This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-96SR18500 with the U. S. Department of Energy.

RECEIPTS MEASUREMENTS AT SRS'S KAMS FACILITY

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Abstract

The Savannah River Site's KAMS facility was designed for the receipt and storage of incoming SNM shipments. MC&A requires confirmation and verification on these items. These items normally arrive packaged in a 9975 container. An Ortec *digi*DART™ coupled to a nominally 2x2 NaI detector is generally used for confirmation measurements. The KAMS facility has a custom designed Neutron Multiplicity Counter (NMC) and a Gamma Isotopic System (GIS) to support verification measurements.

The items contain a whole host of materials from Pu metal to mixed Pu/EU and from items relativity free from impurities to items containing significant amounts of impurities as they relate to NMC assay. The 9975 container itself has proved to be a challenge for NDA work as it contains at least 0.5" of heavy metal shielding as well as hydrogenous materials.

Measurement issues will be addressed in this paper as they apply to the unique application posed by the KAMS environment. These include the 9975 shipping container, confirmatory Measurement Control Program (MCP), Shipper-Receiver reconciliations, and confirmatory receipts measurements vs. timeliness.

9975 PACKAGING

Perhaps the most unique and troublesome aspect of KAMS receipts measurements is the 9975 Package. The 9975 package was designed, among many other criteria, to minimize personnel radiation exposure. This is directly contradictory to conditions for good NDA measurements. Minimizing the radiation exposure also minimizes the very physical characteristic that the NDA specialist attempts to quantify. The fact that the 9975 designers did such a good job in this task severely limits the quality of the NDA measurement.

Figure 2 is a schematic of the 9975 container. Directly above, figure 1 is a top view of the 9975 container showing the many shields that are included in the package that add to the difficulty with receipts measurements. Figure 3 is a cut-away photograph of a typical 9975 container. In figure 2 and figure 3, note the quantities of gamma-ray shielding materials.

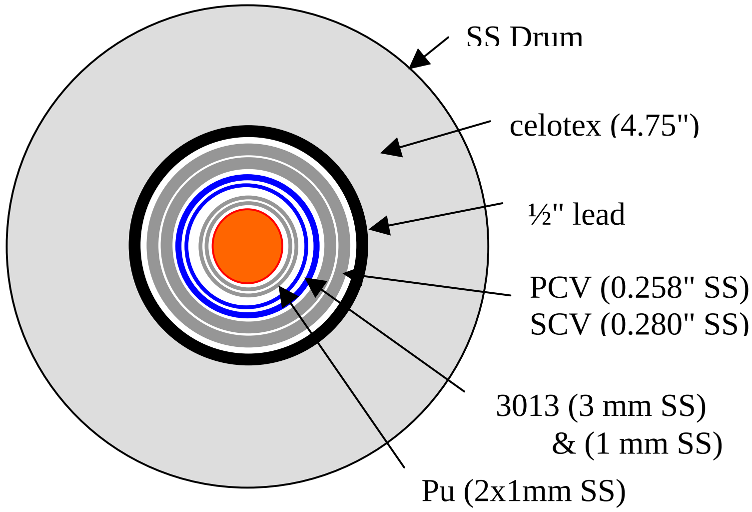

Figure 1 -- Top View of a 9975 Container Showing the Many Levels of Shielding

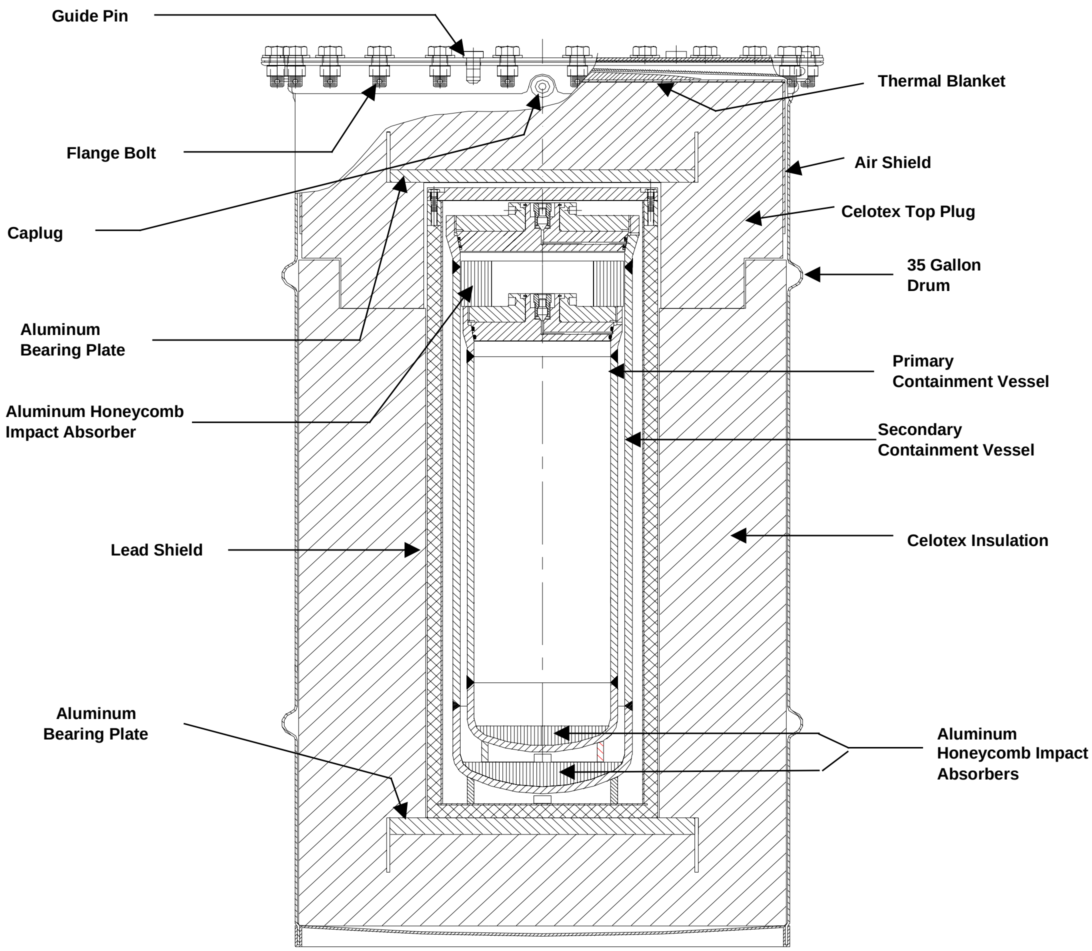

Figure 2 – Side View of a 9975 Container

Figure 3 - Picture of a Crosscut Section of an Actual 9975

Figure 4 is a graphical representation of the effects of the transmission[1] from within the 9975 container. The package is most effective at shielding x-rays and gamma rays under 400 KeV. The numbers included on the bottom of the graph are the transmissions emitting from the SNM within the 9975 container at 200, 300, 400 and 600 KeV. The black vertical lines are representations of the gamma-ray energies most widely used in NDA analysis. Note that almost all the "best" gamma-rays used in NDA analysis are blocked. There are effectively no usable gamma rays below 300 KeV that can be used in NDA analysis.

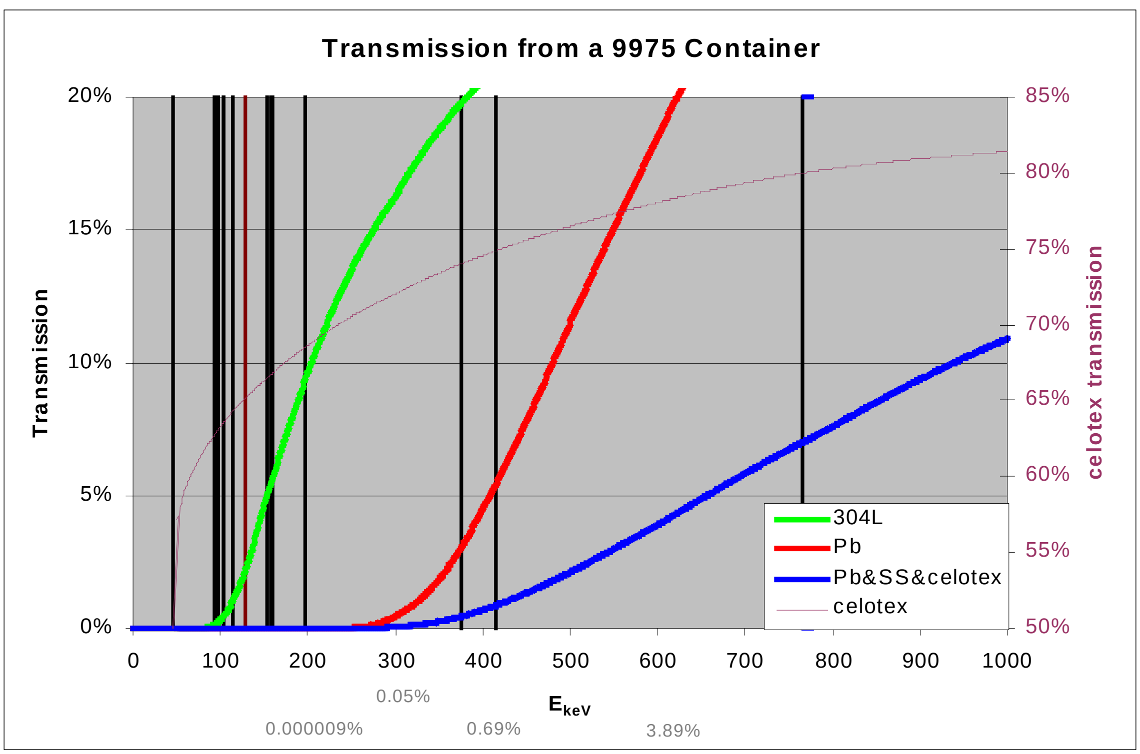

Figure 4-- Graphic Presentation of the Gamma-Ray Shielding Effects of the 9975 Demonstrating Almost Complete Shielding Below 300 KeV.

SHIPPER/RECEIVER AGREEMENTS

Shipper/receiver Agreements have been negotiated between the Savannah River Site (SRS) and other sites in the complex that ship to the KAMS facility at SRS. The constraints of these agreements require confirmatory measurements to be completed within specified timeframes. The 9975 package necessitates more lengthy and complicated verification analysis and sometimes prohibits the confirmation analysis altogether. In cases where the items contains small quantities of SNM and significant amounts of other gamma-ray emitters, these other emitters often overwhelm the analysis and prohibit the confirmation of the SNM. These cases require other steps to be taken to confirm the contents of the shipment.

*Figure 5 - The Ortec digi*DART™

EQUIPMENT AND TECHNIQUES

Confirmation Measurements

Confirmation measurements are intended to confirm the presence of a specific physical characteristic of an item. Of the several physical characteristics normally employed in shipping and receiving of SNM in the DOE Complex, this paper is concerned with the confirmation of the gamma-ray signatures for particular types of SNM.

The standard instrument for confirmation measurement in the past has been the TSA MC-465™. The 465 employs a 1x1 NaI detector and allows for storage of 12 spectra. The interface between the 465 and a computer is often difficult and the fact that the 465 only allows storage for a limited number of spectra requires that the spectra be downloaded many times during the receipt process for a single shipment.

Figure 6 - A NaI Detector

The instrumentation selected for verification measurements at the KAMS facility was the Ortec *digiDART*™ coupled to a 2x2 NaI detector. Figure 4 is a picture of the Ortec digiDART™. It was selected for its portability, ease of operation, ability to store over 600 spectra (@512 channels/spectrum), and its robustness. The newer technology has virtually eliminated any interface issues between the *digi*DART™ and other computers. It is also employed for holdup measurements in contaminated areas at other SRS facilities. Its sealed design assists with contamination control and its low price allows it to be considered expendable in cases where decontamination is not readily achievable.

The NaI detector, figure 5 was selected for is portability and robustness over a HpGe detector. The 2x2 NaI detector significantly improves response over the older 1x1 detector and normally provides information of sufficient quality to complete a confirmation measurement in a 9975 containing larger quantities of SNM. In the few cases where higher resolution information is required, a HpGe detector is employed.

Confirmation of Pu

The confirmation technique is simple and to the point. As the mass and identification of the item are verified, a NDA technician will collect a spectrum of the item. A “sweet spot” has been identified on the 9975 container where maximum gamma-ray activity is most often observed. The assay time varies. If the technician is able to confirm the presence of SNM, the assay is terminated. If the technician cannot confirm the presence of SNM, a 100 or 300 second spectrum normally is obtained and the spectrum is analyzed by more precise methods. If the secondary method is unable to confirm SNM, a HpGe spectrum is obtained. The latter takes considerably more time.

Measurement Control (MCP) is achieved with the measurement of a ^{137}Cs source prior to and just after the receipt measurements. The MCP confirms consistency with the calibration and setup of the confirmation instrumentation. These measurements are included in the confirmation documentation.

The above methodology was qualified and documented by a team at SRS[2,3].

Confirmation of U

Confirmation of U has been very controversial. ^{235}U has only one “useable” gamma-ray at 186 KeV. It is possible to confuse a peak observed from a U bearing 9975 with the 186 KeV peak of ^{235}U. As figure 4 demonstrates, this peak is completely shielded from direct measurements. Figures 7 and 8 further demonstrate why the 186 KeV cannot be used for confirmatory measurements of ^{235}U within a 9975 with NaI detector technology.

Figure 7-- Spectra of ^{235}U Showing the Effects of Increasing Shielding from No Shielding (blue in the background) to 0.5" (green in foreground) of Pb in

Figure 7 presents 6 overlying spectra. The blue spectrum in the background is an unshielded spectrum of ^{235}U. The five overlaid spectra are of the same ^{235}U source with 0.1”, 0.2”, 0.3”, 0.4”, and finally 0.5” of Pb shielding. Note how quickly (at 0.3” it is no longer noticeable) the 186 KeV is completely shielded.

Figure 8 shows spectra of a ^{137}Cs source shielded with 0.5” of Pb (blue spectra in the background) and the same source shielded with 0.5” of Pb *and* 0.5” of SS.

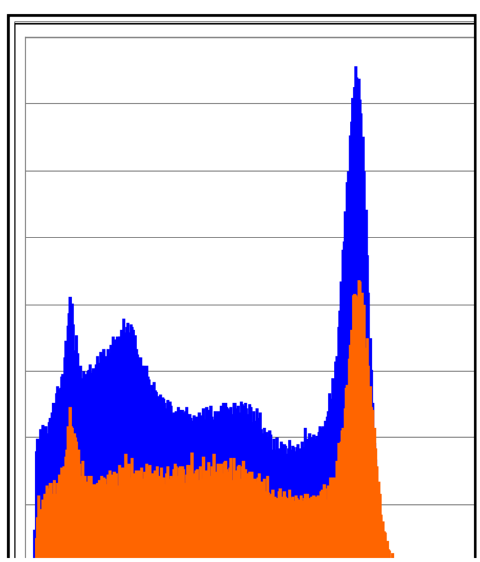

Figure 8-- Spectra of ^{137}Cs with 0.5" Pb Shielding (red foreground) and 0.5" Pb + 0.5"SS (blue background)

This very closely approximates the gamma shielding effects of a 9975. Note the addition of x-ray summation peaks at ~195 KeV. Figure 7's and figure 8's energy scales have been aligned to allow comparison between the two figures. Figure 8 shows how a novice in the field might confuse such phenomena with the 186 KeV peak from ^{235}U. The above discussion and data analysis clearly demonstrates why NaI gamma spectroscopy *cannot* be employed to confirm the presence of ^{235}U signatures in a 9975.

Alternate methods such as HpGe spectrometry with longer assay times (there are some low abundance peaks at higher energies that may be able to be resolved with HPGe and long count times) or active neutron counting have been proposed for these confirmations.

Verification Measurements

As opposed to qualitative confirmation measurements described above, verification measurements are quantitative. The KAMS site employs a high efficiency Neutron Multiplicity Counter (NMC) coupled with a Gamma Isotopic System (GIS) for this measurement. The NMC quantifies amounts of ^{240}Pu in an item. The GIS reports the relative ratio of ^{240}Pu to the total Pu in an item. The results of both techniques are then combined to determine the total Pu content of an item.

The NMC reports an efficiency of over 54% allowing it to be sensitive to smaller or more heavily shielded quantities of SNM. It has been qualified over a range of item material types and acceptance criteria have been established with regard to the uncertainties of the shipper values, the NMC/GIS receipt measurement, and the methodology uncertainties[4].

The GIS has also been qualified for the same range of material types and acceptance criteria where also established[5]. Simply stated, the GIS measures many gamma-rays looking for the isotopes of Pu. Employing the physical properties of these isotopes (i.e. specific activity and branching ratio), the GIS, under normal circumstances, is able to readily able determine the relative ratio of the Pu isotopes in the item in a timely fashion. Unfortunately, this is not the case for the KAMS application. GIS measurements have been dramatically hindered by the 9975 package as discussed above. Almost all of the preferred spectral information is obtained from gamma-ray peaks below 300 KeV. As Figure 4 so dramatically illustrates, the 9975 container effectively eradicates these peaks. This has necessitated the use of higher, significantly less abundant, gamma-ray peak for this analysis and substantially longer assay times. As a result, larger uncertainties are associated with the measurements and in some cases measurement is not possible.

As well as the previously cited references, KAMS verification measurements have been documented in the literature[6].

CONCLUSION

Shipper/Receiver measurement problems are often unique to the application of the specifics of the items received. SRS's KAMS facility is no exception. Usual NDA methods had to be augmented to allow for the confirmation and verification of the contents of the 9975 containers used for shipments to KAMS. Longer assays, more precise methods, and supplemental analysis were all employed to achieve the goals of receipts measurement for the KAMS facility.

It becomes the NDA specialist to use new technologies as they become available. The use of the *digi*DART™ over accepted practices has allowed for quicker and better-documented receipt confirmations. The use of additional technology to supplement the "quick and dirty" methodologies as it becomes necessary adds to integrity of the MC&A receipts program. The prudent use of supplemental methods, that is, only when other simpler methods fail, increases timeliness and associated costs of receipts measurements.

NDA personnel must be careful not to overlook the obvious in their zeal to achieve goals and meet management demands. Our experience has shown us examples that those less well experienced need to be careful that basic 1st principals of physics are not overlooked. It is incumbent upon the NDA specialist to insure that the measurement performed actually is a measurement of a characteristic of the material under scrutiny.

Receipts measurements at SRS's KAMS facility are now more routine than initially. Most measurements are now proceduralized and accomplished as a matter of routine. With the qualifications described in this report, reporting of results is timely and the methodology is readily accepted.

REFERENCES

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[6] "Qualification of SRS's KAMS NMC and GIC Systems", Chris Hodge, Ronnie Jeffcoat, WSRC-TR-2003-00261