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EXPERIENCES WITH CONFIRMATORY MEASUREMENTS AT THE SAVANNAH RIVER PLANT

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ABSTRACT

Confirmatory measurements are performed on all Category I and II plutonium shipments to the Savannah River Plant (SRP). The primary technique employed has been neutron coincidence counting using three instruments; two slab counters, and a well counter. These measurements have provided the required safeguards features to support the physical security measures already in place for inter-site shipments of special nuclear material (SNM). Similar confirmatory measurements have also been performed on a variety of scrap mixed-oxide materials stored at SRP for later processing. The data handling and results for several categories of material will be examined in addition to planned uses of the Rocky Flats Plant (RFP)/SRP Confirmatory Measurements Counter (CMC).

INTRODUCTION

Within the last three years, the Savannah River Plant has become increasingly involved in the receipt and reprocessing of scrap SNM. In order to comply with the material control and accountability aspects of the 5630 Series of DOE Orders, several major programs have been initiated. The objective is to be capable of assaying all receipts within ten days of arrival and before any reprocessing steps are begun. Projects for two new facilities and additional instrumentation have been approved. In the interim, existing nondestructive assay instrumentation, calorimeters, and solid gamma isotopics systems, are utilized to assay material prior to reprocessing. In addition, appropriate confirmatory measurements are carried out on all Category I and II SNM received at SRP. For plutonium-bearing material, coincident neutron counting is used to perform the confirmatory measurements after the material is removed from the transport vehicle and before storage in a vault. Since November 1984, SRP has been using a newly built neutron counting system from RFP to make the measurements on material received from RFP. An identical unit in place at RFP allows each shipment to be measured by both the shipper and receiver. Only a comparison of neutron counts is needed to confirm that no diversion has occurred between measurements. Similar types of measurements using gamma spectroscopy have been used for confirming the contents of several types of mixed oxides stored at SRP, and will be used to make confirmatory measurements as future enriched uranium and mixed-oxide shipments are received.

NEUTRON COUNTING SYSTEMS

Several different types of neutron counters have been in use at SRP during the past eight years. These were primarily used for test and evaluation purposes using the wide variety of material received at the site. The first counter used routinely in a production environment was an SRP slab counter, using BF_3 proportional tubes. This unit was modeled after a Los Alamos unit tested at SRP in 1980-81. Experiences with these two units were used as input in the design of the RFP/SRP Confirmatory Measurement Counter (CMC) (Ref. 1) which has been in use since November 1984 on 6M, 30-gallon shipping containers. SRP also has a LANL designed dual-range coincidence counter (DRCC) for measuring individual containers. This unit was evaluated by LANL/SRP in 1980-81 (Ref. 2) on a variety of metal and oxide receipts.

The normal procedure for making confirmatory measurements involves preplanning with production personnel to decide where the material will be stored, if it will need to be unpackaged immediately due to the type of storage space available, and what type of counting system (well or slab) should be used. Due to the extensive safeguards and security measures involved in unloading, measuring, unpackaging, and storing SNM, these activities are very manpower intensive. In general, the CMC is preferred over the DRCC because fewer containers need measuring, less handling is required, and radiation exposure is reduced. The net result is a reduction in manpower and a time savings of up to 50% when using the CMC rather than the DRCC.

Other factors which determine the counter type and method to be used are the material type and preshipment data. SRP receives material of all types, with a wide variability in quality. Some of the material can be high in americium content which may not allow for unpackaging except in a shielded facility (PUREX canyon). This type of material would only be counted in a slab counter. In some cases, the quantity of material in a shipping container is too low to be efficiently counted in any available counter except the DRCC. When this occurs, the inner container would be counted after the shipping containers were opened, thus increasing the time to complete the measurements.

DATA ANALYSIS AND RESULTS

The confirmatory measurements made at SRP are categorized into three major types: fingerprint, comparative, and verification. The fingerprint type involves comparing shipper's and receiver's neutron values after normalization with standards. This is a qualitative measurement in terms of grams of SNM although good precision can be obtained for the neutron data. A comparative measurement entails correlating neutron data with the shipper's plutonium or effective ^{240}Pu weights. This semi-quantitative method is susceptible to biases and cannot detect small diversions from each container in a shipment. In the third type of measurement, an actual measurement of the Pu content is made by calibrating the neutron counter, usually by determining the Pu weight of selected items in a shipment by calorimetry/solid gamma isotopics. The items are selected to span the mass range of the shipment. Depending on the type and quality of material, these measurements can be made with uncertainties up to ±20%. Specific examples of each method are discussed below.

Fingerprint

If a shipment is received from RFP or another site where a passive neutron count is performed prior to shipment, receipt of the SNM is confirmed by comparison of the background corrected total neutron counting rate for each container before and after shipment. For the RFP to SRP shipments similar strength Cf-252 standards are measured at the respective sites and are used to correct any differences in counter response. If data from a normalization standard are not available, counting data from one of the containers in the shipment are used as an internal standard to correct differences in counter response. The precision of the confirmatory measurements using the total neutron count rate is heavily dependent on variations in the ambient neutron background in the production facility. Measurements of SNM with very high neutron rates (10^6 to 10^7 neutrons per second) such as kilogram quantities of Pu/Al alloy scrap have routinely been made to a high precision with the identical CMC units at RFP and SRP. Figure 1 is a plot of the percent differences, (RFP-SRP)/RFP x 100, in the total count rates observed for a number of shipments. The data have been corrected for about a 2 percent bias observed with the Cf-252 standards. For the same measurements on impure Pu oxide, slightly less precise measurements have been observed. The ability to correctly measure and compensate for a shifting neutron background in the process area due to SNM movement appears to be the limiting factor. The relative precision of the measurement is primarily dependent upon the signal to background ratio for a given type of SNM.

Comparative

When shipments are received that have not been neutron counted by the shipper or have been measured in dissimilar counters (e.g., a DRCC at one site and a CMC at the other), dead time corrected coincidence count rates are used for the confirmation of SNM receipt. The real coincidence rates for each container are correlated with the shipper's information for element weight and ^{240}Pu content. Individual items exceeding predetermined limits are routinely flagged for immediate investigation. This usually consists of verification by calorimetry and gamma-ray isotopics. Figures 2 and 3 are examples of typical coincidence data versus ^{240}Pu weight for SNM measured in the CMC and DRCC systems at SRP. The counting data have not been corrected for multiplication effects, and the coincidence background is generally negligible.

Verification

Under certain conditions, element weights for each container are generated from the neutron counting data using the shipper's isotopic data. A calibration factor for a given shipment is determined by measuring selected containers by calorimetry and gamma-ray isotopics to obtain an accurate value for the effective ^{240}Pu content. This calibration factor and isotopic information is used to calculate Pu element weights for each container. The accuracy of the Pu content for an individual container by this method is 15 percent or less when using the CMC and more precise with the DRCC[1]. However, the overall Pu content of a shipment can be estimated to better than 5 percent when a sufficient number of containers are measured, since much of the error is due to random fluctuations (see Figure 4).

VAULT INVENTORY MEASUREMENTS

Confirmatory type measurements were made on a large variety of SNM stored in several locations at SRP awaiting reprocessing. Two counting techniques, neutron counting and gamma-ray spectroscopy, were used for these measurements. The choice of technique and instrumentation varied according to the material, packaging, location, and instrument availability.

Gamma-ray spectroscopy was chosen as the measurement technique for mixed SNM oxides of plutonium and uranium as well as the enriched uranium (EU) that was stored in a large variety of containers. This technique was also chosen for containers of ^{238}Pu. Generally, the 129 keV gamma ray was used to confirm the presence of ^{239}Pu, 153 keV for ^{238}Pu, and 186 keV for ^{235}U. However, when heavily shielded containers were encountered, the 345 keV gamma ray was used to confirm ^{239}Pu and the 766 keV for ^{238}Pu. Heavy shielding prevented the confirmation of ^{235}U in only a few cases. Correlation with content and gamma-ray intensity could be made for similar material in similar containers. However, only qualitative confirmation could be made for many of the measurements. A portable germanium gamma-ray detector was used for all of the gamma measurements so that counting geometry could be easily changed for the different types of containers. Counting times for each item were generally less than 15 minutes.

Neutron counting was chosen as the measurement technique for high purity plutonium that was stored in an area with access to a neutron counting facility. A DRCC was used for material that was small enough to be placed in the counting well (15 cm diameter). Material stored in larger containers was counted in the CMC. A neutron profile (counts vs. position) was made with a portable neutron counter for material that could not be moved. Correlation could be made between neutron rates (reals) and content for similar material in similar containers.

These measurements confirmed the presence of the SNM that was expected in most of the containers. Those not confirmed could be explained as below the limit-of-detection because of high backgrounds or heavy shielding. Circumstances have given us the opportunity to remeasure several containers of SNM by gamma-ray spectroscopy. All results have been within 25% of the first measurement and most results were within 10%. The same detector and counting geometry were used for the remeasurements. Similar results are expected for remeasurements using neutron counting. This can be used as a quick means to confirm that the contents of a container have not been diverted. This technique could be used for routine inventory confirmation or in response to abnormal SNM situations.

DEVELOPMENT PLANS

The present computer hardware configuration for the CMC includes a DEC PDP micro-11 system utilizing an RT-11 operating system. This combination was chosen initially given the intended scope of the project which was just to develop a means to compare neutron counts for the scrub alloy material. However, since that decision was made, the applications for the CMC have increased significantly, as has the complexity of the data analysis. With its increased usage, nontechnical operators would be required; necessitating a user-friendly software interface. To accommodate this change in scope, the present hardware has been upgraded to a PDP microVAX I and a 31 Mbyte disk drive. Software development is in progress to incorporate these additional data handling needs. A standard file structure will be maintained to allow transfer of data between sites (5-1/4" floppy diskettes) with minimal manual interaction. The new software will be menu driven to allow the operator to choose what type of measurement will be performed (fingerprint, comparative, verification, or outgoing shipment) and will request input for any shipper's data required for analysis. This software development is scheduled for completion in December 1985.

SUMMARY

In a continuing program to maintain the safeguards and security posture of the Savannah River Plant, confirmatory measurements are performed on all plutonium shipments. Efforts have been completed to carry out similar measurements for mixed oxide shipments when they resume. The plutonium measurements are usually made using a neutron slab counter (CMC) which is essentially identical to one at Rocky Flats. For shipments between SRP and RFP, these measurements allow for a rapid assessment of the condition of a shipment after receipt. Using californium standards for site-to-site normalization, neutron differences of less than 2% have been obtained. Comparative or verification measurements have been used on receipts from other sites. Over one hundred different types of materials have been measured with these techniques with acceptable results for material control and safeguards purposes.

REFERENCES

1. J. Gilmer. Confirmatory Measurement Counter (CMC) Procedures Manual and System Guide, NDASE Group, Rocky Flats Plant, August 1984.

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FIGURE CAPTIONS

Fig. 1 Comparison of normalized, SRP totals neutron rates and Rocky Flats Plant data versus drums for five different shipments of Scrub Alloy material (Pu-Al alloy) using the Confirmatory Measurements Counter (CMC).

Fig. 2 Comparison of SRP coincident neutron rates versus shipper's grams of ^{240}Pu for three types of Pu oxide using the Confirmatory Measurements Counter (CMC).

Fig. 3 Comparison of SRP coincident neutron rates versus shipper's grams of ^{240}Pu for three types of Pu oxide using the Dual Range Coincidence Counter (DRCC).

Fig. 4 Percent differences between shipper's Pu weight and SRP's weight as determined by neutron coincidence counting. Dual range Coincidence Counter calibrated by calorimetry and solid isotopics system. Note overall shipper/receiver difference of 1.3%.

Figure 1. Fingerprint Measurement Using CMC

Scrub Alloy (Pu/Al/Am)

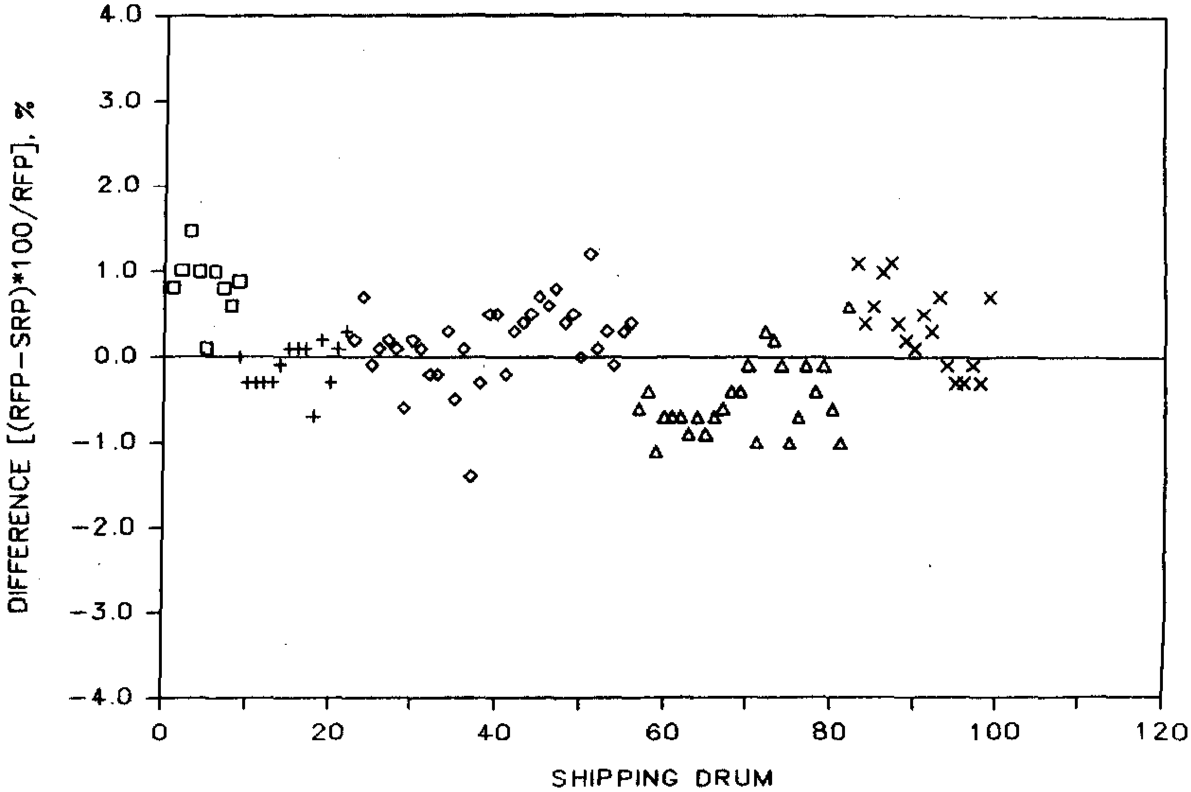

Figure 2. Comparison Measurement Using CMC

Plutonium Oxide

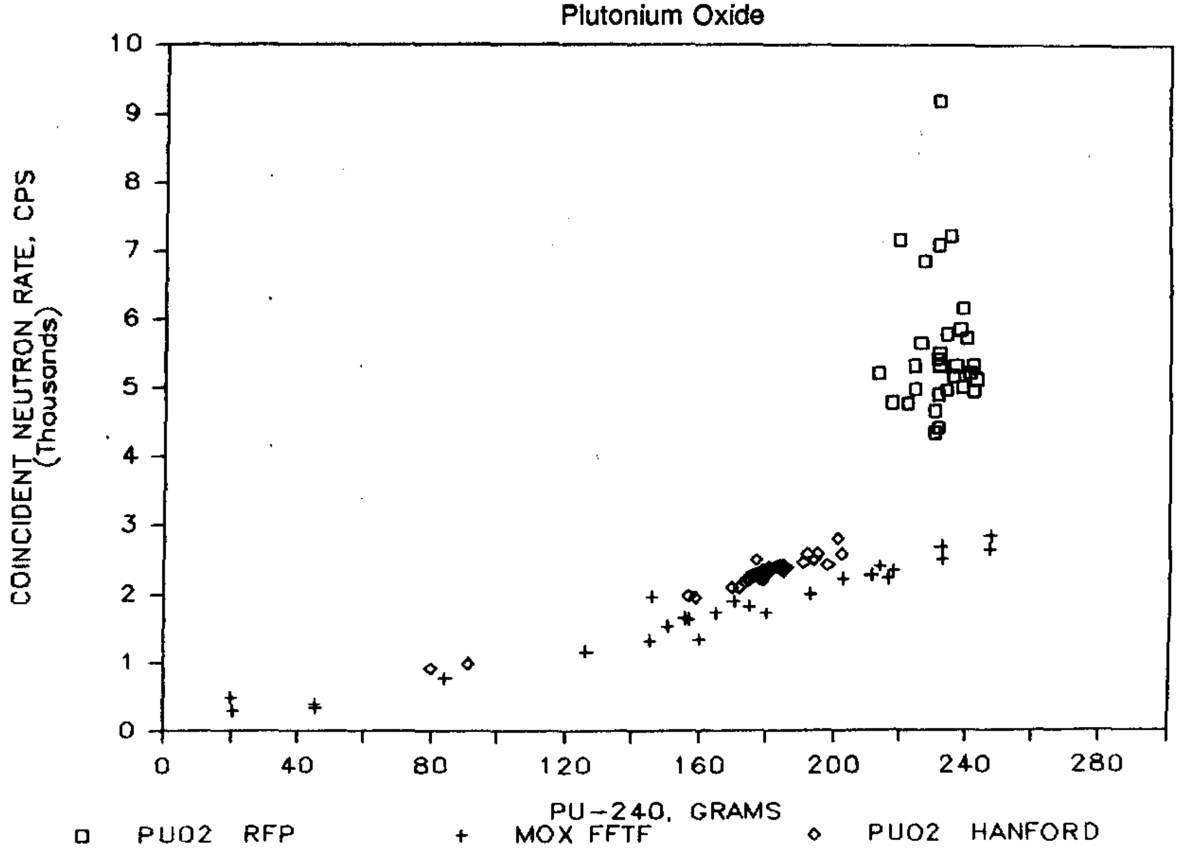

Figure 3. Comparison Measurement Using DRCC

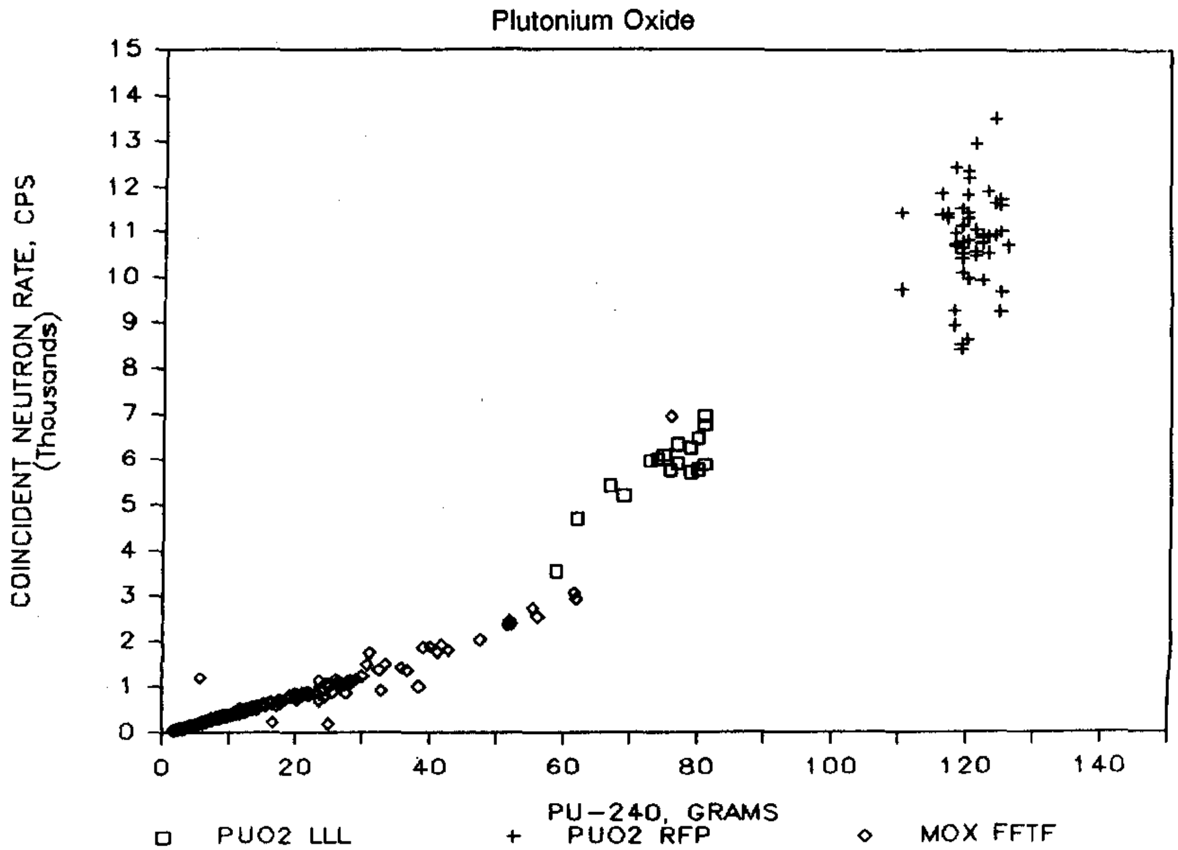

Figure 4. Verification Measurement Using DRCC