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Title: **A Real-Time Alpha Monitoring System for Radioactive Liquid Waste**

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A REAL-TIME ALPHA MONITORING SYSTEM FOR RADIOACTIVE LIQUID WASTE

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ABSTRACT

A real-time monitor for radioactive liquid waste is being developed at Los Alamos National Laboratory (LANL). This detector system is designed to monitor for large changes in alpha activity in a liquid waste stream. The detector is unique in that it monitors the ionization created by alpha interactions with air, using long-range alpha detector (LRAD) technology (1). This is a non-intrusive method that can be used in various complicated geometries. This technique only allows for the monitoring of the surface of the liquid, however, preliminary tests indicate that the technique should allow for real-time, sensitive monitoring of a well-mixed liquid waste stream. This technique will require further research and development, but the final system should be an inexpensive detector system for segregating and monitoring radioactive liquids at national laboratories, processing facilities, and nuclear power plants.

INTRODUCTION

A prototype radioactive liquid waste monitor is being developed for the group CST-13 at Los Alamos National Laboratory. This monitor will be used in the radioactive liquid waste treatment facility (RLWTF) so that the operators know when there is a large change in the activity of the influent waste stream. These spikes in activity will be 10 to 100 times above the average influent activity. The average influent typically has an activity of tens of nano-Curies. Measurements were made in 1994, and the detector was able to monitor liquid below the 100pCi/L level. Current regulations mandate that both influent and effluent be monitored to determine the overall effectiveness of the treatment process. Traditional methods require up to a day and a half for analysis. This monitor will be able to monitor the gross alpha activity from the surface of a liquid stream in real time, giving the operators a chance to better segregate the liquid as well. This technique will save both time and money and may eventually be applied to effluent monitoring before discharge into the environment.

DESIGN

Traditional alpha detectors monitor the alpha particles directly, requiring that they be close to the object being monitored. It is difficult to design a detector to do this because of the changing levels of the liquid stream, humidity, and other engineering concerns. The radioactive liquid waste monitor being developed by LANL is not subject to these constraints because it monitors the airborne ionization created by the surface alpha particles. Tests at LANL have shown that this ionization can be transported via an electrostatic field or by airflow up to distances in excess of several meters, depending on the application. Each 5-MeV alpha particle can create approximately 150,000 ion pairs, therefore this technology has proven to be highly sensitive for monitoring alpha contamination.

This prototype design is based on the electrostatic long-range alpha detector (LRAD). As shown in Fig. 1, the influent is placed in a stainless steel sink. The top portion is removable and consists of two stainless steel signal planes and two electrometers. A current, at the fA level, is measured on each signal plane. These signals are then converted to mV and output to a computer for storage and analysis. The bottom plane measures the ionization of the volume beneath it, which includes the background ionization and the ionization from the sample. The top plate measures only the background ionization in the volume above it. By taking the difference of these two signals, one gets a background-compensated signal that is representative of the alpha activity from the sample surface (2). By calibrating the detector, it is possible to directly convert this signal into a measure of activity. Figure 2 shows the standard calibration using a standard set of National Institute of Standards and Technology (NIST) traceable Pu-239 sources. The source strengths range from 100 to 1100 dpm-alpha. For this prototype, the conversion for dry samples is 1 mV = 58.98 dpm. This detector is clearly able to discriminate dry samples with less than 100 dpm-alpha activity. Initial tests using liquid samples show the prototype to be sensitive to samples of 100 pCi/L. The efficiency of such an electrostatic design is roughly 40 %.

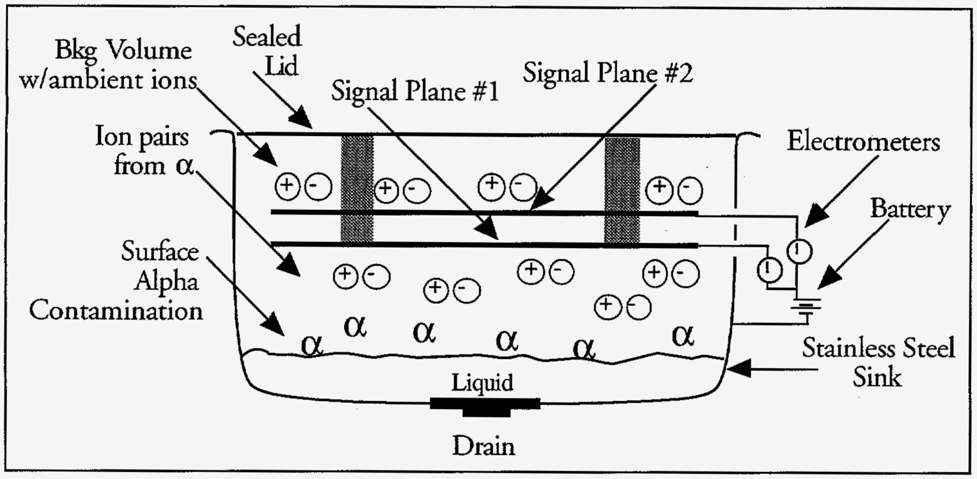

Fig. 1. Schematic drawing of the LRAD radioactive liquid waste monitor prototype. The top volume only measures background ionization, therefore the difference of the two signal planes gives only the contribution to the signal from the surface alpha contamination.

It should be noted that tests will also be made using the airflow LRAD design. In this design, a fan will be used to draw the ions to a detector grid. This design would be useful in monitoring liquid inside large sewer pipes. This type of detector is more subject to noise and has an inherently lower efficiency than the electrostatic design, however it might provide a better indication of the surface activity since it would be able to draw air from a larger volume. All the air drawn off would then be recycled back into the volume.

PRELIMINARY RESULTS

Tests have been performed at the radioactive liquid waste treatment facility at LANL using actual radioactive influent samples. These preliminary tests have shown that this prototype is able to monitor low-levels of alpha contamination in liquids. These tests have consisted of putting both radioactive samples and distilled water in the detector for lengths of time more than three days. As shown in Fig. 3, these tests show that this design is able to adequately compensate for changes in background radiation levels. In Fig. 3, the signals from both the top and bottom signal planes are shown. Both signals track each other well, and the difference of these signals is a smooth line corresponding to the activity of the sample only. Fig. 4 shows the results of running with a radioactive liquid sample over a 3-day period at the RLWTF. The mean signal for this period was 23.5 ± 1.4 mV. This prototype has shown no problems with humidity, despite the fact that a considerable amount of condensation builds up inside the detector. Additional testing has been performed that shows that this detector is also fairly immune to mechanical noise.

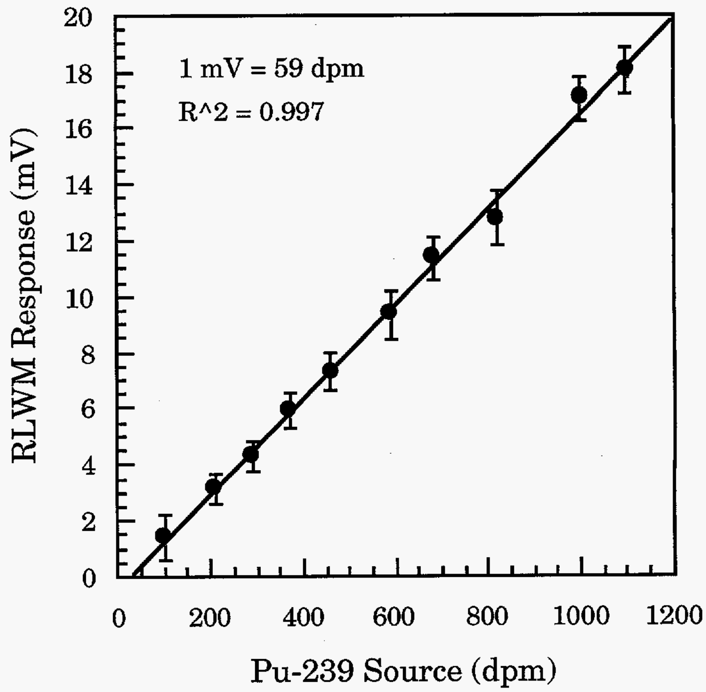

Fig. 2. A linear curve fit of the LRAD radioactive liquid waste monitor prototype using a NIST traceable set of Pu-239 sources. For these sources, the conversion was 1 mV = 59 dpm.

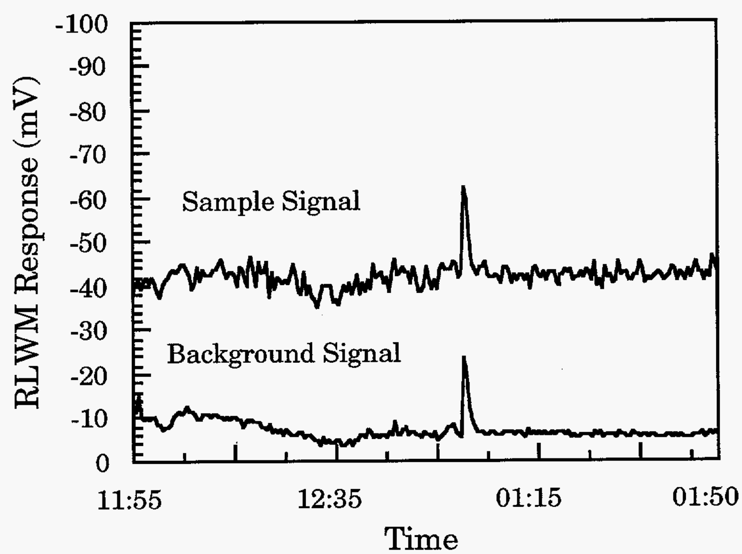

Fig. 3. The top detector plane reads only the background ionization. The result of taking the difference of these two signals is a smooth signal corresponding to the activity of the sample being monitored.

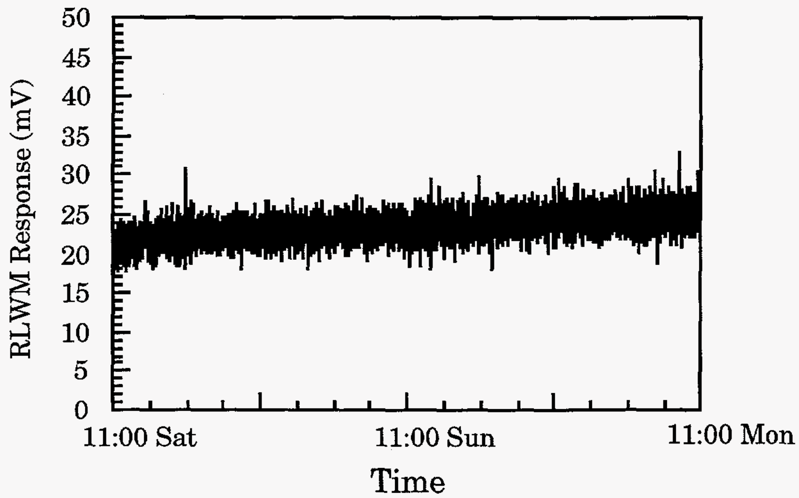

Fig. 4. This plot shows the response of the LRAD radioactive liquid waste monitor over a 3-day period using background compensation. The mean signal was 23.5 ± 1.4 mV.

All of these tests will be repeated and a comparison to laboratory analysis using traditional alpha monitoring will be made. This will allow us to determine a conversion to alpha activity per unit volume. These tests, as well as testing with an airflow LRAD, will be made in February 1995, after which a new prototype will be built for inline testing at the treatment facility. A working real-time monitor for spikes in activity should be installed at the treatment facility and operational in the first half of 1995.

CONCLUSION

This detector has been shown in preliminary tests with radioactive liquid samples to be a sensitive alpha monitor. It is able to compensate for changes in background radiation and it operates in real time. Because the design of this system does not require costly parts and labor, it is inexpensive compared to other real-time alpha monitoring systems.

The preliminary tests carried out at LANL indicate that this detector can be used to monitor for large changes in alpha activity in liquid streams. Further funding will allow further development of this system so that it can be used as a sensitive assay device as well. This type of detector can be used for monitoring before, during, and after processing liquid waste. It can prove valuable to treatment facilities by monitoring processed liquids before release into the environment, thus ensuring regulatory compliance. It could also prove beneficial to the commercial power industry. We are currently seeking an industrial partner to assist in carrying out this development.

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