DESIGN, ASSEMBLY, AND CALIBRATION OF A RADWASTE BARREL SCANNING SYSTEM

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ABSTRACT

Utilities, other waste generators and burial sites are frequently faced with the difficulties of determining the contents of waste containers without the benefit of direct waste sampling. Under these circumstances, the waste container contents must be estimated by using a dose-to-curie methodology and some prior knowledge of the gamma emitting radionuclide distribution. Often, the gamma emitting radionuclides' distribution is not known. This lack of knowledge of the gamma emitting radionuclide distribution can introduce considerable errors. Even when the distribution is measured in a statistically significant number of samples, this distribution varies widely with radionuclide decay and changing conditions within the radwaste generating facility. These errors, in turn, can lead to over and underestimation of the contents of given waste containers. Most generators strive to estimate waste container contents in a conservative manner, i.e. overestimate container contents. This overestimation leads to unnecessarily conservative waste shipment documentation and excess disposal costs. In addition to the economic penalty paid by the generator, this overestimation will lead to premature closure of waste burial facilities. The work presented here describes the design, assembly, and calibration of an automated system for scanning radwaste barrels and other containers. The system can accurately determine the gamma emitting content of these containers as a function of container geometry and waste density. It also has the ability to determine the location of maximum activity to within one inch of vertical height.

INTRODUCTION

Some types of radioactive waste cannot be easily sampled. This difficulty has led to the development of drum counting systems that can analyze the contents of containers by detecting the gamma radiation emitted from the container. The Barrel Scanning System reported here consists of a Grid™ 386 laptop computer, custom designed motor driven elevator, container turntable, and high purity germanium (HPGe) gamma ray spectroscopy system. All aspects of the system are controlled by the computer, providing a user friendly system for the nearly automated scanning of radioactive waste drums and locating the maximum activity zone in the drums to within one inch of vertical height.

During analysis, the waste drum is rotated to decrease the effects of non-uniformity of the contents. The HPGe detector, fully shielded by a tungsten alloy shield and collimator, is moved vertically to scan the full height of the drum. Canberra multichannel analyzer and software provide the basic counting hardware and software.

The overall system is controlled through an "autosequence" file which operates inside the Nuclear Data Accuspec™ software. This autosequence file, along with a number of specially written batch and compiled basic programs, provides a series of commands that automatically directs the hardware, at the direction of the operator, to :

1. Enter waste container specific information (container name, count time per segment, and container weight).
2. Locate the detector at the first scan position.
3. Collect a multichannel analyzer spectrum at each of 33 locations along the vertical profile of the drum.
4. Analyze the combined spectrum for the quantification of the waste in the drum.
5. Print the results.
6. Display the drum activity profile.
7. Archive the results on diskette and store a compressed version in an archive directory on the system hard disk.
8. Return the detector to the initial scan position.

SYSTEM CALIBRATION

One of most difficult aspects of the Barrel Scanning System is its proper and accurate calibration. To properly simulate a waste drum, a dummy drum must be uniformly contaminated with a known quantity of radioactive material. at various densities. To this end, discs of three materials with densities of 0.43 g/cc, 0.99 g/cc and 2.02 g/cc were constructed. Half of these 21 inch diameter by 1 inch thick discs were provided with half inch deep by one inch wide machined grooves. Half inch by one inch square pieces were supplied to fill these groves. Fifteen 250 μCi Eu- 152 sources, in a one inch square configuration, were procured to supply the simulated activity with an energy spectrum that spans the desired range. These fifteen sources were distributed in the machined grooves at various radial and vertical locations. Twenty-two calibration runs were completed for the initial system calibration on standard 55 gallon drums.

From the collection of calibration runs, five runs were chosen as the most characteristic of a uniformly distributed waste drum. These data are shown in Fig. 1. Because the spline fitting method was used for energy efficiency fitting, the data were extrapolated to 1600 Kev. This allows analysis of nuclides that emit gammas to this level of energy. The data were then curvefit via least squares analysis to a second order polynomial of the following form:

Efficiency = Constant + Density * (X Coeff 1) + Density ^ 2 * (X Coeff 2)

From the generated equations, efficiency data were calculated for the range of densities (drum weights) used for the Drum Scanning System. The generated data are shown in Fig. 2. These data were then entered into eight efficiency files corresponding to the eight drum weight ranges.

Since drums are analyzed with only eight discrete efficiency ranges, a small amount of error is introduced because each drum's density must be approximated by one of the eight ranges. A drum that falls exactly between the weight ranges will incur the most error. At high energies this error will range from 3% for high density waste to 7% for low density waste. For low energy gammas, the introduced error varies from about 2% for high density waste to 11% for low density waste.

The major source of error in analyzing drums involves the assumption of waste uniformity. If most of the activity in a drum of waste is located in the center, the gamma spectrum will be attenuated by the media. The drum contents will be underestimated by this effect. To test this effect, all of the activity was placed in the center of the simulated waste drum. The error from non-uniformity of waste is greatest for the high density waste and low energy gamma emitters, since the most attenuation occurs for these extremes. This error ranges from 10% for high energy gammas in low density waste to as much as 100%, when low energy gammas are attenuated completely by high density waste media.

SUMMARY

In summary, a system was designed for the automated analysis of waste containers. This system was calibrated for the waste container geometry at three waste densities. These three data sets were then used to provide a range of efficiency factors, such that waste over the range of 0.1 to 2.0 g/cc in density and gamma emitting radionuclides over the range of 0.1 to 1.5 Mev. The system allows the location of maximum activity can be defined to within one inch of vertical distance.

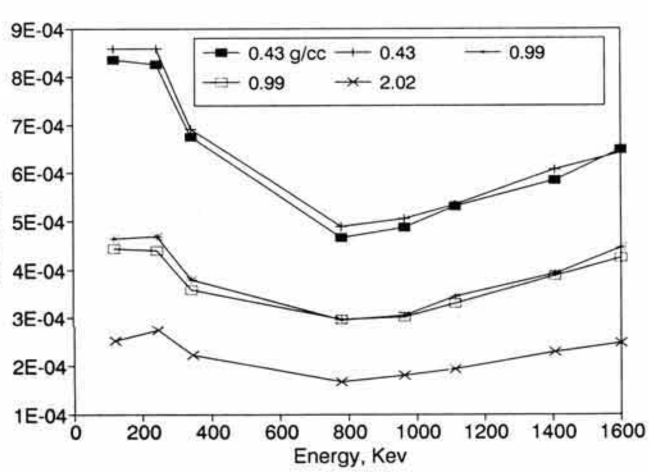

Fig. 1. Efficiency vs. energy.

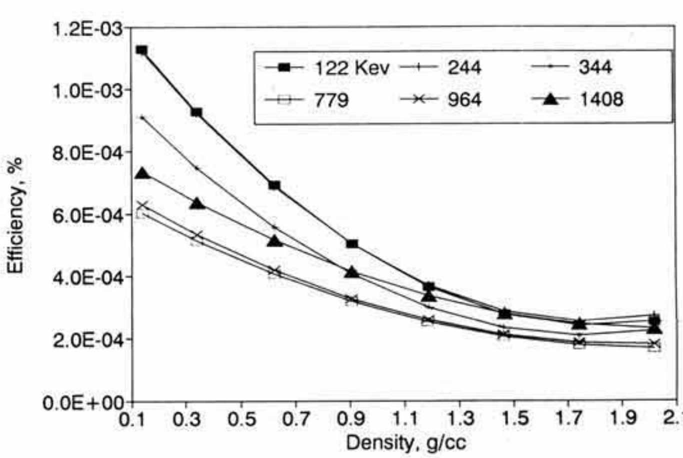

Fig. 2. Efficiency vs density.