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TECHNOLOGY INFORMATION PROFILE: RL321103
IN SITU GAMMA SPECTROMETER

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Technology Information Profile: RL321103

Common Name of Technology: In Situ Gamma Spectrometer

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Affiliation: Pacific Northwest Laboratory

Technology Category: Characterization and Monitoring

Developed by: Pacific Northwest Laboratory

- 1. What is the need for the technology? (If this technology is part of a system of technologies, what is its role in the system and what is the need for the system?)**

Past operations of uranium production and support facilities at several Department of Energy (DOE) sites have occasionally resulted in the local contamination of some surface and subsurface soils. Such contamination commonly occurs within waste burial sites, cribs, pond bottom sediments, and areas surrounding waste tanks or uranium scrap, ore, tailing, and slag heaps. The thorough cleanup of these sites is a major public concern and a high priority for the DOE, but before any effective remedial protocols can be established, the three-dimensional distributions of the uranium contaminants must be adequately characterized. Unfortunately, traditional means of obtaining soil activities (e.g., grab sampling followed by laboratory analyses) are notoriously cumbersome, expensive, time-consuming, and often non-representative when very large areas are being surveyed. Hence, new technologies must be developed, or existing ones improved, to allow for the cheaper, better, faster (i.e., real-time) and safer characterization of uranium concentrations at these critical sites.

- 2. What are the technology's objectives? (How does it satisfy the needs identified above?)**

- a. What are the objectives of this technology (for example, will this technology destroy volatile organic compounds [VOCs] in groundwater)?**

The primary objective for this program is to develop, construct, and field/pilot test the in situ gamma spectrometer for the rapid (i.e., real-time) measurement of uranium in surface and shallow subsurface soils at the Fernald site in Ohio.

- b. What is the technology that is currently used for this application (baseline technology)?**

Myriad soil samples are obtained by hand, and time-consuming laboratory analyses are performed. Multiple radiochemical separations are often necessary, extensive beta and gamma counting techniques are employed, and the original soil samples and resulting solutions are disposed of as mixed radioactive waste.

3. Process Description (Please describe the technology in terms that can be easily understood by interested members of the public. Include information on where the technology is applied—in place or above ground—what media the technology is used in—soil, groundwater, air— and what contaminants the technology targets)

The in situ gamma spectrometer is suspended one meter above the soil surface and measures the radioactivity present within many hundreds of square meters. This detector also evaluates subsurface soils (directly below the unit) to a depth of 15-20 centimeters. Hence, a large surface area may be characterized in a relatively short period of time, and a preliminary indication of the depth distribution may also be obtained. No soil removal or disturbance is required and no material, hazardous or otherwise, is generated when using this monitoring technology. The system is sensitive to virtually any photon-emitting radionuclide.

4. What is the status of the technology's development?

A prototype sensor currently exists and has been demonstrated successfully for the characterization of uranium contamination (at the Fernald, Ohio site) in surface and shallow subsurface soils. The second generation of this detector will be constructed and demonstrated at Fernald during late 1993. Further improvements are planned for 1994, and the final development stage is expected to be complete by September of that year.

5. Summary of technology advantages (compared with the baseline technology: Is it faster, better, cheaper, safer?)

Traditional means of measuring soil activities (e.g., grab sampling followed by laboratory analyses) are notoriously cumbersome, expensive, time-consuming, and often non-representative when very large areas are under consideration. Furthermore, investigators must often wait weeks to months for the results of these analyses when such are contracted to outside laboratories. The profiled technology generates results in near real-time, does not require the removal and subsequent handling of contaminated soils, and precludes delayed and costly lab analyses.

6. Summary of technology limitations (compared with the baseline technology)

A previous knowledge of the depth distribution of the radioactive contamination is necessary with this technique; otherwise, a uniform distribution may be assumed (despite occasional evidence to the contrary), thereby providing information about the "average" radioactivity levels within the soil volume.

7. Major Technical Challenges for the Technology

Major technical challenges are few and include improvements to the sensor design that will simplify its field operation and eliminate the need for scientifically trained operators (e.g., there will be a single-button start-up with inherent intelligence to allow the unit to "think" for itself).

8. Technical Effectiveness: Performance Criteria

- a. What contamination will remain after the technology is applied? (Will the mobility of the contamination be reduced? Will the volume be reduced? Will the contaminant be less toxic? This criterion applies primarily to retrieval treatment technologies.)**

This section is not relevant for a "monitoring" technology.

- b. What process waste (secondary waste) does the technology produce? (Is the secondary waste mobile? What is its volume? What hazards are associated with the secondary waste? Can it be recycled?)**

No material, hazardous or otherwise, is generated by this monitoring technology. Unlike the baseline technology (grab sampling and laboratory analyses), soil removal or disturbance is not a result of, or a requirement for, the operation of this sensor.

- c. Describe the treatment or storage needed for the secondary waste and its availability.**

Not applicable.

- d. Describe the requirements for decontamination or decommissioning of equipment.**

The in situ gamma spectrometer is suspended above the ground by a tripod assembly and only the feet come in direct contact with the contaminated or potentially contaminated soil. Plastic disposable foot covers may be used to prevent contamination, or the assembly may be monitored and washed following use, if necessary.

- e. How must the secondary waste be disposed of? Is disposal available?**

No material is generated by this technology that would require disposal.

- f. What future cleanup options are precluded by this technology? (Applies primarily to treatment technologies)**

Use of this technology will not preclude or foreclose future cleanup options.

- g. How reliable is the technology? (Please address potential breakdowns, effectiveness, and sensitivity to operating conditions).**

The operational reliability of in situ gamma spectrometry as a field technique is proven and well-documented, and the ongoing modifications and improvements to this system will serve to further enhance its reliability.

- h. If the technology fails, how are the effects of the failure controlled?**

There would be no consequences to the remedial effort as a result of system failure. This technology has proven its reliability and sound construction, but should the unit fail, a backup system could be made available.

- i. How easy is the technology to use? (Please describe the level of skills and training required to use the technology.)**

The in situ gamma spectrometer is designed for single-button use, and the system is self-contained and automated to the degree that minimal operator effort is required.

- j. What infrastructure (buildings, power sources, personnel) is needed to support the technology?**

The current status of this technology requires minimal contributions from the existing infrastructure (e.g., line power, personnel support, etc.), and projected system modifications will serve to reduce these needs significantly, as each unit will operate on battery power and require only a single technician for normal operation.

- k. How versatile is the technology? (That is, can it be applied to other types of contamination, in other media, or at other locations?)**

The in situ gamma spectrometer can be used effectively to characterize any radioactive material that emits photons (gamma rays or x-rays). With few exceptions, this includes nearly every radionuclide contaminant. Although this methodology has been tailored for measuring radioactivity in soils, it has proven its viability in other areas (e.g., laboratory measurements, high-energy physics experiments, cosmic and astrophysical detection).

- l. Describe the technology's compatibility with other elements of the system? (Please include a general description of the system that the technology is part of.)**

This technology is particularly well suited to large-scale cleanup activities because of its ability to characterize large surface areas relatively quickly. Detailed maps of radioactivity in surface and shallow subsurface soils can be generated daily to support

excavation efforts, and re-characterization can follow such soil removal to help determine how effective the cleanup is.

- m. **Can the technology be procured "off-the-shelf"? (Is it an innovative use of an existing technology?) Which components are available and which must be developed?**

Although many of the components comprising this spectrometer are commercially available (e.g., the high-purity germanium detector, liquid nitrogen reservoir, support tripod), the data acquisition electronics and user interface software were custom designed and originate from the Pacific Northwest Laboratory and/or Los Alamos National Laboratory. Hence, this unit is not available off-the-shelf at this time, but commercialization is being investigated.

- n. **How difficult is the technology equipment to maintain? (Please include information on frequency as well as ease of maintenance. Also describe the level of skill or training required to maintain the technology.)**

Regular maintenance is limited to the intermittent addition of liquid nitrogen (a non-toxic material) to the system reservoir. This is a simple process, although appropriate safety precautions must be observed because the fluid is quite cold, and may be easily performed by trained operator.

- o. **What equipment safety measures (such as automatic shutdown devices) are needed and in place to protect workers and the public?**

The use or failure of this unit poses no threat to workers or the public as it neither contains, nor generates, toxic material. The observance of proper safety precautions during the transfer and addition of cold liquid nitrogen to the system reservoir should preclude any harm to operating personnel.

- p. **Describe the technology's ability to function as intended. (Does the technology work as intended? If not, describe functional problems.)**

This technology is proven and well-documented and was demonstrated in the preliminary characterization of uranium contamination at two sites within the Fernald facility. The overall results from this technique matched those predicted from site historical information.

- q. **What are the scale-up issues and how are they being addressed?**

Few or no modifications would be required before the in situ gamma spectrometer(s) could be used in a scaled-up scenario (e.g., multiple units being employed concurrently for rapid, large-scale soil monitoring), as each unit is designed to be operated independently and does not rely on the proper operation of other sensors.

9. Cost (Please include assumptions on which you base your estimates.)

- a. What is the start-up cost of the technology (including development costs, procurement and construction, permitting, and other costs necessary to begin operation)?**

After commercialization of the upgraded hardware/software package currently under development at the Pacific Northwest Laboratory and Los Alamos National Laboratory, it is anticipated that the cost of an individual unit will not exceed \$8K. This does not include the cost of the actual gamma ray detector, as a large number of types and sizes are commercially available and prices will vary according to user needs.

- b. What are the operations and maintenance costs of the technology?**

Operational costs are essentially limited to those associated with labor and the purchase of liquid nitrogen. The latter is relatively inexpensive, and costs for a full-service unit (i.e., operating continuously on a daily basis) should not exceed a hundred dollars per month.

- c. What are the life cycle costs of the technology (including facility capital cost; startup, operation, and maintenance; decommissioning, regulatory, or institutional oversight; and future liability)?**

Life cycle costs are limited to initial purchase, liquid nitrogen, and labor. Material costs (i.e., excluding labor) for an individual unit with a moderately priced gamma detector are not expected to exceed a hundred thousand dollars in its entire lifetime.

10. Time

- a. When will the technology be available for commercial use or use at other sites?**

This technology is currently available (although the number of units on hand is limited), and planned improvements are intended to be incorporated within the next two years.

- b. What is the speed or rate of the technology? (Please use metrics)**

Count times are a function of the total radioactivity in the sample, such that lower activity levels require longer count times for the same precision. Currently, only a few hundred seconds are necessary to characterize extremely low levels, and the upgraded system is designed to determine (automatically) the shortest counting times necessary at each sample location to minimize labor costs and facilitate rapid cleanup.

- c. At the speed or rate identified in 10(b), what is the total time required for the technology to achieve its objectives?**

Total time is a function of the actual amount of radioactive contamination in the soil, such that lower levels require longer count times to ensure precise readings. With optimal detection equipment, maximum count times for individual sample locations are not expected to exceed 5-10 minutes.

11. Environmental Safety and Health: Worker Safety

- a. **What potential is there for workers to be exposed to hazardous materials and/or other hazards? Describe those materials and hazards.**

Operators should be cognizant of normal hazards associated with using liquid nitrogen, a cold, non-toxic material necessary for proper operation of the in situ gamma spectrometer. Gloves, faceshields, and the observance of appropriate safety precautions should prevent operator harm.

- b. **What are the physical requirements for workers?**

The total weight of an individual unit is not expected to exceed about 60 kg.

- c. **How many people are required to operate the technology?**

Each unit is designed to be maneuvered and operated by a single person.

12. Environmental Safety and Health: Public Health and Safety

- a. **What is the technology's history of accidents? (Has there been a history of accidents and, if so, what was the nature of the accidents.)**

No accidents have occurred to date through the use of this technology.

- b. **Does this technology produce routine releases of contaminants?**

No releases are associated with the use of this technology.

- c. **Are there potential impacts from transportation of equipment, samples, waste, or other materials associated with the technology?**

Due to the lightweight, self-contained nature of the in situ gamma spectrometer, it can be maneuvered by a single operator in the field and no unusual transportation requirements are foreseen.

13. Environmental Impacts

- a. **What impact will this technology have on the ecology of the area (for example, wildlife, vegetation, air, water, soil, or people)?**

This technology does not affect the ecology of the site under observation.

- b. What aesthetic impacts does the technology have (for example, visual impacts, noise)?**

No aesthetic impacts result from the use of this technology.

- c. What natural resources are used in the technology's development, manufacture, or operation? (Address energy resources in 14[d].)**

No natural resources are consumed during the operation of the in situ gamma spectrometer.

- d. What are the technology's energy requirements? (Use metrics)**

Existing equipment consumes minimal power, and modified systems will rely on battery power exclusively.

14. Socio-Political Interests: Public Perception

- a. What is the reputation of the technology's developer and/or user? (Principal investigators: this is a point of discussion for stakeholders; do not answer.)**

- b. How familiar is the technology to the public?**

In situ gamma spectrometry is a proven and well-documented technique, although its use in the U.S. is somewhat limited, perhaps due to an incomplete understanding of the physical processes associated with its proper operation. This technology is often used in Europe and the former Soviet Union for the characterization of regional Chernobyl contamination.

- c. How easy is the technology to explain to the public?**

The underlying theory associated with this technology is relatively simple and easily understood.

15. Socio-Political Interests: Tribal Rights/Future Land Use

- a. How will the technology affect future unrestricted use of land and water?**

The use of this monitoring technology will in no way mitigate the opportunity for unrestricted use of the land in the future.

16. Socio-Economic Interests

- a. What are the potential economic impacts of this technology? (For example, what are**

the effects on the economic base of the community? Are there infrastructure requirements?)

No impacts to the economic base of the surrounding community will result from the use of this technology.

b. How will the technology affect labor force demands?

No significant labor force demands are expected through the use of this technology.

17. Regulatory Objectives

a. Describe the technology's compatibility with cleanup milestones.

Initial field tests at the Fernald site have shown that this technology is sensitive enough to accurately identify uranium activities as low as 35 pCi/g (the current cut-off for remedial action), and results are generated on a daily basis, thereby placing few time constraints on the overall cleanup efforts. Lower levels of detection (e.g., on the order of 5-10 pCi/g) and significantly shorter counting periods (on the order of a few minutes) are quite possible and simply a function of the capabilities of the actual gamma-ray detector purchased.

b. How familiar are regulators with this or a similar technology ?

The in situ gamma spectrometer relies on technology that is proven and well-documented, and this information is readily available to regulators.

c. What is the technology's regulatory track record?

Acceptance of this technology by regulatory agencies is being actively solicited.

d. How does the technology comply with applicable regulations?

The speed, accuracy, simplicity, and low operating costs associated with this technology are expected to satisfy all issues of regulatory compliance.

18. Industrial Partnerships

a. What is the name of the industrial partner?

No partnerships have been established to date, although a number of private vendors have expressed an interest in marketing this technology.

b. What is the rationale for this partnership?

Mass production of the upgraded in situ gamma spectrometer hardware/software package is anticipated.

c. What is the contract mechanism?

Not applicable at this time. A Cooperative Research and Development Agreement (CRADA) may be pursued in the near future.

d. Are there other potential partners?

Technology transfer through publications and conference presentations is expected to encourage further industrial contacts.

e. Are there potential international partners?

The potential for international involvement is a distinct possibility, particularly due to the interest that already exists in Europe and the former Soviet Union.

19. Intellectual Property

a. Who owns the patent for this technology?

Currently, no patent exists for the upgraded in situ gamma spectrometer hardware/software package, although one may be pursued in the near future.

b. Are there other patent owners?

Not applicable.

c. Is there a patent number for this technology?

Not applicable.

20. Cost Sharing

a. What is the background of this technology? (Where did the idea come from? Who else is doing similar work? What have the results been to date? What is the most significant competitor to this technology?)

In situ gamma spectrometry is a proven and well-documented technique, although the upgraded hardware/software package for data acquisition and manipulation is new technology resulting from a collaboration between the Pacific Northwest Laboratory and Los Alamos National Laboratory. Other investigators are pursuing similar efforts (i.e., electronic miniaturization for photon detection techniques), but the modular unit under development in this program is best

suited for the high-resolution characterization of radioactively contaminated soils. Results to date have been quite encouraging and full development is anticipated within the next two years. Commercial competition does exist (e.g., EG&G ORTEC, Oak Ridge, TN), although such equipment is significantly inferior to the upgraded in situ gamma spectrometer and generates "approximate" results (compared to true quantitative characterization offered by the profiled technology).

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