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Use of a Sensitive Gamma Assay Instrument for Classification of Waste in a Plutonium Stabilization Facility

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Abstract

A sensitive Qualitative and Quantitative (Q^2) gamma assay instrument manufactured by CANBERRA Industries has been installed in a Department of Energy (DOE) plutonium stabilization facility to segregate low level waste (LLW) from transuranic (TRU) waste. At a life-cycle disposal cost of approximately $1,221 per cubic foot more to dispose of TRU waste compared to LLW disposal, a significant savings can be achieved if it can be shown that waste previously classified as TRU waste is in fact below the TRU threshold of 100nCi/g. Traditional neutron and gamma measurement methods have not been sensitive enough to detect tens of nano-curies-per-gram levels of transuranic radionuclides. With classification made according to the location of origin of the waste, the result has been some waste classified as TRU that is in fact LLW. The Q^2 has the required sensitivity with a ^{239}Pu minimum detectable level below 20nCi/g for waste in the net weight range of 17 to 35 kg. In the first months of operation the instrument identified as LLW thirty-two of forty-two waste containers previously classified as TRU. This resulted in a cost saving of $250,000. An estimate of the projected cost savings shows the savings should pay for all costs associated with the project within 18 months of startup.

Introduction

The handling and disposal cost of radioactive waste is very high and varies according to waste type and method of disposal. Some of the costs associated with waste handling and disposal are materials (drums, drum liners, bags), transportation, tracking, storage, measurement, burial, and surveillance costs. The FB-Line plutonium stabilization facility at the DOE Savannah River Site (SRS) has traditionally disposed of waste based on the radiological survey levels of the room from which the waste is removed. The recent installation of a Q^2 gamma spectroscopy system to distinguish LLW from Transuranic waste has resulted in a large cost savings over a very short period of time.

Background

Since the end of the cold war the mission of the FB-Line facility at the (DOE) Savannah River Site has changed from plutonium production to plutonium stabilization. In fiscal year 1998 this facility generated approximately

13,900ft^3 of solid TRU and LLW. Of this waste, 951ft^3 were classified as TRU (>=100nCi/g). The cost of disposing of contaminated waste is typically very high throughout the DOE complex. At the SRS FB-Line facility the cost of disposing of TRU waste is $1300/ft^3 (~$10,000 per 55-gallon drum) whereas the cost of disposing of LLW is $79/ft^3 (~$600 per 55-gallon drum). The potential cost of the loss of confidence by our customer and the public as a result of improper disposal of TRU waste is much higher. Accurate radiological content determination and proper disposal are required.

Waste classification and disposal at the FB-Line facility is based upon knowledge of where the waste is generated. The level of contamination likely to be found in the waste is determined from room postings and room surveys performed by radiological personnel. Classifying waste based on the room posting is a conservative measure until the radiological content of the waste can be quantified. Waste from a glove box will likely contain high levels of contamination. Waste from a room posted as a contamination area has the potential to be LLW but because it was generated in a room with a high posting it is considered TRU waste until it can be shown otherwise. Waste streams are identified for different types of waste such as TRU, Low Level, and Mixed waste. All waste is segregated, packaged, and tracked according to waste stream.

Current Waste Measurement

After it is segregated and packaged, all radiological waste is measured using Neutron Coincidence Counting (NCC), Segmented Gamma Scanning (SGS), and/or portable gamma measurements. The measurement method chosen depends on the size and location of origin of the waste. The detection limit for both the NCC and the SGS is approximately 0.1 gram of ^{239}Pu. Scaling the facility distribution to the 0.1g ^{239}Pu results in a total package activity greater than the TRU threshold of 100nCi/g. The portable gamma system has an even higher detection limit than the NCC and SGS. Before the Q^2 was available, waste packages containing levels of contamination that fell below the NCC and SGS minimum levels of detection potentially resulted in LLW being disposed of as TRU waste at a significantly higher processing and burial cost.

With the end of the cold war, DOE budgets and resources have become very tight. Minimizing waste handling and disposal costs has become a necessity. An improvement in the sensitivity of the waste assay instrumentation would translate into fewer drums incorrectly disposed of as TRU waste. In an attempt to solve this problem, a sensitive Qualitative and Quantitative (Q^2) near field gamma assay instrument, manufactured by CANBERRA industries, was installed in the FB-Line facility.

Q^2 Description

The Q^2 system is a sensitive near-field gamma spectroscopy system that can measure several transuranic radionuclides, including ^{239}Pu, below a 100nCi/g concentration. The system consists of a 6-inch-thick low background steel shield and three planar low-energy germanium detectors configured vertically on one side of the shield. The shield completely surrounds the detectors and sample in all directions. The waste is placed inside the shield, weighed, and rotated to decrease the effect of heterogeneity in the waste. The operator enters an estimate of the fill height of the container. The Q^2 software then calculates the waste density from the weight and volume of the waste. The density is used to correct for attenuation effects. The system is intended for LLW only so a transmission source is not required. A library driven peak search is performed and activity is reported for all isotopes identified in the waste package. The system reports a minimum detectable activity (MDA) for those nuclides identified in the library but not found in the waste. For a complete discussion of the design, performance, and sources of error see Reference 1.

Figure 1: CANBERRA Q^2

Implementation

The Q^2 system installed in the FB-Line plutonium facility was designed to measure drums, drum liners, 21" cube boxes, and bagged waste placed in a drum over pack container. The system was installed in a low background area close to the loading dock for easy waste removal. Non-fissile waste from the facility is measured on the NCC described above and all waste that measures below the MDA of the Neutron Counter is then assayed on the Q^2. The facility waste distribution is scaled to the ^{239}Pu activity reported by the Q^2 to arrive at the total TRU activity in the package. Packages with TRU activity (plus two sigma) below the 100nci/g limit are reclassified as LLW. This determination was automated by modifying a report template provided by the manufacturer. System startup was very straightforward requiring the usual hazard reviews, procedures, and operator training.

The cost of purchasing and installing the Q^2 in the FB-Line facility totaled $503K. The equipment cost was $340K with the balance making up installation and project overhead costs. The cost of startup, training, and development of operating procedures was approximately $100K. The Q^2 became operational in June 1998.

Results and Projected Savings

In the seven months since the start of Q^2 operation, 77% of facility TRU waste ($205ft^3$ of $265ft^3$) has been reclassified as LLW, resulting in a cost saving of $250K.

The CANBERRA catalog (ref. 2) quotes a typical lower limit of detection (LLD) of 11.1nCi/g for ^{239}Pu at a density of 0.1g/cc and 5.3nCi/g for ^{239}Pu at a 0.3g/cc density. Measurements of ^{239}Pu as low as 10.97nCi/g have been achieved for FB-Line facility waste in the density range of 0.10 to 0.14. Minimum Detectable Activity values of 1.0nCi/g have been achieved for waste with a density of 0.10g/cc and 1.96nCi/g for waste with a density of 0.32g/cc. Table I identifies the sensitivities quoted by CANBERRA and Table II summarizes those achieved at the Savannah River Site FB-Line facility.

The FB-Line facility generated $951ft^3$ of TRU waste at an average of $80ft^3$ per month. Assuming the same generation and reclassification rates for fiscal year 1999, potentially the resulting cost savings could pay for the equipment costs in less than four months and pay for all costs associated with its purchase, installation, and startup in less than seven months.

Conclusion

Cleanup of the DOE complex requires accurate waste measurements and proper disposal of waste to ensure the public that the environment is preserved while maintaining efficient and cost effective disposal methods. The results achieved at the SRS FB-Line facility demonstrate that the current waste procedures are conservative for

the FB-Line TRU waste stream in that no TRU waste has been disposed of as LLW. The Q^2 system results have not only validated the facilities waste generation, segregation, and tracking procedures but also the Health Physics departments' radiation measurement and posting program. The cost savings realized at the FB-Line facility cannot be guaranteed at other facilities but does illustrate the potential for cost savings at similar TRU processing facilities.

The sensitivities achieved confirm the capabilities of the Q^2 system to assay Plutonium in a low background environment. The modifications required for the TRU/LLW determination were minor but require that a facility waste distribution be available.

References

1. F. L. BRONSON, "Q^2 - A Very Low Level Quantitative and Qualitative Waste Assay and Release Certification System", 1990 Waste Management Conference, Tucson Arizona, February 1990
2. CANBERRA Industries, "Edition Nine Systems Supplement", CANBERRA Nuclear Catalog, (1996)