WIPP WAC Equivalence Support Measurements for Low-Level Sludge Waste at Los Alamos National Laboratory - 12242

Kathleen M. Gruetzmacher*, Roland M. Bustos*, Scott G. Ferran*, Lucas E. Gallegos*, and Randy P. Lucero**

*Los Alamos National Laboratory, Los Alamos, New Mexico 87545
**Pajarito Scientific Corporation, Santa Fe, New Mexico 87507

ABSTRACT

Los Alamos National Laboratory (LANL) uses the Nevada National Security Site (NNSS) as an off-site disposal facility for low-level waste (LLW), including sludge waste. NNSS has issued a position paper that indicates that systems that are not certified by the Carlsbad Field Office (CBFO) for Waste Isolation Pilot Plant (WIPP) disposal of Transuranic (TRU) waste must demonstrate equivalent practices to the CBFO certified systems in order to assign activity concentration values to assayed items without adding in the Total Measurement Uncertainty (TMU) when certifying waste for NNSS disposal. Efforts have been made to meet NNSS requirements to accept sludge waste for disposal at their facility. The LANL LLW Characterization Team uses portable high purity germanium (HPGe) detector systems for the nondestructive assay (NDA) of both debris and sludge LLW. A number of performance studies have been conducted historically by LANL to support the efficacy and quality of assay results generated by the LANL HPGe systems, and, while these detector systems are supported by these performance studies and used with LANL approved procedures and processes, they are not certified by CBFO for TRU waste disposal. Beginning in 2009, the LANL LLW Characterization Team undertook additional NDA measurements of both debris and sludge simulated waste containers to supplement existing studies and procedures to demonstrate full compliance with the NNSS position paper. Where possible, Performance Demonstration Project (PDP) drums were used for the waste matrix and PDP sources were used for the radioactive sources. Sludge drums are an example of a matrix with a uniform distribution of contaminants. When attempting to perform a gamma assay of a sludge drum, it is very important to adequately simulate this uniform distribution of radionuclides in order to accurately model the assay results. This was accomplished by using a spiral radial source tube placement in a sludge drum rather than the standard three source tubes seen in debris PDP drums. Available line sources (Eu-152) were placed in the spiral tubes to further accomplish the desired uniform distribution of radionuclides. The standard PDP drum (PDP matrix drum 005) and PDP sources were used to determine the lower limits of detection (LLD) and TMU. Analysis results for the sludge drum matrix case for two HPGe detectors were tabulated and evaluated. NNSS has accepted the methodology and results of the measurements towards demonstrating equivalence to CBFO certified systems.

INTRODUCTION

Most of the characterization of LLW at LANL's Technical Area (TA)-54 Area G and other LANL technical areas is performed by the LANL Waste and Environmental Services – Waste

Generator Services (WES-WGS) characterization team based out of TA-54 and by the Chemistry and Metallurgy Research – Operations (CMR-OPS) team (hereafter referred to as the gamma spectroscopy teams) using controlled-approved procedures. Both gamma spectroscopy teams utilize portable HPGe detector systems for the NDA of LLW for characterization. Controlled-approved procedures and processes for the use of such systems to assay LLW items are currently in place and being followed by the gamma spectroscopy teams. Also, a number of performance studies have been conducted historically by the gamma spectroscopy teams to support the efficacy and quality of assay results generated by this NDA process [1, 2, 3].

LANL currently uses and intends to continue to use the NNSS as an off-site disposal facility for some LLW. NNSS has issued a position paper DOE/NV-1121 [4] that indicates that systems that are not certified by the CBFO for WIPP disposal of TRU waste must demonstrate equivalent practices to the CBFO certified systems in order to assign activity concentration values to assayed items without adding in the TMU – i.e., only using the systems reported assay value – when certifying waste for NNSS disposal. The LANL WES-WGS characterization team has identified that while most of the practices established for CBFO certified systems are currently being executed within existing WES-WGS and CMR-OPS processes and procedures, some supplementary NDA performance measurements are required in order to demonstrate full equivalence. The LANL report EP-TD-2203 [5] documents the results of the measurements performed toward this effort for some common waste matrices, excluding sludge. As a supplement to EP-TD-2203 [5], measurements were performed on sludge drums and the results were tabulated and evaluated to further establish WES-WGS characterization program's WIPP WAC (Appendix A) [6] equivalence.

METHOD AND RESULTS

Annual Calibration Confirmation and Performance Check Measurements

Every portable NDA detector that the gamma spectroscopy teams use is calibrated for intrinsic efficiency and angular response when it is first procured and commissioned into service. Energy calibration is performed initially before the efficiency calibration and daily during periods of operation – this is part of the daily Quality Control (QC) checks specified in approved LANL operating procedures.

DOE-WIPP-02-3122 [6] Appendix A specifies that verification of a NDA system calibration is performed if major system repairs or modifications occur. If a gamma spectroscopy team's HPGe detector system undergoes repair or modification, a new efficiency calibration is performed to replace the initial calibration. Thus, verification of the initial efficiency calibration is not applicable when system repairs or modifications occur. The angular response calibration for a particular detector/shield/collimator configuration is a mathematical function depicting the relative response the detector has for the range of angles that the gamma rays could be entering the detectors field of view. This curve (for a particular detector/shield/collimator configuration) is dependent only on the size of the detector crystal and remains valid even if the efficiency of the detector is recalibrated.

DOE/WIPP-02-3122 [6] Appendix A specifies that the confirmation of each calibration or re-calibration be performed by evaluating replicate measurements of a non-interfering matrix for accuracy and precision. Also, DOE/WIPP-02-3122 [6] Appendix A specifies that as part of performance checks, the long-term stability of the NDA system matrix correction of an interfering matrix must be assessed. Surrogate waste containers used must reflect the type of waste (e.g., zero/empty, debris, sludge) currently being assayed.

With the modeling program Spectral Nondestructive Assay Platform (SNAP™), most of the elements normally associated with a WIPP certified system calibration correction factor are mathematically calculated to produce a method-specific "calibration" each time: using the item-to detector geometry, the matrix and filter attenuation losses, gamma-ray emission probability per decay, HPGe efficiency calibration, and field of view angular response. The only elements of this method-specific calibration that are unique to a particular HPGe detector and shield configuration are the HPGe intrinsic efficiency calibration and field of view angular response. All the other elements of the SNAP™ method-specific "calibration" are the same for all portable HPGE NDA detector systems.

Thus, as a means to baseline the confirmation of the SNAP™ portable HPGe detector calibrations, a set of calibration confirmation measurements has been performed using two of the gamma spectroscopy teams' HPGe detector systems – representative of the full inventory of HPGe detectors. The measurements made were evaluated for accuracy (%R or % recovery) and precision (%RSD or % relative standard deviation) in accordance with DOE/WIPP-02-3122 [6] Appendix A and DOE-CBGO-01-1005, Performance Demonstration Program Plan for Nondestructive Assay of Drummed Wastes for the TRU Waste Characterization Program, criteria set forth by the CBFO, as applicable.

Further, in order to assess the long-term stability of the SNAP™ NDA process's matrix correction of an interfering matrix, similar measurements, and accuracy and precision evaluations will be done annually as performance check measurements. The annual performance check measurements will use a different subset of WES-WGS HPGe detector systems each year until all used HPGE detector systems have participated. Thereafter, the detector system selection cycle will repeat.

The two detectors used for the initial measurements were serial numbers 11987031 and 43-TN12002A (also referred to as SAM and HOMER, respectfully.) SAM is a P-type detector with a 50% relative efficiency and HOMER is an N-type detector with a 60% relative efficiency. These same two detectors were used for the supplemental measurements on the sludge drums.

The measurements performed for EP-TD-2203 [5] were targeted to satisfy two ranges of activity concentration loadings and two matrix types for two container types (55-gal drum and ST-90 box). Those nominal sets of measurements covered containers, matrices, and activity loadings being assayed in real LLW cases, not including sludge. Radioactive source standards used to achieve the activity loadings for EP-TD-2203 [5] and the supplemental sludge drum measurements were different than the radioactive source standards used for the intrinsic efficiency calibrations.

Several WIPP PDP Pu source standards were available at LANL's TA-54 Area G and used for the EP-TD-2203 [5] Most of the sources used for those measurements were of weapons grade (WG) isotopic composition with Pu-239 the dominant radionuclide present by mass. These sources were also available for the sludge drum measurements as well as several Eu-152 line sources.

PDP drums (55-gal) used by the CBFO PDP program were also available for the EP-TD-2203 [5] measurements. These LANL owned PDP drums and sources were graciously shared by the Central Characterization Project (CCP) and Mobile Characterization Services (MCS) at LANL, who have priority for their use for WIPP characterization activities. The empty "Zero" matrix (identified as PDP matrix drum 001) and the debris matrix (identified as PDP matrix drum 003) drums were used for the EP-TD-2203 [5] measurements.

The PDP sludge matrix drum (identified as PDP matrix drum 005), with 186 kg of net matrix weight, was available for the sludge measurements. Also available was a sludge drum with a spiral tube configuration (identified as the spiral sludge drum) with 232 kg of net matrix weight. In the case of sludge waste, the radioactive material in the sludge mix is extremely likely to be uniformly distributed (especially along the radial coordinate). This expectation of uniform distribution is much stronger in the case of sludge than the matrices used in EP-TD-2203 [5]. The spiral sludge drum was specifically designed to simulate a uniform source distribution in the matrix. The relative tube positions and naming convention for the spiral sludge drum are shown in Figure 1. The PDP drum 005 does have multiple tubes (four, see Figure 2); however, the geometry was not specifically designed to represent a uniform source distribution. Thus, because the assumption of uniform distribution for sludge is so strong, only the spiral sludge drum was used for the annual calibration and confirmation and performance check measurements where uniform distribution is the target source distribution. The PDP matrix drum 005 was used for the TMU and LLD measurements presented in subsequent sections.

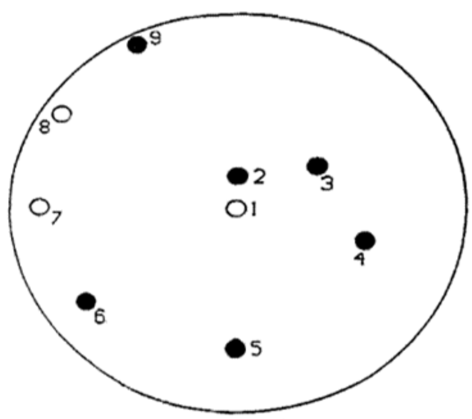

Fig 1. Spiral Drum Radial Tube Placement And Naming Conventions.

Six (6) Eu-152 line sources each approximately 4.5 μCi, were used in the spiral sludge drum to simulate a uniform distribution – one line source extending the full length of the source tube was placed in each of tubes 2, 3, 4, 5, 6 and 9 for a total of 26.4 μCi. Table I lists the measurements taken on the spiral drum. All of the annual calibration confirmation and performance check measurements were performed with the detector(s) shielded in lead on the sides (un-collimated) at a distance of 24” from the drum.

Table I. Sludge Matrix Annual Calibration Confirmation and Performance Check Measurements

Container	Matrix	Eu-152 Activity (µCi)	Nominal Radioactive Material Distribution	Number of Replicates	Count time
55-gal Drum	(Spiral) Sludge	26.4	Uniform Distribution	6	900 sec

The %R and %RSD results for the PDP drum measurements were tabulated for Eu-152 activity and are shown in Table II. The 411keV Eu-152 gamma-ray was used for the activity calculation as this gamma ray is very close in energy to the 414keV gamma-ray that would be typically be used for Pu-239 for a sludge drum. Differential peak analysis was performed comparing the results using other strong Eu-152 gamma-rays (such as the 121.8keV and 1408keV gamma-rays) and showed good agreement with the 411keV results. The source tubes used to position the Eu-152 line sources are included in Table II.

Table II. Annual Calibration Confirmation and Performance Check Measurement results for 55-Gal Spiral Sludge Drum

Container	Matrix	Source Tubes	Eu-152 Activity (µCi)	Detector	Average Eu-152 Measured Activity (µCi)	Average %R	%RSD
55-gal Drum	(Spiral) Sludge	2,3,4,5,6,9	26.4	SAM	21.6	82%	3%
				HOMER	22.7	86%	3%

LLD Measurements

DOE/WIPP-02-3122 [6] Appendix A specifies that the LLD for each radioassay system must be determined. Instruments performing TRU/low-level waste discrimination measurements must have a LLD of 100 nCi/g or less (total TRU alpha activity concentration). This is more correctly referred to as the Minimum Detectable Concentrations (MDC). The LLD for SNAP™ based HPGe systems has been determined and documented by LANL for Pu-239 [1]. To demonstrate the LLDs for all the WIPP tracked nuclides that contribute to the total TRU alpha activity, replicate measurements were made on the range of containers and matrices being assayed in real LLW cases. The waste containers and matrices described in EP-TD-2203 [5] plus the sludge drum case comprised the full range tested. Some key measurement conditions that affect the LLD are the count time, background, waste matrix and density, and source-to-detector geometry and shielding. All of the LLD measurements were performed with the detector(s) shielded in lead on the top, bottom and sides (un-collimated) at a distance of 24” from the drum under typical background conditions for LANL’s TA-54. The target measurements that were performed for the sludge drum case, including nominal count time, are defined in Table III. The LLD measurements were performed for the two HPGe detector systems SAM and HOMER for the PDP sludge matrix drum 005.

Table III, Sludge Matrix LLD Measurements (One Time)

Container	Matrix	Matrix Mass (kg)	Activity Loading	Number of Replicates	Count Time
55-gal Drum	Sludge	186	0	6 - Sam 4 - Homer	900 sec

LLD values in units of nCi/g (MDC) were tabulated for all of the ten WIPP tracked radionuclides and U-235. The MDCs are based on the gamma-ray for each radionuclide providing the optimum MDC (except for Am-241 where the 59.5 keV gamma is optimum, but not generally used because of its low energy). The results for the detectors SAM and HOMER for the PDP sludge drum are shown in Table IV and Table V, respectively.

Table IV. MDC Results for SAM for the PDP Sludge Drum

SAM	Am-241	Cs-137	Pu-238	Pu-239	Pu-240	Pu-242	U-233	U-234	U-235	U-238
	keV	keV	keV	keV	keV	keV	keV	keV	keV	keV
	125.29	661.66	152.68	413.71	160.28	158.8	317.13	120.91	185.74	1001
	nCi/g	nCi/g	nCi/g	nCi/g	nCi/g	nCi/g	nCi/g	nCi/g	nCi/g	nCi/g
Average	3.28E+01	3.57E-04	9.50E+01	2.29E+01	2.02E+02	1.85E+02	5.09E+00	4.38E+00	1.18E-03	3.36E-02
STDev	8.79E-01	2.87E-05	8.09E-01	7.94E-01	3.57E+00	2.37E+00	1.66E-01	1.03E-01	3.09E-05	1.68E-03
%RSD	2.68%	8.06%	0.85%	3.47%	1.77%	1.28%	3.25%	2.35%	2.61%	5.01%

Table V. MDC Results for HOMER for the PDP Sludge Drum

HOMER	Am-241	Cs-137	Pu-238	Pu-239	Pu-240	Pu-242	U-233	U-234	U-235	U-238
	keV	keV	keV	keV	keV	keV	keV	keV	keV	keV
	125.29	661.66	152.68	413.71	160.28	158.8	317.13	120.91	185.74	1001
	nCi/g	nCi/g	nCi/g	nCi/g	nCi/g	nCi/g	nCi/g	nCi/g	nCi/g	nCi/g
Average	2.53E+01	3.03E-04	7.73E+01	2.00E+01	1.63E+02	1.47E+02	4.04E+00	3.24E+00	9.49E-04	2.76E-02
STDev	1.89E+00	2.42E-05	5.68E+00	5.66E-01	8.68E+00	1.20E+01	1.52E-01	2.58E-01	7.21E-05	3.96E-03
%RSD	7.49%	7.99%	7.35%	2.83%	5.31%	8.13%	3.76%	7.98%	7.59%	14.31%

TMU Bounding Measurements

In SNAP™, the combined geometry and attenuation (G&A) component of the TMU is calculated for the 95th percentile worst location in the assayed container. Consequently, for some assayed waste cases SNAP™ calculates large TMU estimates. In most of these cases the radioactive material is not likely to be located in the 95th percentile worst position on the container. Thus, for such cases, the 95th percentile G&A error is an overestimate and is not used for final reporting. Instead the expert analyst will reduce the error based on historic studies and experience of what error estimate would better represent a real world waste item with several dispersed sources of radioactive material in heterogeneous matrices or uniform activity spread throughout the waste matrix in homogenous matrices. Several LANL technical papers [1, 2] provide a basis for error reduction in many such cases. However, in order to better establish specific guidelines for the expert SNAP™ analyst to achieve the best uncertainty reporting, additional measurements were performed to further understand the effects of source positioning on assay results and establish TMU bounds for error reduction.

Replicate measurements were performed on PDP sludge drum 005 using two PDP source NTP-085 and NTP-0092 positioned in two nominal source locations. Both sources were of weapons grade (WG) Pu isotopic composition. The activity concentration used and nominal source positions measurements are defined in Table VI. All of the TMU bounding measurements were performed with the detector(s) shielded in lead on the top, bottom and sides (un-collimated) at a distance of 24" from the drum.

Table VI, Sludge Matrix TMU Bounding Measurements (One Time)

Container	Matrix	Activity Concentration (nCi/g)	Nominal Radioactive Material Distribution	Number of Replicates	Count Time
55-gal Drum	Sludge	255	Center/Center	6	900 sec
			Uniform Distribution		

Figure 2 shows the tube arrangement and naming convention for PDP sludge drum 005. The two PDP sources were positioned in the drums using the aluminum source tubes 1, 2, 3 and 4. Detailed design specifications for the PDP drums can be found in DOE/CBFO-01-1005 [7].

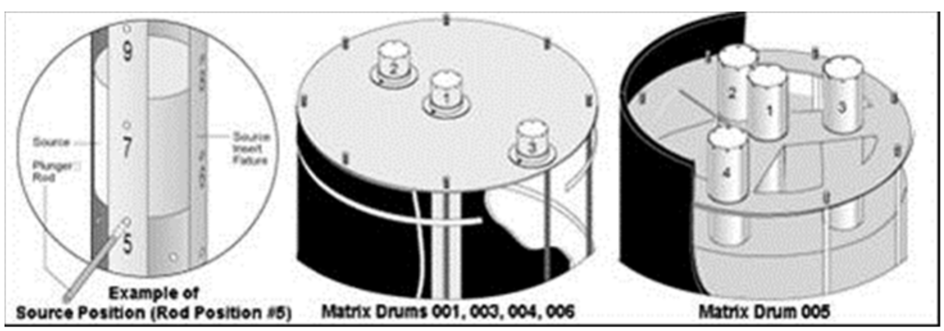

Fig. 2, PDP Drum(s) Radial Tube Placement and Naming Conventions

Tube 1 is located at radius = 0 inches (the radial center of the drum). All the sources were positioned with the center of the source at a height of 15.5 inches in the source tubes – the approximate vertical center height of the matrix material. For the target "uniform distribution" loading, NTP-0085 was placed in tube 3 and NTP-0092 was placed in tube 4 both with the vertical center of each source at height 15.5 inches from the bottom of the drum. For the center/center loading, NTP-0092 was placed directly on top of NTP-0085 in tube 1 with the center of the combined sources at 15.5 inches from the bottom of the drum.

Table VII. TMU Measurements Results for 55-gal PDP Sludge Drum

Container /Matrix	Sources	Activity Conc. (nCi/g)	Pu-239 Mass (g)	Detector	Source Tubes	Average Pu-239 Measured Mass (g)	Average %R	%RSD
55-gal Drum/ Sludge	NTP-0085 and NTP-0092	255	0.57	SAM	3 and 4	0.55	96%	4%
					1	0.13	22%	14%
				HOMER	3 and 4	0.48	84%	7%
					1	0.11	20%	16%

The %R and %RSD results for the PDP sludge drum measurements were tabulated for Pu-239 mass using the 414keV gamma-ray. The PDP sources used, the tubes used to position the PDP sources and the results are included in Table VII.

DISCUSSION

Annual Calibration Confirmation and Performance Check Measurements

The Annual Calibration Confirmation and Performance Check Measurements were evaluated against the scoring criteria set forth by the WIPP PDP Program [7]. The scoring criteria for the PDP program are divided into two waste matrix categories: Non-interfering and Interfering. The Interfering matrix category is applicable to the sludge matrix. Further, the PDP scoring criteria are divided into α-activity range categories: Low, Mid-Low, Mid-High, and High. Because Eu-152 does not decay through alpha emission, the Eu-152 line source measurements cannot be put into one of these categories. However, as established in EP-TD-2203 [5], typical LANL LL waste loadings are in the Low α-activity range category and so the criteria for that range are used. The detailed PDP scoring criteria are presented in Table VIII.

For the 55-gal spiral sludge drum using the Eu-152 line sources to simulate uniform distribution, for both detectors, the average %R was well within the allowed range 40%-160% and the average %RSD was within the allowed maximum of 16%. In fact, the %RSD also was within the tighter High category allowed maximum of 6%. Because of the large attenuation properties of the sludge matrix, the 411 keV Eu-152gamma-ray was used in the analysis of the 55-gal spiral sludge drum data as it is very close in energy to the 414keV Pu-239 gamma ray.

LLD Measurements

The goal of the LLD measurements is to establish that the detectors used by the gamma spectroscopy teams have a LLD (or MDC) of 100 nCi/g or less (total TRU alpha activity concentration). The LLD is that level of radioactivity which, if present, yields a measured value greater than the critical level with a 95% probability, where the critical level is defined as that value which measurements of the background will exceed with 5% probability. The MDC calculation algorithm in SNAP™ is consistent with this definition. For completeness, MDC values for all ten WIPP tracked radionuclides plus U-235 were calculated and tabulated for each of the waste matrix/container combinations. However, the primary nuclide of interest here is Pu-239. This is because when characterizing Pu waste at LANL, Acceptable Knowledge about the isotopic composition of the Pu is generally used. A common isotopic composition at LANL is WG Pu – where Pu-239 accounts for 94% of the total Pu mass and over 70% of the total TRU alpha activity – and is applicable to the PDP sources used. The Pu-239 activity is generally directly measured and the activity of the other Pu isotopes and Am-241 (if not detected) are determined by correlation to the Pu-239 activity. The Pu isotopes and Am account for all of the reportable TRU alpha activity in WG Pu, so in this case the MDC for Pu-239 drives the MDC for WIPP equivalent characterization.

For the PDP sludge drum 005, for both detectors, the MDC for Pu-239 for the 55-gal drum measurements was < 25 nCi/g. These results are in the same range as the debris and metal drums from EP-TD-2203 [5]. For the sludge drum the minimum detectable activity (MDA) is actually higher than for the debris and metal drum, but because of the increased weight of the sludge drum, the MDC is comparable to the more benign matrix cases.

TMU Bounding Measurements

The main goal for the TMU bounding measurements was to compare nominal "bad source location" measurement data against nominal uniform distribution measurements data using the same activity loading, in order to aid in reducing reported uncertainties (from the SNAP™ default uncertainty estimates) when necessary.

The nominal source loading for the TMU bounding measurements using the NTP-0085 and NTP-0092 sources -- each approximately 0.3g Pu-239 – was in the Mid-Low α-activity range category. The tubes 3 and 4 "uniform distribution" %R results were within the allowed 40%-160% %R range and the %RSD results were within the allowed maximum of 12%. The PDP source "uniform distribution" %R results were in the same range as the Eu152 line uniform distribution source measurement results, indicating that the tubes 3 and 4 loading of the two approximately equal PDP sources simulated a true uniform distribution reasonably well. The center/center %R results were outside the allowed 40%-160% %R range and the %RSD results were outside the allowed maximum of 12%, however, it should be reiterated that the center/center radioactive material distribution is not expected in a sludge matrix and represents a "bad to worst case" scenario.

For all of the 55-gal sludge drum cases (both detectors considered), the %R for the tubes 3 and 4 "uniform distribution" source positioning data was 65% to 75% better than the tube 1 center/center source positioning data, and in general consistently showed a %R<100% representing a low bias. This was expected as the tube 1 center/center position represents a "bad case" attenuation scenario for the drum while the model assumes a uniform distribution scenario. The large difference in %R between the "uniform distribution" and center/center cases supports that the sludge matrix has significant attenuation effects. Although there was a low bias in the tube 3 and 4 "uniform distribution" case, the %R was never lower than 84% (SAM detector), representing a -16% (under 100%) bias that is still well within the PDP program's allowed 40%-60% %R range.

Table VIII. NDA PDP Activity Ranges and Associated Scoring Acceptance Criteria [7]

		Maximum Measured Precision[b]		Bias Range[c] (%RL and % RU)	
Activity Range	**Range of Sample Activity in α-curies[a]**	**Non-interfering Matrix (%RSD)**	**Interfering Matrix (%RSD)**	**Non-interfering Matrix (%R)**	**Interfering Matrix (%R)**
Low	> 0 to 0.02	14	16	Lower: 70	Lower: 40
				Upper: 130	Upper: 160
Mid-Low	> 0.02 to 0.2	10.5	12	Lower: 70	Lower: 40
				Upper: 130	Upper: 160
Mid-High	> 0.2 to 2.0	7	12	Lower: 70	Lower: 40
				Upper: 130	Upper: 160
High	> 2.0	3.5	6	Lower: 70	Lower: 40
				Upper: 130	Upper: 160

%R = percent recovery
%RSD = percent relative standard deviation
a Applicable range of TRU activity contained in a PDP sample; units are curies of alpha-emitting TRU isotopes with half-lives greater than 20 years.
b Measured precision that must be met to satisfy the precision criteria at the 95% upper confidence bound, based
on six replicates. The values are one relative standard deviation referenced to the known value for the test.
c %RL and %RU values used in Equation 3 to determine the 95% confidence bound for the ratio of the mean of the measured values to the known value, expressed as a percent.

CONCLUSION

In conclusion, the WES-WGS and CMR-OPS gamma spectroscopy teams at LANL have defined and performed measurements that serve to establish and demonstrate equivalency with the processes used by CBFO certified NDA systems. The supplemental measurements address four key areas in Appendix A of DOE/WIPP-02-3122 [5]: Annual Calibration Confirmation and Performance Check measurements; LLD determination; and TMU definition. For these measurements the containers, matrices and activity loadings are selected to represent items being assayed in real LLW cases. The LLD and the TMU bounding measurements are to be performed one time and will not be required to be repeated in future campaigns. The annual calibration and performance check measurements were performed initially and planned to repeat in annual campaigns in order to maintain NNSS certification. PDP sources and a PDP sludge drum as well as Eu152 line sources and a spiral sludge drum were used for the measurements. In all cases, the results for accuracy and precision (%R and %RSD, respectively) were within allowable ranges as defined by the WIPP PDP program [7]. LLD (or MDC) results were established for all the ten WIPP reportable radionuclides and U-235, and the MDC for Pu-239 was established in all cases to be well under 100 nCi/g. Useful results for reducing estimated uncertainties were established and an interesting unexpected case of high bias was observed and will be applied toward this end.

REFERENCES

1. Steven C. Myers, Kathleen Gruetzmacher, Roland Bustos and Scott Ferran, LA-UR-01-5728, Systematic Bias Estimates of the SNAP™ Analytical Technique in Measurement Trials of Known Pu Standards in Mockup Drums at Los Alamos National Laboratory, 2001.

2. REPORT-SWO-0031, R.0 Matrix Uncertainty Testing for the SNAP™ Gamma Spectroscopy Modeling Routine, January 14, 2004.

3. Steven C. Myers, Kathleen Gruetzmacher, Candice Scheffing, Lucas Gallegos, LA-UR-02-0300, Practical Gamma Spectroscopy Assay Techniques for Large Volume Low-Level Waste Boxes, 2002.

4. DOE/NV-1121, Determining Transuranic Alpha Activity Concentration for Compliance with the Nevada Test Site Waste Acceptance Criteria, Revision 0, May 10, 2006.

5. EP-TD-2203, R.0 WDP-LLWD WIPP WAC Appendix A Equivalence Support Measurements, February 26, 2010.

6. DOE/WIPP-02-3122, Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant, Revision 6.3, effective date: February 5, 2009.

7. DOE/CBFO-01-1005, Performance Demonstration Program Plan for Nondestructive Assay of Drummed Wastes for the TRU Waste Characterization Program, Revision 2, April 2009.