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LRAD Surface Monitors

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by
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ABSTRACT

The long-range alpha-detection (LRAD) technique depends on the detection of ion pairs generated by alpha particles losing energy in air, rather than on detection of the alpha particles themselves. Typical alpha particles generated by uranium or plutonium travel < 3 cm in air. In contrast, the ions have been successfully detected many inches or feet away from the contamination. Since LRAD detection systems are sensitive to all ions simultaneously, large LRAD surface monitors can be used to collect all of the ions from a large area. The LRAD surface monitors are designed around the fan-less LRAD detector. In this case, a five-sided box with an open bottom is placed on the soil surface. Ions generated by alpha decays on the soil surface are collected on a charged copper plate within the box. These ions create a small current from the plate to ground, which is monitored with a sensitive electrometer. The current measured is proportional to the number of ions in the box, which is, in turn, proportional to the amount of alpha contamination on the surface of the soil. This report includes the design, construction, and testing of two types of soil surface monitors.

I. ALPHA MONITORING

Traditional alpha-contamination-monitoring techniques are limited by poor sensitivity and by the short range of alpha particles in air. To be effective, a traditional monitor must be held within a few centimeters of or in contact with the source of contamination. If the contaminated surface is large or complex, traditional monitoring is difficult or impossible to achieve. All traditional techniques rely on direct detection of alpha particles. The alpha particle must pass through the air and still have enough energy remaining to penetrate the detector. This direct alpha particle detection limits traditional alpha contamination monitoring of potentially contaminated objects and soil surfaces. In contrast, the technique of the long-range alpha detector (LRAD) depends on the detection of the ions generated by the alpha particles in air. These ions can travel many meters before recombining, leading to the "long-range" description of this detector. Preliminary LRAD results and an introductory discussion of several applications are discussed in Refs. 1-3; this report draws heavily on three internal reports that appeared separately.[4-6]

A. Floor Monitoring

Within plutonium processing facilities and in many decontamination projects, potential alpha-emitting contamination on the floor is a serious problem. Loose material is easily tracked from room to room, spreading the contamination. Traditional alpha floor monitors employ a portable alpha monitor with a very large detector head that slowly scans over the floor. These monitors suffer from three significant problems:

(1) Traditional alpha floor monitors are not sensitive enough to find small sources of contamination. Intrinsically poor sensitivity, detector front windows, and the necessity of holding the detector a finite distance above the floor all contribute to this poor performance.

(2) Although floor monitors may perform relatively well immediately after construction, use in a plant environment by relatively unskilled individuals quickly degrades the performance. Traditional alpha detectors are not well suited to non-laboratory use.

(3) An individual of unknown training scans the floor monitor over the floor surface. Because the sensitivity of alpha detection depends directly on the length of time the monitor covers any given spot, the already poor detector sensitivity may be further degraded by scanning too quickly.

All of these concerns are addressed by the LRAD surface monitors described in this report. Many of the advantages of the LRAD system coincide exactly with the requirements of floor monitors.

B. Soil Surface Monitoring

Soil contamination is possible in any location where nuclear material has been (or is being) mined, processed, or machined. Older sites are often more contaminated since fewer regulations existed to control the release of radioactive material. If the contamination level is high, it can be detected with conventional field instrumentation; however, detecting the low-level alpha contamination that may surround many nuclear facilities is more difficult. A typical environmental soil-surface-monitoring problem involves a large area (acres) contaminated at a level (10 to 100 pCi/g) only slightly above natural backgrounds and located far from utilities such as ac power. Large-scale soil surface monitoring requires fieldable alpha detectors that cover a large area and are extremely sensitive; neither of these criteria is satisfied by traditional hand-held instrumentation.

All LRAD alpha monitoring systems depend on the collection of alpha-generated ions to produce a measurable signal. The "standard" LRAD uses a small fan or fans to move the air and transport the ions.[7-9] The moving air is essential in applications such as object and personnel monitors, where ions must be transported from partially enclosed areas into the ion detector. In soil surface monitors (SSMs), floor monitors, and other "flat-surface" monitors, the fans are not only superfluous but possibly detrimental. The moving air current caused by the fan may stir up dust and contribute to the spread of contamination.

II. SURFACE MONITOR DESIGNS

The fan-less LRAD used in the soil monitors is depicted schematically in Fig. 1. The open side of a five-sided aluminum sample enclosure is placed on the soil. In practice, a perfect air seal is not required, but externally induced air currents must be eliminated. This creates a closed box, with the soil surface making one side. Alpha particles emitted from the soil surface lose their energy by creating ion pairs in the air. Each alpha particle loses about 35-eV per ion pair produced,[10] so a typical 5-MeV alpha particle will produce about 150 000 ion pairs. As shown in Fig. 1, the signal plane is maintained at + 300 V by a battery (both positive and negative bias voltages work equally well, the positive voltage was used for historical reasons). The positively charged signal plane attracts the negative ions while the positive ions are repelled back to ground. The accumulation of ions on the signal plane causes a small (~100 fA) current to flow through the Keithly 617 electrometer. The output of the electrometer is fed into a Macintosh PowerBook 170 for averaging and processing similar to that described in Ref. 8.

If the ground plane is not present, any leakage currents from the signal plane to ground will directly affect the electrometer. If the signal plane is at 300 V and the desired leakage current is < 100 fA, then the insulation resistance determined from Ohm's Law is

$$R_{No,Guard} = \frac{300}{10^{-13}} = 3\times10^{15}\Omega \quad .$$

This is a very large resistance to be maintained under field conditions of humidity and dust, so the guard plane is inserted to help control the leakage current. The guard plane is also held at + 300 V by the battery. The leakage current determined above flows from the guard plane to ground *without* passing through the electrometer. The only leakage current passing through the electrometer is created by the offset voltage of the electrometer itself, < 5 mV. If the offset voltage is taken to be 3 mV and the desired leakage current is again < 100 fA, then the required insulation resistance becomes

$$R_{Guard} = \frac{0.003}{10^{-13}} = 3\times10^{10}\Omega \quad .$$

Thus, the requirement on the insulation resistance is reduced by a factor of at least 10^5 by the presence of the guard plane. Because no air is flowing through the LRAD detector, a solid plane can be used instead of the wire mesh grids required in airflow designs. Solid planes add to the mechanical stability required in a field instrument.

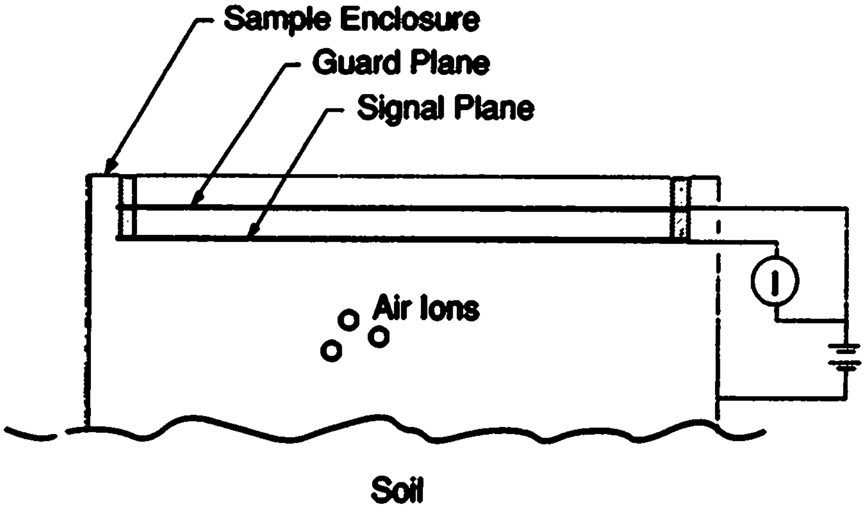

Fig. 1. The fan-less LRAD used in SSMs, floor monitors, and similar surface monitors. No airflow is required in this LRAD. The ions are electrostatically attracted to the signal plane, and the ion current is read out by the electrometer.

A. Medium Surface Monitor

The medium surface monitor (MSM) pictured in Fig. 2 is suitable for floor monitoring and soil monitoring in confined spaces (such as near buildings). The MSM's sample enclosure is a 0.5-m by 0.5-m by 0.15-m aluminum box that is open on the bottom, making the surface sampling area ~ 0.5 m by 0.5 m. The guard and signal planes are copper sheets (0.47 m by 0.483 m by 1.6 mm) that are mounted to the sample enclosure and each other using four, 2.5-cm-long, Teflon® standoffs for each plane. Because air does not flow through the signal "grid" in the MSM, the LRAD signal "grid" can be a solid plane. A Keithley 617 electrometer and a Macintosh Powerbook 170 are used as the data acquisition system. A laboratory desktop version of this system is described in detail in Ref. 8. The [illegible] MSM uses a portable computer and battery power supply but its programming is identical to the laboratory version.

Fig. 2. Medium surface monitor, 0.5 by 0.5 m, mounted on a dolly.

B. Large Surface Monitor

The tractor-mounted large SSM pictured in Fig. 3 is suitable for monitoring large soil areas. These SSMs use detectors that are 1 m by 1 m by 20 cm (thick), with 3.2-mm copper planes mounted on five 3.8-cm polycarbonate insulators. This "1-m" SSM is constructed of aluminum plates and covered with insulating tape to reduce the influence of external ion sources. All exposed metal surfaces, including the battery connections, must be covered to reduce noise.

The 1-m SSM is mounted on the front lifting arms of a compact tractor as shown in Fig. 3. Because a full-sized SSM, ruggedized to withstand the forces of the tractor hydraulics, weighs 300 lb, a counterweight is required on the back of the tractor. The tractor is essential for transporting the SSM between sampling locations as well as for positioning the detector at each sample location.

Not shown in Fig. 3 are the power connections for the SSM. The bias voltage for the LRAD is supplied by a 300-V dry-cell battery. For field operation, both the electrometer and the data acquisition computer are ac-powered. This ac is generated locally using a 12-Vdc car battery and a dc-to-ac inverter. For sensitive measurements a good electrical ground is required. This can be accomplished using a 50-cm brass "grounding rod" that is driven 10 to 30 cm into the soil at each sample location. The same data acquisition system is used for the SSM as the MSM.

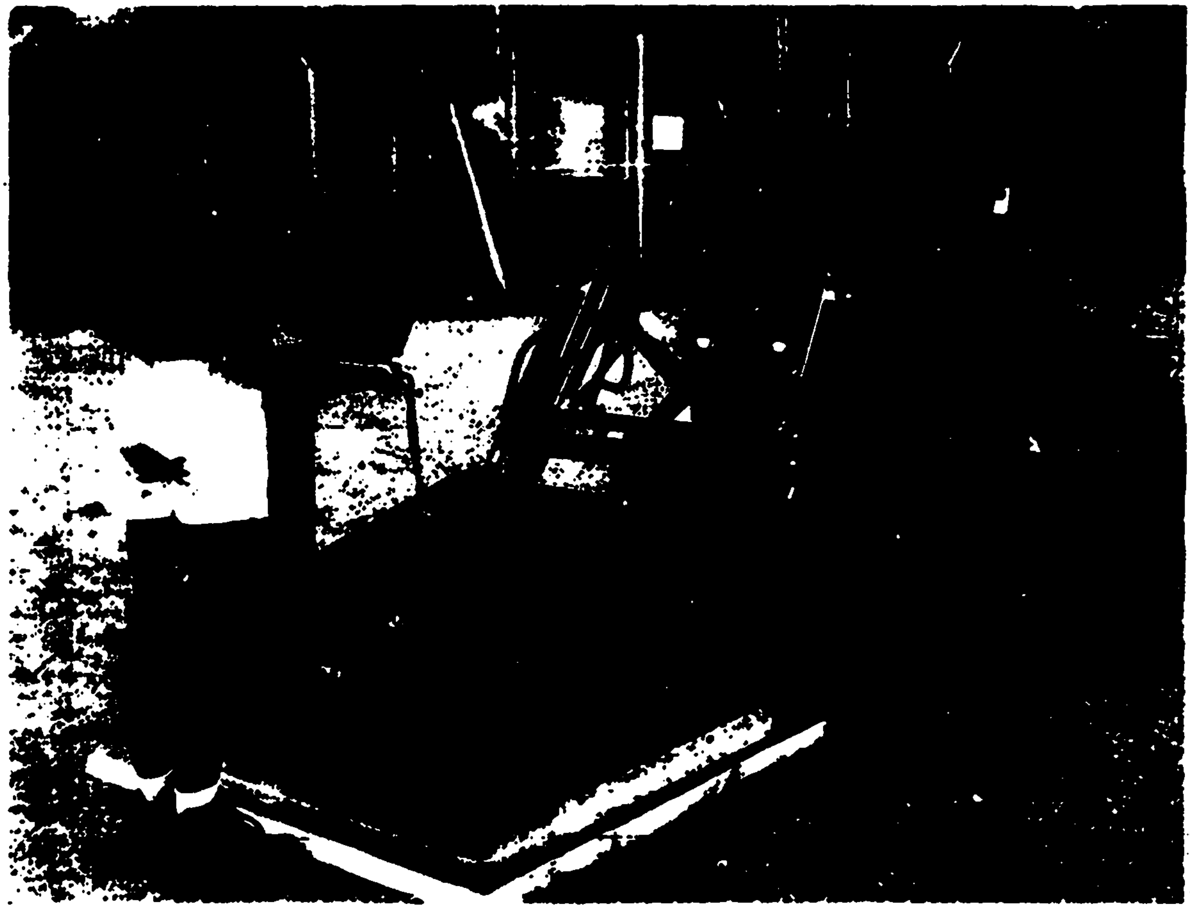

Fig. 3. Tractor-mounted soil surface monitor, 1 m by 1 m.

III. RESULTS

The SSM and MSM have been tested on a variety of surfaces including concrete, weathered asphalt, and exposed soil. This report presents the results of these measurements and an analysis of the data.

A. Loading Dock Surface Monitoring

Figures 4-7 show results of a series of measurements that were performed with the 0.5-m by 0.5-m MSM on a 2.5-m by 2.5-m section of concrete loading dock. Although this surface was outdoors and exposed to the weather, the results are equally applicable to concrete floors located indoors.

Measurements were made at each grid intersection (0.5-m grids) so that a total of 25 measurements is shown in each figure. In this sample, the surface was completely monitored so that no "hotspot" would be missed. The result of each measurement was plotted at the corresponding grid intersection. A commercial graphing program (DeltaGraph Pro 2.0 for the Macintosh) was used to interpolate values between the measured points. In all cases, 10 dpm/100 cm^2 corresponds to approximately 2 std dev of the response. The monitor was calibrated using a NIST-traceable 1100-dpm ^{239}Pu source.

The background levels measured on the concrete pad are illustrated in Fig. 4. No radiation sources other than those naturally occurring were present for this measurement. The natural background in most of the measured area was a fairly uniform 50 to 70 dpm/100 cm^2. (For comparison, the public release limit is 300 dpm/100 cm^2.) Of particular interest are the two "hotter" areas at the top center and lower left of the figure. Even though these levels are well within release limits, the variation is large enough to significantly affect other LRAD measurements.

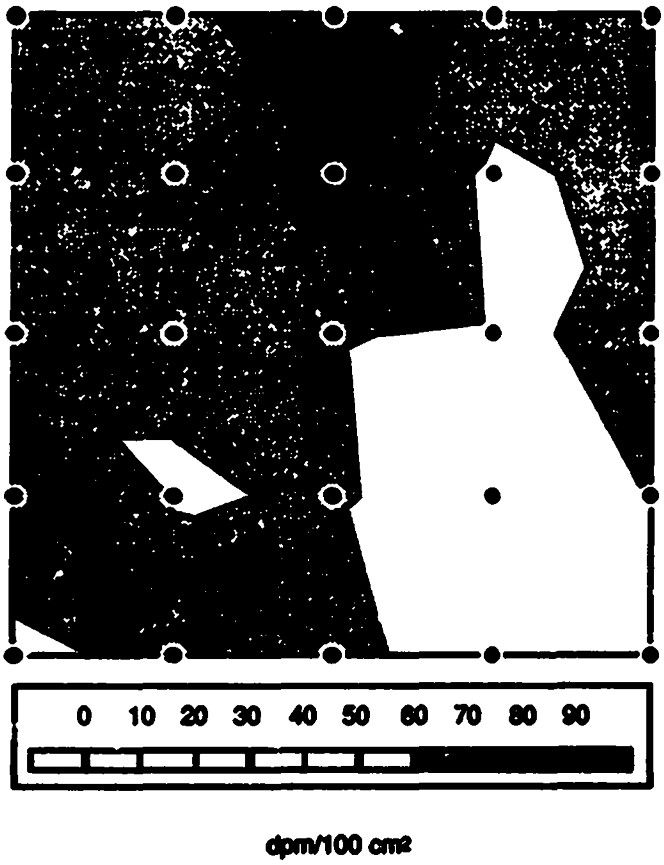

Fig. 4. Measured natural background levels on a 0.5-m grid. A measurement was made at each grid intersection using the 0.5-m by 0.5-m MSM.

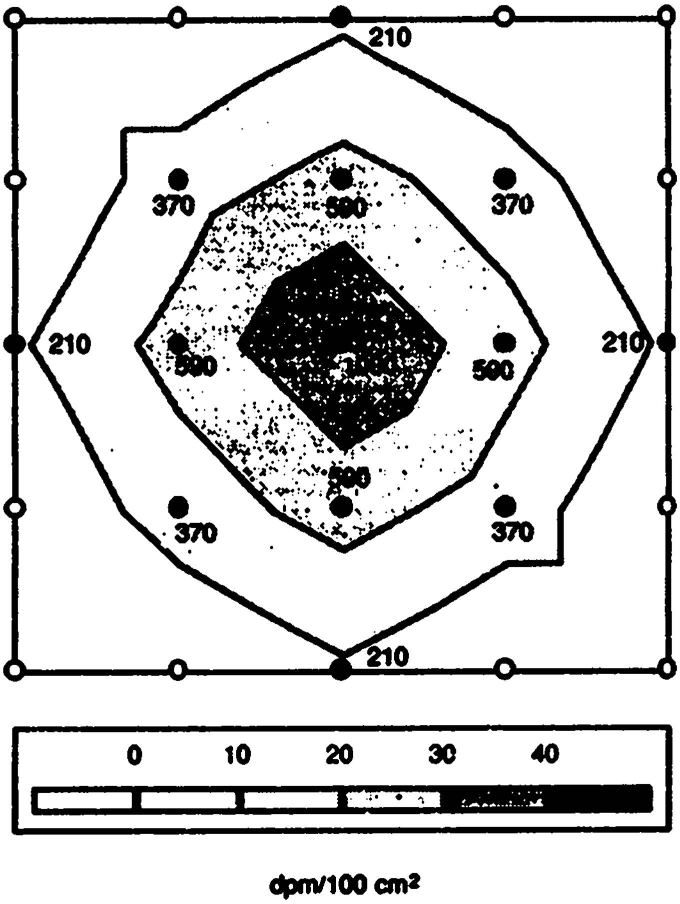

Fig. 5. Predicted source distribution on a 0.5-m grid. A calibrated ^{239}Pu source (measured in disintegrations per minute) was placed at each of the grid intersections indicated with a solid dot, and the predicted distribution was generated with the same graphing program that was used to analyze the measured results.

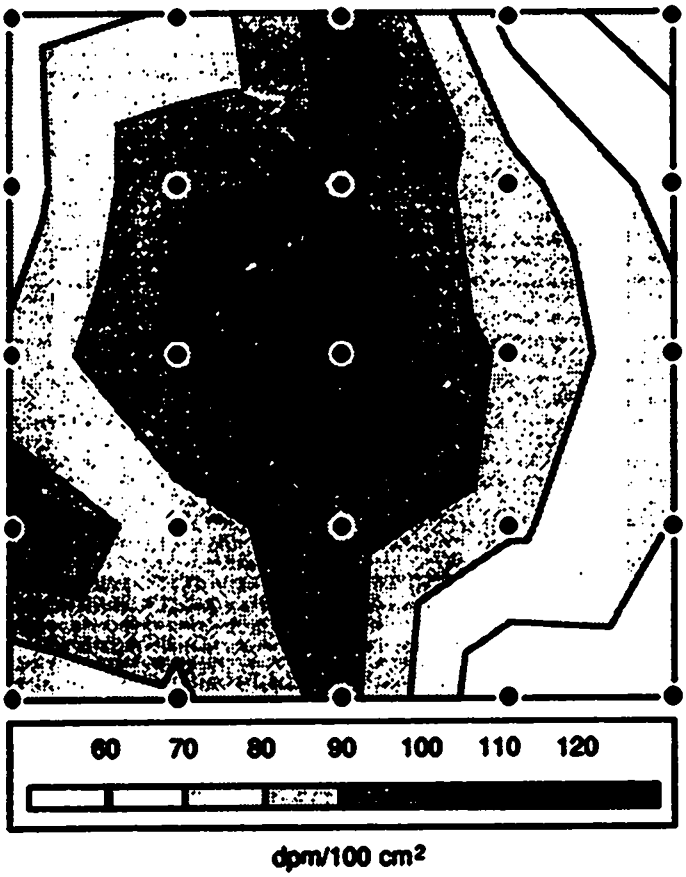

Fig. 6. Measured sources and background. A measurement was made at each grid intersection using the 0.5-m by 0.5-m surface monitor. Note the suppressed zero in this plot.

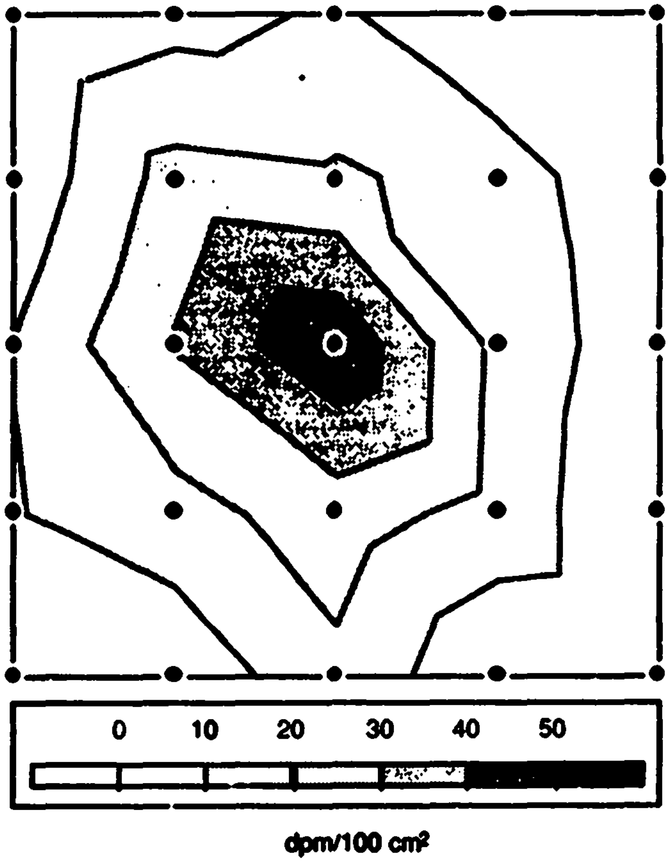

Fig. 7. The computed source strength calculated by subtracting the measured background (Fig. 4) from the measured source response (Fig. 6). The scale shown in the figure is absolute and has not been altered in any way. A measurement was made at each grid intersection using the 0.5-m by 0.5-m surface monitor.

A set of calibrated ^{239}Pu sources, ranging in strength from 290-dpm to 1100-dpm, was placed in the measurement area to simulate a very weak "hotspot." The source positions, along with the calculated response, are shown in Fig. 5.

The measured response obtained when the sources illustrated in Fig. 5 were placed on the concrete pad is illustrated in Fig. 6. The expected central hotspot appears as do the higher background areas at the top center and lower left that were noted in Fig. 4.

Subtracting the measured source response of Fig. 4 from the measured source response of Fig 6 results in the calculated source response shown in Fig. 7. Several conclusions can be drawn from the comparison of this result with the prediction of Fig. 5.

- The LRAD's response is stable over time and repeated measurements of the same point give similar results. This is especially demonstrated since 5 days passed between the two sets of measurements. The small "hotter" features at the sides of the source measurement were well canceled by the similar features in the background measurement.

- The relatively good agreement between the predicted response of Fig. 5 and the actual response of Fig. 7 verifies the ability of the LRAD monitor to reliably detect features in the 20- to 50-dpm/100 cm^2 range, indicating the sensitivity possible with LRAD monitors.

- The LRAD surface monitor can be absolutely calibrated for surface contamination with confidence that the resulting measurements will give a true reading of the actual contamination level.

B. Blasting Pad

The LRAD Soil Surface Monitor was taken to the site at Two Mile Mesa site (TA-06 at Los Alamos) to measure the residual alpha contamination on an old asphalt blasting pad that had been used for explosives testing during the Manhattan Project.

1. Description.

The blasting pad is in the process of being reclaimed by nature: in many places the asphalt is loose, and weeds and grass are growing through it. The boundary of the pad is difficult to ascertain because the asphalt disappears into the dirt. An attempt to find the edges suggests that the pad is more of a patchwork than a single pour. The visible pad is roughly 12 m by 18 m and could be mistaken for an abandoned parking lot except for a rectangular concrete-lined pit (60 by 150 and 60 cm deep), which contains pieces of metal and wood. We believe this pit was used as a catch pan after implosion tests. The concrete around the edge of the pit has been chiseled away, possibly an attempt to remove contamination. A rectangular metal cover plate is located adjacent to the pit, and another large metal plate, this one round and greatly dented, is located nearby.

2. Measurements.

To determine how contamination is distributed on the pad, we took a set of readings at 3-m intervals along each of several rows. The rows were 1.5 m apart, and the data collection points were staggered by 1.5 m from row to row, similar to a five-spot on a pair of dice. In addition to points on the grid, we also took measurements off of our grid in areas of special interest: the metal cover plate, the circular metal plate, and several points near the pit. The MSM was set on each data collection point for about 10 min, then moved manually to the next point. A Ludlum 139 (a hand-held alpha meter) was used to confirm hot spots.

Figure 8 shows results of an MSM scan of the blasting pad. The surface of the pad was monitored at the sample points indicated in the figure, and radiation levels between those points were interpolated by a computer graphics program. The MSM registered variations in natural background over most of the pad, but two areas near the sump indicated minor residual contamination. The "hottest" spot measured between 350 and 400 dpm/100 cm^2. For comparison, the DOE standard for public release is 300 dpm/100 cm^2 for transuranics.

Figure 9 shows a comparison of the SSM monitoring results with those generated using a traditional fieldable device. An area scan is not feasible with the Ludlum 139, but it was again used to verify the "hot spots." Even at the most radioactive points, the Ludlum 139 barely read above background, but its readings do agree qualitatively with the SSM results. Because of low count rates and the small monitoring area of the Ludlum 139 (1.75 by 7 in.), these count rates are only an estimate; however, there was a definite reading above background contamination.

The pit was too small for the MSM, so it was checked with the other instrument. No detectable contamination was found in the pit. The rectangular cover plate and the round metal plate had average radiation levels of 283 dpm/100 cm^2 and 406 dpm/100 cm^2, respectively.

C. Large SSM at Fernald

We operated a tractor-mounted SSM similar to that shown in Fig. 3 as part of the Uranium in Soils Integrated Demonstration[11] (USID) at Fernald, OH. From August 18 – 28, 1992, we operated a 1-m by 1-m SSM at Fernald monitoring both the sewage treatment plant/incinerator (STP) area and the decontamination and decommissioning (D&D) areas. The LRAD SSM is primarily a surface alpha monitor, so all of the data presented in this report represents surface alpha contamination.

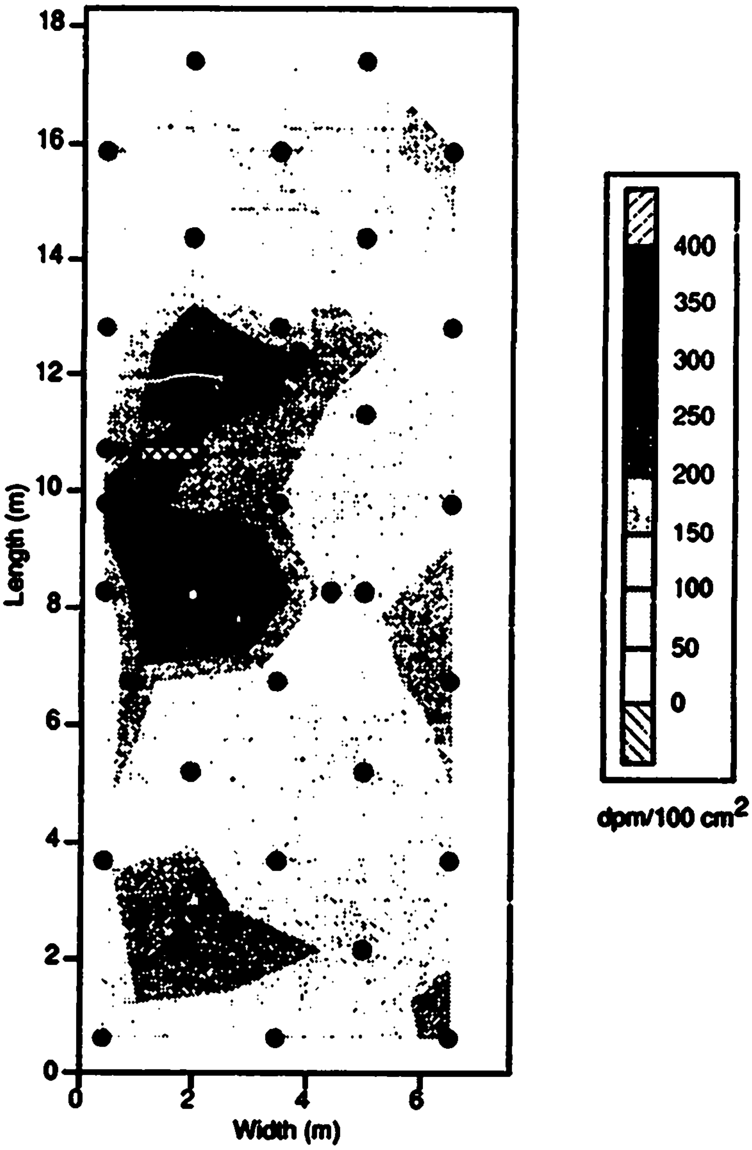

Fig. 8. Results of SSM scan of blasting-pad site. The black dots and the white dot at about (2,8) represent sampling locations; the rectangle at (2,11) represents the concrete "sump" located in the blasting pad.

1. **Description.** The STP monitoring area is about nine acres of field located adjacent to the sewage treatment plant and incinerator facility at Fernald. The incinerator is not currently operational. No monitoring was performed inside the fence surrounding the facilities. The very thick grass that grows throughout the STP area was cut immediately prior to monitoring. Forty-eight-inch-square areas were cut flush with the soil surface, and the clippings were raked off. The terrain in the STF area is moderately rolling; and the SSM was operated at moderate angles (up to ~ 20 deg) and over < 10-cm-deep ruts. Any sample points beyond these limits were skipped. Several of the proposed sample points that were covered with water or mud were also skipped.

The D&D monitoring area is ~ 2.5 acres located in a relatively contaminated part of Fernald. The grass is spotty within this area because of the presence of a large amount of slag and random bits of metal on the surface. With the exception of roadbeds and a railroad line, the D&D area is relatively flat. Anti-contamination coveralls, booties, and gloves were required for workers within this area.

In each area a grid of points separated by 18.3 m was pre-established. All data was taken on grid points although data was not acquired at every grid point.

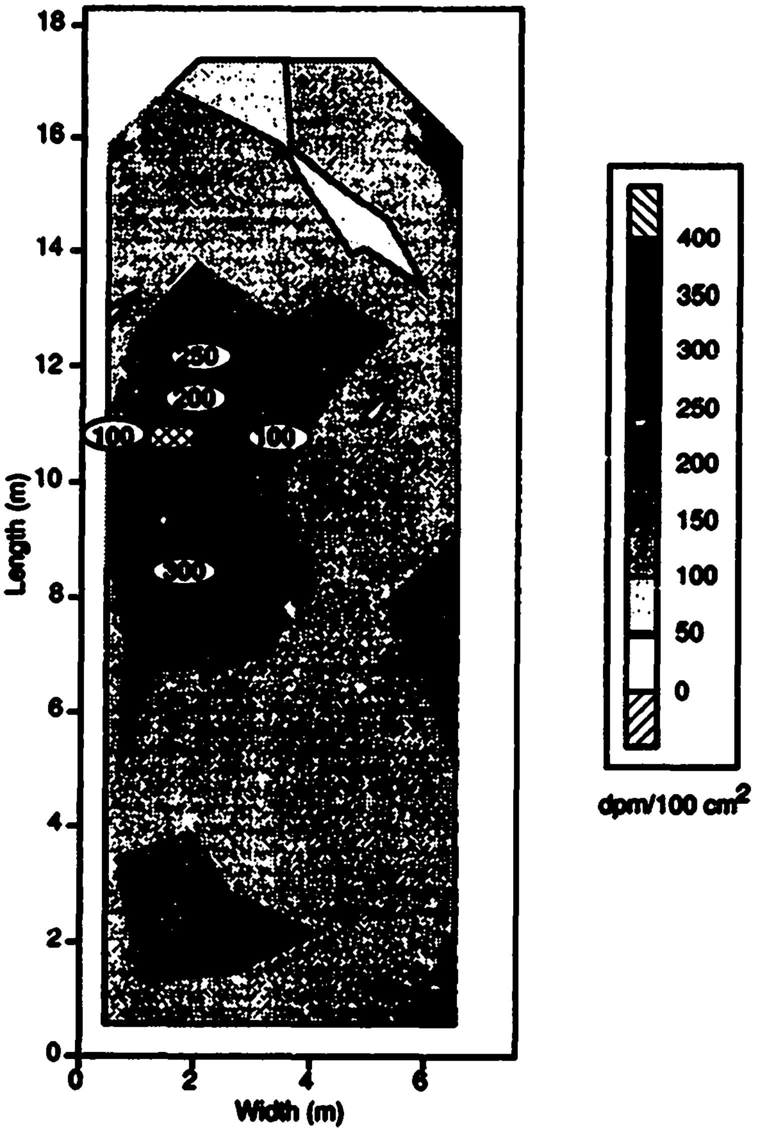

Fig. 9. Comparison on the results of MSM scan with spot results generated by a Ludlum 139 hand-held alpha scanner. The highlighted numbers are the results (in counts per minute) measured by the Ludlum 139; the rectangle at (2,11) represents the concrete "sump" located in the blasting pad.

2. **Analysis.** The detector reading in femtoamps was converted to picocuries per gram using the following constants. The measured electrical leakage current in the 1-m SSM was between 350 and 400 fA. This quantity was checked each day. The SSM was left running on a clean aluminum or wood surface every night, and the background fluctuations were observed each morning. A value of B = 400 fA was used in all subsequent analysis. The sensitivity of the detector is established by its response to a calibrated (NIST traceable) ^{239}Pu alpha source. The SSM measured 180 fA in response to a 1100-dpm alpha source: thus, the sensitivity of the SSM is given by S = 180/1100 = 0.164 fA/dpm. This sensitivity was checked each day either with a 2660-dpm ^{239}Pu source or a lantern mantle. All error bars quoted in the text refer to 1 std dev.

The area covered by a single SSM measurement is 10^4 cm^2. The response (R) of the SSM to 1 dpm/100 cm^2 can be determined from

$$R\left(\frac{fA}{SSM}\right) = S\left(\frac{fA}{dpm}\right) \times 1\left(\frac{dpm}{100cm^2}\right) \times 100\left(\frac{100cm^2}{SSM}\right),$$

where S was determined above. In these units, R = 16.4 fA/(dpm/100 cm^2).

The measurements can be converted to picocuries per gram by assuming an average penetration distance of alpha particle through the soil to be 30 µm, then the soil volume sampled in one measurement is $V = 10^4 \times 30 \times 10^{-4} = 30\ \text{cm}^3$. If we further assume that the density of the soil is 5 g/cm^3, then the mass of soil monitored in a single measurement is M = 150 g. Both the penetration distance and the density are simple multiplicative factors. Although the numerical scales in the data presentations depend on these values, the relative differences presented in the graphs do not. If different constants are used, the graphs will be unchanged, but the values on the scales will change.

The response, R, of the 1-m SSM to 1 pCi/g of soil contamination can be determined from

$$R\left(\frac{fA}{SSM}\right) = S\left(\frac{fA}{dpm}\right) \times K\left(\frac{dpm}{pCi}\right) \times 1\left(\frac{pCi}{g}\right) \times M\left(\frac{g}{SSM}\right),$$

where S and M were determined above, and K = 2.2 dpm/pCi. Substituting in the appropriate values, R = 54.1 fA/(pCi/g). At this point it is clear that the instrument background variation was equivalent to < 1 pCi/g and, hence, negligible.

3. **Measurements for the STP Area.** Figure 10 shows the results of the 1-m SSM scan of the STP area. Data was taken at each of the points indicated by the open circles, and the contours were interpolated by the DeltaGraph graphing program for the Macintosh. Figure 10 is the unenhanced output of the graphing program; some of the very sharp features are probably a figment of its "imagination."

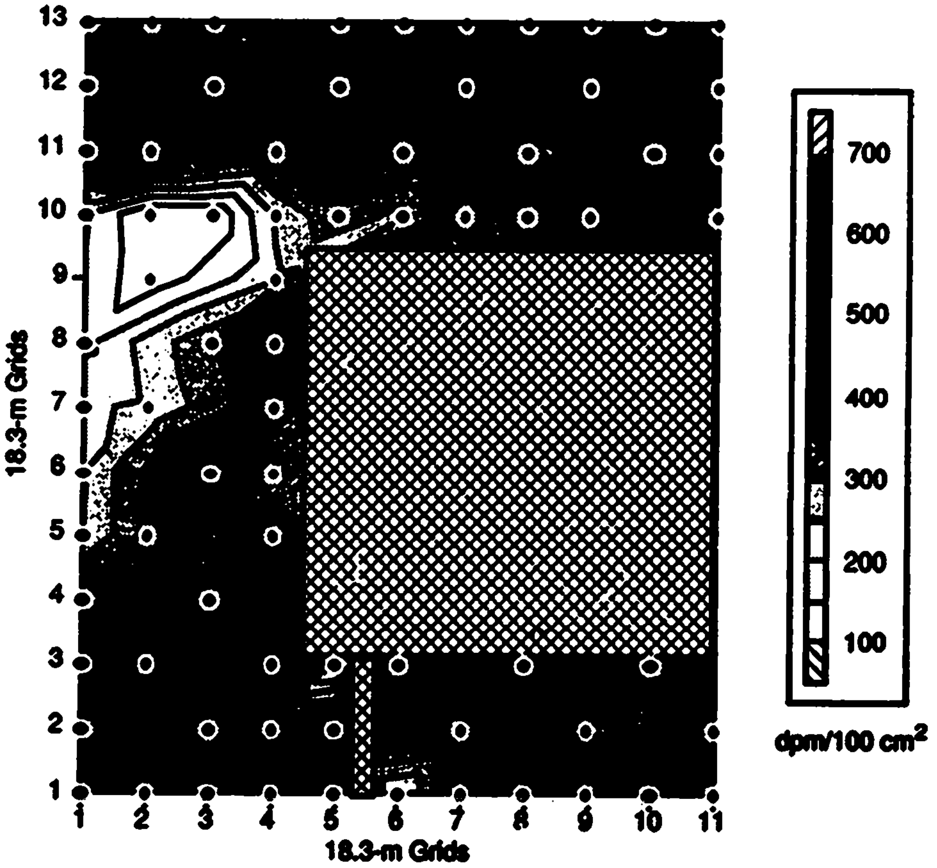

Fig. 10. Result of soil monitoring at the STP area of the Fernald plant. SSM measurements were made on the highlighted points on a grid; each grid value (in both directions) corresponds to 18.3 m. The contours were interpolated between the measurements. The large cross-hatched area corresponds to the sewage treatment plant itself, and the smaller area represents the STP access road. Neither of these areas was monitored.

Some points were not measured on the STP grid because of the topog[illegible] [illegible] [illegible]cations, and others were not measured because of time constraints. However, we fe[illegible] [illegible] [illegible] [illegible]easurements taken do adequately quantify the contamination levels in the STP area. The [illegible] [illegible] [illegible]are, cross-hatched area represents the fenced STP area (including the sewage treatment [illegible] [illegible]self and the old incinerator) that was not monitored. The small rectangular area represents the access road to the STP and is included to help in site orientation.

While the absolute calibration may be as much as 50 % in error, the relative contamination levels should be correct. The statistical error associated with any given measurement is ± 2 pCi/g. If the SSM were removed and immediately replaced, the short-term repeatability is ± 4 pCi/g. Finally, if a point is repeated at several times throughout the day, the long-term repeatability is ± 10 pCi/g. The statistical error is directly related to the measurement time; if greater statistical accuracy were required longer measurements could be used. With this prototype, 15 min between points and a 5-min measuring time were required for data believability. Thus the measuring time of this specific device cannot be decreased significantly. We suspect that the larger variation in repeated measurement is due to changes in the air seal between the SSM and the soil. Even small air leaks can significantly affect the measurement. The major source of uncertainty is the time of day and soil conditions. The soil outgassing, radon levels, and alpha penetration length all depend on the moisture content of the soil and can change drastically under the sun or after a rainstorm. Because this "environmental" fluctuation was so large, we did not attempt to further reduce the other error contributions. It is interesting to note that the humidity levels (50 to 98 %) present during these measurements did not seem to adversely affect the SSM.

The large "hot" area between (2,12) and (11,12) is the result of incinerator ash falling to the surface. The hot areas around (4,8) and (8,3) correspond to known leakages from the fenced STP area (the grid was not sufficiently close to the fence to detect similar leakages on the other fence boundaries). The "hot" area at (4,1) corresponds to a previously known hotspot whose source is unknown. The hot area extending from (1,3) to (4,3) was previously unknown, but the number of measurements (some repeated) in this area makes us confident of its existence. This area may extend under (5,3), where the clean gravel overburden would obscure the signal.

We interpret the cold area around (5,3) as being caused by the clean gravel spread over the surface to form a parking area. Similarly (6,1) was covered with older, dirty, gravel. The large cool area around (2-3,9-10) corresponded to a wet, swampy part of the site. The water could have been covering some of the contamination, or running water could have dispersed the uranium. These spots were near the swampy area, but were dry when monitored.

Any feature that is smaller than a grid is probably not believable. This would include the "feature" at (11, 2) and the "artifact" between (5,2) and (6,3). We attempted to compare our results with those obtained with both Ludlum 139 and Eberline traditional portable alpha detectors. None of the contamination at the STP site was detectable with either portable alpha instrument.

4. Measurements for the D&D Area. Figure 11 shows the results of the 1-m SSM scan of the D&D area. In this area, the contamination levels were so high (~ 100 to 3000 pCi/g) that we didn't subtract the instrument background (~ 8 pCi/g). Data was taken at the points indicated by the open circles and the contours were interpolated by the DeltaGraph graphing program for the Macintosh. Some points were not measured on the D&D grid because of the topography of the locations, and some were not measured because of time constraints. The irregular cross-hatched area was neither gridded nor monitored.

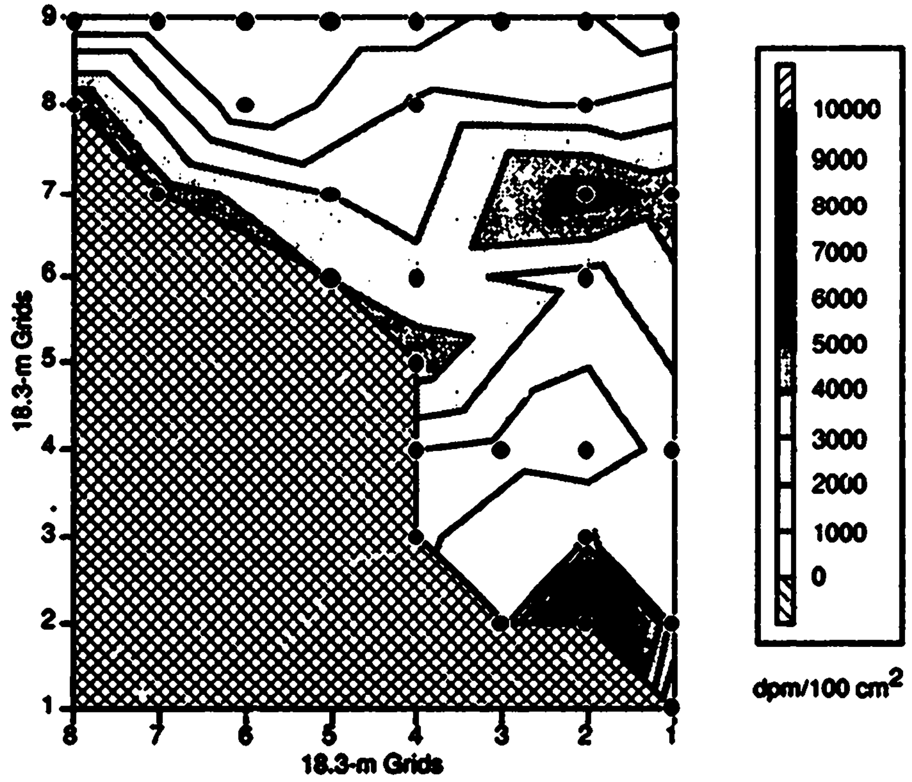

Fig. 11. Result of soil monitoring at the D&D area of the Fernald plant. SSM measurements were made at each of the highlighted points on a grid: each grid value (in both directions) corresponds to 18.3 m. The contours were interpolated between the measurements. The irregular cross-hatched area was not marked or monitored.

As mentioned above, while the absolute calibration may be somewhat in error, the relative contamination levels should be correct. The statistical error associated with any given measurement in the D&D area is ± 10 to 20 pCi/g. If the SSM were removed and immediately replaced, the short-term repeatability is ± 30 pCi/g. Finally, if a point is repeated at several times throughout the day, the long-term repeatability is ± 100 pCi/g. Because LRAD readings are statistical in nature, higher contamination levels are expected to generate larger uncertainties. Because the "environmental" fluctuation again dominated the error estimates, we did not attempt to further reduce the other error contributions. The humidity levels (50 to 98 %) present during these measurements did not seem to adversely affect the SSM.

The hot area around (2,7) had been identified by Fernald personnel. The very hot area at (2,2) was not anticipated, but was explained after our measurement as a location where an unspecified barrel had spilled. In addition, there were several bits of metal in this area that might have carried additional contamination. The point at (2,2) was measured several times with consistent results. We do not have an interpretation for the hot area along the edge of the measurement area from (8,8) to (4,5). The very cold area along the top of the figure corresponds to a roadbed that may be covering other contamination.

IV. CONCLUSIONS

Traditional alpha detection and monitoring systems are unable to meet many of the current demands for sensitivity, efficiency, and portability. The LRAD surface monitors described in this paper *can* meet these demands. In particular, both the MSM and SSM systems have been used successfully in field conditions. Each of the tests leads to more specific conclusions. The **following conclusions relate to the performance of the MSM.**

Test Area	**Conclusions Based on MSM Performance**
Loading Dock	• Can efficiently monitor floors, either indoors or outdoors • Can completely monitor small areas for surface alpha contamination in a reasonable time • Can detect changes in surface contamination as small as 10 dpm/100 cm^2 • Is sensitive enough to reliably detect contamination levels that were previously unmeasurable • LRAD can make surface measurements that are stable and reproducible
Blasting Pad	• Is a fully field-tested alpha monitoring system and can be operated reliably from a battery power supply and a local ground (requires no connections to existing electrical systems) • Can scan moderate-sized areas for surface alpha contamination in a reasonable time • Is sensitive enough to detect changes of 10 dpm/100 cm^2 in field monitoring

The following conclusions relate to the performance of the SSM.

Test Area	**Conclusions Based on SSM Performance**
Fernald	• Is a fully field-tested alpha monitoring system and can be operated reliably from a battery power supply and a local ground (requires no connections to existing electrical systems) • LRAD system used in the SSM is not adversely affected by high-humidity operating environments • Can be used to scan large areas (~ 10 acres) for surface alpha contamination in a reasonable time • Has a dynamic range from 30 dpm/100 cm^2 (10 pCi/g) to at least 9000 dpm/100 cm^2 (3000 pCi/g) • Is sensitive enough to reliably detect soil contamination levels that were previously unmeasurable • Functions well in high-contamination areas, but it is better suited for use in areas of much lower contamination • Is best used as an "environmental" monitor to look at large contamination features in relatively clean areas

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