electret, and 48 cm^2 ion chambers

Goals and Objectives

The goals and objectives of the E-PERM® demonstration were to:

- locate and quantify HEU contamination in selected areas of 321-M
- compare and evaluate the technology against the baseline hand probe and smear surveys
- provide sufficient data to facilitate deployment at SRS and throughout the DOE complex

The E-PERM® technology has potential for use at any DOE facility that has alpha contaminated surfaces.

System Operation

The E-PERM® EIC is a passive detector that requires no external electrical power or batteries. The ionization chambers, with electrets installed, are small, lightweight chambers that can be easily affixed to most flat surfaces. The 48 cm^2 ionization chambers are approximately 1 5/8 in. (4 cm) high by 3 1/4 in. (8 cm) in diameter. The 180 cm^2 chambers are approximately 3 1/4 in. (8 cm) high by 7 5/16 in. (19 cm) in diameter. The chambers and electrets weigh only 6 to 8 ounces.

A typical sequence of activities to measure alpha contaminated surfaces is as follows:

1. Make initial electret voltage readings using SPER2 data logging reader and barcode reader. This initial reading records the electret serial number, location, initial voltage, and initial time. The time can also be manually entered to accurately record the electret placement time.

2. Load electrets into the ion chambers.

3. Determine approximate exposure time and deploy detectors at selected locations. Exposure times will depend on the contamination level; times must be long enough to effect a voltage drop of about 30 v. A few hours will be sufficient in areas with higher contamination levels. For very low contamination levels, overnight exposures may be used. In these cases, the detectors may be deployed in the afternoon and removed the next morning. Record electret serial number and location

4. After exposure time has elapsed, collect detectors. Electrets should either be removed from the ion chambers or covers placed on the chambers to prevent additional exposure of the electret.

5. Make final electret voltage readings using SPER2 data logging reader and barcode reader. The final reading provides the final voltage readings and times required to compute contamination levels.

6. Connect the SPER2 reader to a PC and download data for reporting purposes.

7. For every 10 detectors deployed, one beta/gamma background detector should be deployed and analyzed the same way as the other detectors in order to quantify contamination levels from alpha sources only.

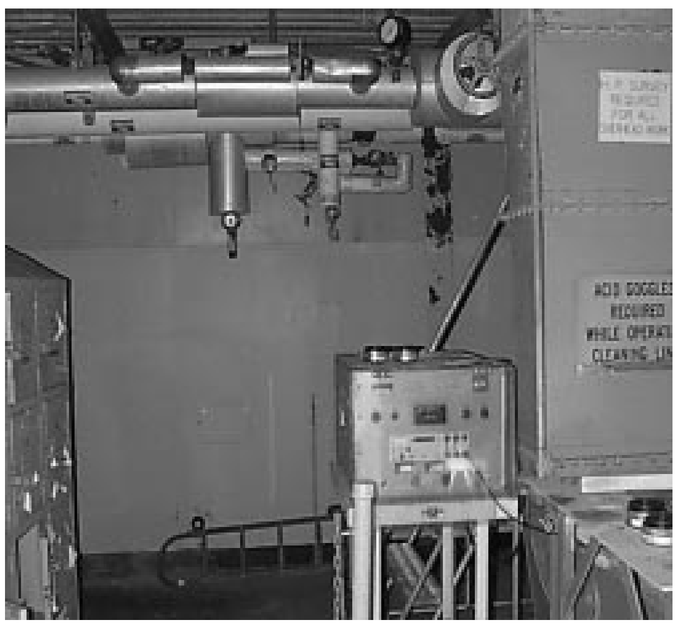

Figure 3. Electret Ion Chambers placed in 321-M's Tube Cleaning Room

Manpower Skills and Training Requirements

The EIC's and SPER2 microprocessor are simple and easy to use and require no special operator training. A short, 2-hour orientation session, given by the manufacturer, is normally sufficient.

Secondary Waste

The electrets do not normally come in contact with contaminated surfaces. Spent electrets would normally be clean waste. The ion chambers may be contaminated on the external surfaces in contact with contamination, but may be decontaminated if necessary. If decontamination is not possible, the ion chambers may become low level waste. There is no hazardous waste created by the technology.

SECTION 3

PERFORMANCE

Demonstration Plan

The demonstration of the E-PERM® alpha monitor was performed in the following locations in Building 321-M:

- Component cleaning room
- Tube cleaning room
- Billet Assembly and Weld Area
- Overhead ducts, electrical, and structure

The component cleaning room is a contamination area (CA). The tube cleaning room and billet assembly and weld area are posted as radiological buffer areas (RBA). The building overheads have isolated contamination areas.

In the component cleaning room and tube cleaning room, surveys were repeated with both the 48 cm^2 and 180 cm^2 ionization chambers for comparison. Each size was deployed in identical locations to compare final readings and deployment times.

Performance Objectives

The primary objective of this demonstration was to evaluate the capabilities and performance of the E-PERM® alpha monitor. The elements of the demonstration were:

- Locate and quantify HEU contamination in selected areas in 321-M
- Compare and evaluate the EIC's against the baseline hand probe and smear surveys, i.e., productivity, cost, dose reduction, etc.
- Provide results so that the technology can be considered for deployment across SRS and throughout the DOE complex.

Results

Results were evaluated for the following studies:

a) In the component cleaning room and tube cleaning room, surveys were repeated with both the 48 cm^2 and 180 cm^2 ionization chambers for comparison;

b) Contamination of ten hot areas in the component cleaning room was measured with the 48 cm^2 and 180 cm^2 ionization chambers, and the measurements were evaluated against contamination estimates from baseline hand probe surveys; and

c) The precision of measurements with the 48 cm^2 and 180 cm^2 ionization chambers was determined using standard sources.

Figure 4. Positioning of Large Chamber EICs in Component Cleaning Room.

Alpha measurements were performed with both the 48 cm^2 and 180 cm^2 ionization chambers in the component cleaning room and tube cleaning room. Each size was deployed at the same locations to compare final readings and deployment times. Twenty-five chambers and three background chambers of each size were used to measure twenty-five locations in each room. The background chambers contained a carbon coated Tyvek window to remove alpha radiation. The exposure time for the 48 cm^2 chambers was 22 hours, while the 180 cm^2 chambers were exposed for 6 hours.

A comparison of results for the small and large electret ionization chambers is shown in Table 1. Since the large chambers (LC) measured about four times the area that the small chambers (SC) measured, the results are not directly comparable. Both chambers verified that the contamination was below 100 dpm alpha/100 cm^2 for forty-six of these areas. Also, both chambers measured the contamination levels for four of the areas to be above 100 dpm alpha/100 cm^2 with agreement to within a factor of two (SC/LC = 1.5). This agreement is considered acceptable, since different, but adjacent areas of the same general location were measured.

Table 1. Comparison of Large Chamber (LC) and Small Chamber (SC) EIC Results for the Component Cleaning Room (CCR) and Tube Cleaning Room (TCR)

Area Surveyed	Average Results SC ($dpm/100cm^2$)	Average Results LC ($dpm/100cm^2$)	SC/LC Data (4)>100 $dpm/100cm^2$	Average Probe Survey ($dpm/100cm^2$)
CCR (25 low alpha locations)	77	73	1.5	
TCR (25 low alpha locations)	11	13		
CCR (10 hot areas)	654	780		724

Contamination of ten hot areas in the component cleaning room was measured with the 48 cm^2 and 180 cm^2 ionization chambers, and the measurements were evaluated against contamination estimates from baseline hand probe surveys. Background measurements were performed at the locations where the ambient radon and gamma radiation was high enough to contribute to the response of the electret ionization chambers. Again, since the large chambers measured about four times the area that the small chambers measured, the results are not directly comparable.

In general, the electret ionization chamber (EIC) results showed about the same level of contamination as the hand probe surveys. In a few instances, the agreement between the hand probe and EIC results showed a variation greater than a factor of two, but this would be expected since the contamination is not uniformly distributed in these areas.

The 48 cm^2 ionization chamber had advantages of a lower background and less sensitivity for high level contamination measurements. However, the 180 cm^2 ionization chamber had the advantages of a shorter exposure time, a larger measurement area, and was more sensitive for low level contamination areas.

Based on duplicate measurements of NIST traceable standard alpha sources, the measurement precision for voltage changes of about 40 volts was determined to be better than 3% for the 48 cm^2 chambers and better than 4% for the 180 cm^2 chambers.

Both the 48 cm^2 and 180 cm^2 ionization chambers were able to show that contamination was below 100 dpm/100 cm^2 alpha (uranium–235), and the results showed satisfactory agreement with readings from hand probe surveys. Results from these studies support the potential use of this technology as a method to measure alpha (U-235) surface contamination at SRS and throughout the DOE complex.

SECTION 4

TECHNOLOGY APPLICABILITY AND ALTERNATIVES

Competing Technologies

The hand probe and smear method is the baseline technology usually selected for measuring alpha contamination on material surfaces.

Hand probe and smear method disadvantages include:

- Accuracy is dependent on operator technique. Probe scanning speed and distance to the surface being scanned determine the accuracy of the method. Sensitivity decreases markedly when scan speed and distance is increased.

- Probing of large surface areas may become tedious and prone to operator error. Accuracy and productivity may decline after several hours of surveying.

- The alpha scintillation detectors used in hand probing are fragile. The mylar window is easily punctured and requires replacement. Calibration and maintenance are routine tasks.

- Hand probe and smear is a slow process requiring manpower to scan, count smears, and write reports.

- Release limits in free release surveys may be below the detection capabilities of hand probes or the time to make reliable readings may be prohibitive.

Technology Applicability

The E-PERM® EIC technology addresses the aforementioned disadvantages of the baseline technology. The EIC eliminates the potential inaccuracies caused by operator technique and has potential for reducing the overall manhours required for the surveying process. Since the EIC's are passive detectors, they can be placed in position and left until the monitoring time is complete. An operator does not remain in the area and is free to perform other work. Data are stored in the SPER2 microprocessor during the initial and final voltage readings. The data can be downloaded to a PC and used to reduce the manhours required to manually create final survey reports. Additional advantages and benefits of the EIC's are shown in Table 2 on the next page.

Measurement applications include:

- Measurement of contaminated surfaces and swipes

- Measurements for free release of contaminated sites

- Secondary verification of other monitoring systems

- Ideal for monitoring large areas using the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidelines.

Table 2. Advantages of E-PERM® ALPHA SURFACE MONITOR

FEATURE	ADVANTAGES	BENEFITS
Passive Detector	No moving parts or batteries	Low equipment costs. In situ measurements. Electrets can be used numerous times. Ion chambers can be used indefinitely.
Integrated Measurements	Detect low contamination levels	Extended measurements Free release limits
Robust Technology	Unaffected by shock, humidity, and temperature	Measurement possible in all environments
Simple to use and analyze	Semi-skilled technicians sufficient	Low cost per measurement
Small size and weight	Can be easily located in difficult to access areas	Can be used on floors, ceilings, wall, and on equipment.
Universality	Same reader and sensors usable for making other related measurements	More cost competitive when used for multiple purposes
"Faster, cheaper, and safer"	Several hundreds of detectors can be read and deployed in a short time using a single reader. Data can be analyzed in a short time	No need for operator to be in radiation area during measurements. No radioactive waste generated during use.

Other Applications

The E-PERM® radon monitor uses the same EIC's as the alpha monitor and is widely used in the United States, Europe, and South Africa for measuring radon levels in buildings. The electrets may also be used with a beta chamber that can distinguish and characterize beta radiation.

Patents/Commercialization/Sponsor

The E-PERM® Alpha Surface Monitor is commercially available from Rad Elec Inc. Rad Elec Inc. holds the basic patent, 4,853,536(1898), and related patents for the E-PERM® technology.

SECTION 5

COST

Introduction / Methodology

This cost analysis compares the innovative E-PERM® Alpha Surface Monitor technology with the baseline probe and smear methodology of surveying. Both technologies were demonstrated at DOE-Savannah River Site, and this analysis presents data representing actual characterization work at the site. The analysis of the technologies was based on data recorded during the Large Scale Demonstration and Deployment Project (LSDDP) at building 321-M. Cost and performance data were collected for each technology during their respective demonstrations. The cost elements that follow were identified from the Hazardous, Toxic and Radioactive Waste Remedial Action Work Breakdown Structure (WBS) and Data Dictionary (HTRW RA WBS), US Army Corps of Engineers. Data were collected to analyze the cost effectiveness of the EIC's based on the following cost elements:

- Mobilization
- Characterization
- Demobilization.

Mobilization costs include the costs of equipment preparation, calibration, and operational checks necessary for routine use. Initial electret readings and installation in the ion chambers are included in mobilization costs of the innovative technology.

Characterization includes all direct and indirect activities associated with performing characterization work, i.e., placing and removing EIC's, reading EIC's, performing probe surveys and taking smears, recording data, and reporting.

Demobilization includes the decontamination and clearing of equipment from radiological areas and removal from the work area. The bagging of the ion chambers for storage is included in the innovative technology demobilization costs.

Personal Protective Equipment (PPE) costs are included in this demonstration and reflect the cost of PPE's and labor for donning and removing.

Cost Analysis

In an overall context, productivity and costs were measured during the demonstration so that unit costs could be determined, i.e., cost per reading.

Labor rates used in the innovative technology analysis were those in effect for the SRS site labor agreement. Crews for the various activities were based on the recorded data. Indirect costs were omitted from the analysis, since overhead rates can vary greatly among contractors. Engineering, quality assurance, administrative costs and taxes were also omitted from the analysis so that the cost information presented herein can be used by managers, et al across the DOE-complex without having to first "backout" SRS specific data.

Capital equipment costs for the innovative and baseline technologies are based on the cost of ownership. The cost of the ion chambers and reader is $8,730.00 with an unspecified useful life. The following assumptions were made to assign equipment costs for the innovative technology: 1) expected useful life of the new technology equipment is 10 years; 2) equipment is operated 5 hours per day, 5 days a week for 50 weeks a year; and 3) sixty readings per hour can be made with reader. Based on this use scenario, the equipment cost per reading is slightly more than $0.01, or $0.72 per hour of operation.

The technology vendor rents ion chambers, electrets, and readers. This option may be cost effective for small jobs with fewer readings.

Capital costs for the baseline technology is $1215 for the Ludlum AC3 probe and meter and $850 for the Ludlum 1000 scaler for reading the smears. Based on extensive discussions with Health Physics Technicians and on demonstration data, the following assumptions were made to assign equipment costs for the baseline technology: 1) expected useful life of the probe and scaler is 5 years; 2) equipment is operated 5 hours per day, 5 days per week for 50 weeks a year; and 3) forty-five probe readings can be made per hour of operation. Based on this real use scenario, the equipment cost per reading for the probe and smear is less than $0.01, or $0.20 per hour of operation. The cost per reading for the scaler is less than $0.01 per reading, or $0.14 per hour of operation.

Maintenance costs for both technologies were excluded from the cost analysis. There is no predictive maintenance for the EIC's other than occasional replacement of the ion chambers if damaged or contaminated. Maintenance and calibration costs for the baseline was not available, but are expected to be relatively high due to the fragile nature of the probe and meter.

Cost of electrets depends on the number of electrets purchased and the number of times each is used. For this demonstration, electrets were purchased at a cost of $15.00 each. Each electret can be used a number of times depending on the voltage drop of each reading. An average of fifteen readings per electret was used to determine electret cost for each measurement. This gives an average cost of $1.00 per reading or measurement.

Electret unit costs at the time of the demonstration range from $25.00 to $13.50 each. The lowest cost is based on the purchase of 500 units. Spent electrets can be replaced at a cost of $12.50 each. Electret costs for surveys with a large number of readings could be reduced depending on the number of electrets purchased.

Surveying productivity using the EIC's is higher than for the baseline method; 22 readings per hour for the EIC's compared to 16 readings per hour for the probe and smear. The innovative technology is based on a total of 178 EIC readings made in deployments of 12 to 28 EIC's per deployment. The baseline technology is based on 207 probe and smear readings.

The readings per hour for the EIC's are based on the manhours required for the electret deployment, pickup, and final readings. For this demonstration the initial electret readings were considered a mobilization task since the final readings of the first deployment became the initial readings for the next deployment, etc. Separate initial readings were not required for each deployment. Vendor experience shows that the number of readings per hour can be increased on projects with large numbers of readings using the MARSSIM guidelines for grid surveys. An assessment of the EIC's conducted in Building K-1401 at the East Tennessee Technology Park in Oak Ridge, Tennessee (Reference 2) indicates that up to thirty-three readings per hour can be obtained when deployed in a systematic and planned manner. Productivity should also increase as experience with the overall process grows.

A comparison of the unit cost elements is shown in Table 3. Mobilization, PPE, and demobilization costs are not included in the summary unit costs.

Table 3. Summary Unit Cost Comparison

EPERM® (InnovativeTechnology)			Probe and Smear (Baseline Technology)		
Cost Element	**Unit Cost (per reading)**	**Production Rate (Readings per hour)**	**Cost Element**	**Unit Cost (per reading)**	**Production Rate (Readings per hour)**
Characterization	$2.45	22	Characterization	$2.01	16

Cost Conclusions

As assessed during the demonstration, the baseline technology offers a slight cost savings over the innovative technology with an average unit cost per reading of $2.01 vs. $2.45. If relative maintenance costs are considered, the innovative technology costs are expected to be lower than the baseline technology, therefore reducing the cost difference. The maintenance of probes at SRS is included in overhead costs and is not available as a separate cost element.

The costs of the E-PERM® Alpha Surface Monitor technology may be further reduced by the following:

- Larger deployments, such as release surveys using the MARSSIM guidelines, are expected to increase the productivity of the EIC technology and reduce the unit cost per reading.
- When used for release surveys, contamination levels will be lower allowing more readings per electret.
- The primary difference in the unit costs of the technologies is attributable to the cost of the electrets. Electret costs can be reduced by either buying larger quantities or taking advantage of the replacement costs of spent electrets
- The full use of the bar code reader and software with the SPER2 reader will reduce electret reading and reporting times.

SECTION 6

REGULATORY AND POLICY ISSUES

Regulatory Considerations

There are no Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or other regulatory considerations related to this technology.

The use of this technology as an alternative to the baseline technology requires approval by responsible site or facility health physics departments.

SECTION 7

LESSONS LEARNED

Implementation Considerations

- After the initial electret reading, the final reading of a measurement becomes the initial reading of the next measurement. If the time span between the measurements is lengthy, the electrets may lose voltage charge due to background or other radiation fields and must be re-read before using again.

- During normal use, the electret may attract dust and other small particles that may cause erroneous readings. Pressurized dry air or nitrogen is recommended for removing these particles.

- The Teflon® surface of the electret should not be touched. Touching the surface or other mis-handling will discharge the electret and render it useless.

- Electret exposure times should be estimated to reduce overexposure or underexposure. This can be done by estimating contamination levels from previous surveys or experience, or by periodic electret readings after placement. The SPER1 reader is easily carried to areas of deployment for making periodic readings. Regardless of the methodology employed, the electrets should never be fully discharged

- The EPERM® technology can be used most efficiently in: 1) Areas where access with the baseline technology is limited or difficult (e.g., overheads, gloveboxes); and 2) Final surveys of areas using the MARSSIM guidelines.

Technology Limitations and Needs for Future Development

The E-PERM® technology has potential application for measuring alpha contamination in pipes and on the surfaces of small items. A system designed to provide flowing air through contaminated pipe coupled with a chamber to contain the ions and hold the electret would provide an inexpensive monitor. A similar system with a chamber to hold tools or small items and a second ion chamber could do the same for small items.

The software that allows the downloading of data, stored in the SPER2 microprocessor, to a PC should be updated and made more “user friendly.”

Limitations of the EIC are as follows:

- Surfaces where the EIC’s are placed should be relatively flat and smooth to form an enclosed space with the EIC. Gaps between the EIC and surface being monitored may cause erroneous readings.

APPENDIX A

REFERENCES

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Meacham, S. A., P. Kotrappa, and L. Stieff, 1999*. Field Evaluation of the Rad Elec Inc's E-PERM® Alpha Monitoring System*.

Stieff, Lorin and Paul Kotrappa, 1997, *Application of Passive Integrating Electret Ion Chambers for Expedited Facility Characterization*. Paper presented at X-Change '97, December 1997.

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APPENDIX B

TECHNOLOGY COST COMPARISON

Introduction

The analysis in this appendix presents realistic cost comparisons between the E-PERM® Alpha Surface Monitor technology with the baseline probe and smear technology for evaluating surface contamination levels.

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

Some costs are omitted from this analysis so that it more realistically reflects a typical commercial application. The general and administrative (G&A) markup costs for the site contractor managing the demonstration are omitted from this analysis. Overhead rates for each DOE site vary in magnitude and in the way they are applied. Decision-makers seeking site-specific costs can apply their site's G&A rate to this analysis without having to first back out the rates used at SRS.

The following assumptions were used as the basis for analyzing the costs of the EIC's:

- Oversight, engineering, quality assurance, and some administrative cost for the demonstration were excluded.
- As applicable, equipment hourly rates for innovative and baseline pieces of equipment reflect government ownership, and are based on general guidance contained in the Office of Management and Budget's (OMB) Circular No. A-94 for Cost Effectiveness Analysis.
- Equipment unit rates are determined based on information recorded in the ACOE data collection forms.
- Standard labor rates established by the Savannah River Site were used for the work performed.

Innovative Technology Cost Elements

MOBILIZATION (WBS 331.01)

Perform Initial Electret Voltage Readings and Prepare for Deployment: SRS labor to read the initial electret voltage, record data, and install electrets in ion chambers.

CHARACTERIZATION ACTIVITY – (WBS 331.02)

Place Electrets: SRS labor to place electrets in desired location to measure contamination levels, including removing ion chamber from plastic bags, placing electret on chamber, and placing electret in position.

Remove Electrets: SRS labor to retrieve placed electrets, including removing electrets from ion chambers and placing chambers in plastic bags.

Perform Electret Voltage Readings (Final) and Prepare Reports: SRS labor to read the final voltage from the electrets, record data and prepare report.

Don/Removal of Personnel Protective Equipment, (PPE): Labor to don and remove PPE's as required to perform work in a radiological area.

DEMOBILIZATION (WBS 331.21)

Clear and Remove Equipment from Radiation Area: SRS labor to decontaminate/clear and remove electrets and ion chambers from radiological areas. Includes bagging of ion chambers for storage

Baseline Technology Cost Elements

MOBILIZATION (WBS 331.01)

Prepare Instruments/Mobilize to Work Area: SRS labor to check instruments and carry to work area.

CHARACTERIZATION ACTIVITY – (WBS 331.02)

Probe/Smear: SRS labor to perform hand probe measurements and record readings.

Count Smears: SRS labor to measure activity on smear samples and record readings.

Prepare Reports: SRS labor to prepare written reports for hand probe and smears readings.

Don/Removal of Personnel Protective Equipment: SRS labor to don and remove PPE's as required to perform work in a radiological area.

DEMOBILIZATION (WBS 331.21)

Clear Instruments from Area: SRS labor to decontaminate, clear and remove instruments from radiological areas.

The details of the cost analysis for the innovative and baseline technologies are summarized in Table B-1 and B-2.

Table B-1. Innovative Technology E-Perm Cost Summary

Work Breakdown Structure (WBS)	Unit Cost (UC)						Total Unit Cost ($/Unit of Measure)	Total Quanity (TQ)	Unit of Measure	Crew
	Labor			Capital Equipment		Other				
	Total Hours	Hrs/Unit Measure	Rate	Hrs/Unit Measure	Rate					
Moblization (WBS 33.01)										
Perform initial Electret voltage readings and prepare for deployment	1.4	0.025	$ 32.06	0.0174	$ 0.72		$ 0.81	56	Readings	1 HP Tech.
Characterization (WBS 331.02)										
Place Electrets *	2.14	0.012	$ 32.06			$ 1.00	$ 1.38	178	Readings	1 HP Tech.
Don/Removal of Personeal Protective Equipment, (PPE)	0.8	0.4	$ 32.06			$ 22.60	$ 35.42	2	Day	1 HP Tech.
Remove Electrets *	2.3	0.013	$ 32.06				$ 0.42	178	Readings	1 HP Tech.
Perform Electret Voltage Readings (Final) and Prepare Reports *	3.56	0.02	$ 32.06	0.0174	$ 0.72		$ 0.65	178	Readings	1 HP Tech.
Demobliziation (WBS 331.21)										
Clearing and Removing Equipment from Radiation Area	1.0	1.0	$ 32.06				$ 32.06	1	Job	1 HP Tech.

NOTES:

1. Labor Rates are $32.06/hr for Health Protection (HP) Technician
2. Capital Equipment unit rates are for the Electret Reader and Ion Chambers.
3. Tasks identified with an asterisk are added to determine the summary unit cost.

Table B-2. Baseline Technology Probe and Smear

Work Breakdown Structure (WBS)	Unit Cost (UC)										
	Labor			Equipment		Other	Total Unit Cost ($/Unit Measure)	Total Quanity (TQ)	Unit of Measure	Crew	Comments
	Total Hours	Hrs/Unit Measure	Rate	Hrs/Unit Measure	Rate						
Moblization (WBS 33.01)										1 HP Tech.	
Prepare Instruments/Mobilize to work area	1.0	1.0	$ 32.06				$ 32.06	1	Job	1 HP Tech.	
Characterization (WBS 331.02)											
Probe/Smear *	4.6	0.022	$ 32.06	0.022	$ 0.20		$ 0.70	207	Readings	1 HP Tech.	
Count Smears *	3.5	0.017	$ 32.06	0.017	$ 0.14		$ 0.54	207	Readings	1 HP Tech.	
Prepare Reports *	5.0	0.024	$ 32.06				$ 0.77	207	Readings	1 HP Tech.	
Don/Removal of Personeal Protective Equipment, (PPE)	0.4	0.4	$ 32.06			$ 11.30	$ 24.12	1	Set	1 HP Tech.	Other Rate is PPE, $11.30/set
Demobliziation (WBS 331.21)											
Clear Instruments from Area	1.0	1.0	$ 32.06				$ 32.06	1	Job	1 HP Tech.	

NOTES

1. Labor Rates are $32.06/hr for Health Protection (HP) Technician
2. Tasks identified with an asterisk are added to determine the summary unit cost.
3. Capitol equipment unit costs are for the meter and probe or scaler.

APPENDIX C

ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Description
ALARA	As Low As Reasonably Achievable
CA	Contamination area
CCR	Component Cleaning Room
DOE-SR	Department of Energy – Savannah River
EIC	Electret Ionization Chamber
FDD	Facilities Decommissioning Division
LC	Large ionization chamber
LLW	low level waste
LSDDP	Large Scale Demonstration and Deployment Project
PC	Personal Computer
RBA	Radiological Buffer Area
RCO	Radiological Control Operations
SC	Small ionization chamber
SRS	Savannah River Site
SRTC	Savannah River Technology Center
TCR	Tube Cleaning Room
USACE	U. S. Army Corps of Engineers
WSRC	Westinghouse Savannah River Company