Radiological Characterization Of High Cs-137 Waste Items At LANL Combining Cs-137 NDA Results And Acceptable Process Knowledge – 15592

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ABSTRACT

Radiological characterization is an important component to disposition and disposal of radioactive waste at the Los Alamos National Laboratory. Gamma and neutron based non-destructive assay systems are available at LANL's TA-54 Area G for radiological characterization and are generally very effective in quantifying the transuranic radionuclide concentration required for a TRU or low level waste disposition determination. This is routinely performed by scaling some nuclides to direct assay results using acceptable process knowledge scaling from a directly measured key TRU nuclide, e.g., for gamma systems using a standard isotopic distribution to determine the amount of Pu-240 associated with a measured value of Pu-239. However, for two groups of LANL waste items that have high levels of Cs-137, these non-destructive assay systems were unable to make a standard TRU/LLW determination. Therefore, it was necessary to apply an extension of the typical scaling technique that keyed in on the direct Cs-137 gamma assay result to effectively characterize these waste items for TRU processing or LLW disposition.

Two basic types of waste packages contained the high Cs-137 waste requiring special scaling: drums and boxes. The drums included 55-gallon, 85-gallon and 110-gallon volume sizes and the boxes included a corrugated metal box, a Standard Waste Box, and several overpack boxes containing oversized waste. All of these items contained radioactive waste generated from operations at the Chemistry and Metallurgical Research facility at LANL that included hot cell, metallographic sectioning and maintenance activities. All of the drums as well as the CMB, SWB and one oversized item in a plywood box were located above-ground at LANL's TA-54 Area G, while five of the oversized items were hot cell liners in metal boxes stored below-ground in shafts.

All of the items were measured in the 2013-2014 time period at TA-54 Area G with LANL NDA systems. Most of the items were counted with LLW certified far-field gamma spectroscopy systems employing portable far-field HPGe detectors and carts and some of the items were counted on WIPP certified gamma only or gamma with neutron NDA systems. In all cases Cs-137 was quantified directly with a gamma measurement but the key TRU nuclides were not detectable. Thus, for each waste item AK/PK was studied and scaling factors to Cs-137 were established and applied to provide a comprehensive radiological characterization. A total of 49 waste items were successfully characterized as LLW based on this technique. The above ground waste items were dispositioned and disposed of at an offsite LLW repository and the below ground boxes were left in place as LLW in the TA-54 Area G shafts. This NDA with scaling application has proved effective and defensible in these high Cs-137 cases at LANL and will continue to be used as applicable and appropriate for future waste characterization at LANL.

INTRODUCTION

Radiological characterization is an important component to disposition and disposal of radioactive waste at Los Alamos National Laboratory. Some of this waste is part of a 2012 Framework Agreement [1] between DOE/NNSA and the New Mexico Environment Department (NMED) that prioritizes several waste management objectives including the removal of the above-ground cemented transuranic (TRU) wastes and

the disposition of several below-ground waste categories at Area G in Technical Area 54 (TA-54 Area G). In this context TRU waste is defined as waste containing more than 100 nanocuries (3700 becquerels) of alpha-emitting transuranic isotopes per gram of waste.

One radiological characterization technique that has been historically and extensively used and continues to be used at LANL includes gamma spectroscopy based non-destructive assay (NDA). This technique is generally very effective in directly quantifying the key TRU nuclides required for a TRU or low level (LL) waste disposition determination. However, for waste items that have high levels of non-TRU gamma emitting nuclides (such as Cs-137) the gamma NDA technique may be unable to detect TRU nuclides at the level necessary to make a direct TRU/LLW determination. Using neutron based NDA systems to supplement gamma measurements can often achieve the TRU detection levels needed to make a TRU/LLW determination, but are not always available or useable for waste items of concern at LANL.

Scaling some non-detected nuclides to direct assay results using acceptable process knowledge (AK/PK) is routinely preformed for the TRU/LLW characterization of waste at LANL, and generally is done by scaling to a directly measured key TRU nuclide, e.g., for gamma systems using a standard isotopic distribution to determine the amount of Pu-240 associated with a measured value of Pu-239. However, due to gamma interference and the unavailability of neutron data, this was not achievable for some high activity Cs-137 waste items at LANL. Therefore, it was necessary to apply an extension of this scaling technique keying in on the direct Cs-137 gamma assay result to effectively characterize these waste items for TRU processing or LLW disposition.

NDA SYSTEMS AND LIMITATIONS

Several NDA systems are available and used for radiological characterization at TA-54 Area G including far-field high purity germanium (HPGe) spectroscopy detectors and high-efficiency neutron/HPGe counters (HENC). High Cs-137 (generally in the mCi range) waste can cause complications for both of these system types.

The neutron mode of the HENC assay is generally not adversely affected by high Cs-137 signal and can be used to directly determine the Pu-240 effective mass in a drum -- and then the TRU activity concentration if the gamma mode data can determine the waste isotopics or AK/PK is available to scale the rest of the TRU nuclide activities. However, the HENC systems are closed cavity based and sized for 55-gallon drums, so items that are larger than 55-gallon drums will not fit inside the systems. Also, the HENC systems are calibrated for a defined range of drum weights and matrix types, so drums that fall outside those ranges cannot be measured in those systems. Finally, because of the set distance between a drum loaded into a HENC cavity and the HPGe detector, high Cs-137 drums cause high detector dead time outside of functional range requiring AK/PK is available for scaling.

The far-field HPGe gamma detectors can be positioned at different distances away from a waste item, so the dead-time associated with high Cs-137 waste can generally be managed to be within functional range. But even at increased distance for dead-time control, the Cs-137 signal can cause enough Compton scattering interference that the minimum detectable concentration (MDC) for the TRU nuclides, using standard scaling from directly measured Pu-239, is above the 100nCi/g threshold and a TRU/LL waste determination then cannot be made. A photograph of a LANL portable far-field HPGe detector system is shown in Fig. 1.

Fig.1. Portable far-field HPGe detector system.

Two groups of high Cs-137 waste from the 2012 Framework Agreement priority list (one above-ground and one below-ground) were identified in 2013 that caused radiological characterizations complications using standard NDA/scaling techniques. So for these waste items a modified scaling technique was implemented that applied AK/PK scaling factors to directly measured Cs-137 activities from portable far-field HPGe detector systems (rather than the directly measured Pu-239) to achieve radiological characterization sufficient for a TRU/LLW disposition determination.

ABOVE-GROUND HIGH Cs-137 WASTE ITEMS

The above-ground high Cs-137 waste stream group consisted of forty-two (42) drums and two (2) boxes generated in the 1980s from Wing 9 hot cell and maintenance activities in the Chemistry and Metallurgical Research (CMR) facility at the LANL. The waste consisted of trash and debris from housekeeping and maintenance activities, with residual contamination from cutting, grinding, polishing, etching, and cleaning operations (1982 to 1986). The drums were part of the entire waste spectrum from the CMR Wing 9 hot cells and packaged according to procedure by the CMR waste generator such that the radiation dose on the outer container was less than 200 millirem/hour (mrem/hr). TABLE I summarizes the containers in this population. The 110-gallon and 85-gallon drums contain an inner 85-gallon or 55-gallon drum. The contents of the two (2) metal boxes originated at CMR, are contaminated from the same operations, but were large enough that they were size reduced and packaged at the historical Size-Reduction Facility (SRF) at LANL. The corrugated metal box (CMB) has a welded top, the standard waste box (SWB) has the standard bolted top. The containers were historically managed as potentially TRU waste based on theoretical worst case calculations provided by the waste generator.

TABLE I Above-ground waste population.

Container Type	Count of Packages
110-GAL	**2**
concrete lined	2
55-GAL	**18**

concrete lined	14
lead lined	4
85-GAL	**22**
concrete lined	19
lead lined	3
CMB	**1**
hot cell liner from SRF	
SWB	**1**
hot cell liner from SRF	
TOTAL	**44**

Process History of CMR Hot Cells

The CMR mission was analytical chemistry, physical and inorganic chemistry, and metallurgy operations. The hot cells provided remote-handling capabilities to support post-irradiation examination of irradiated fuels from DOE test and research breeder reactors. The work included destructive examination of over 1600 irradiated fuel pins from 1971 to 1986 [2, 3]. CMR Wing 9 consisted of two (2) banks of eight (8) hot cells each, separated by a corridor. Each bank was arranged in two (2) rows of four (4) cells located back to back with an interior corridor for sample and waste egress. Operations with irradiated uranium were conducted in cells 1 through 8 in the gamma bank. Cells 9 through 16 comprised the alpha-gamma bank for work with plutonium [4]. The gamma cells had open-topped containment boxes, whereas, the alpha-gamma cells had sealed stainless-steel containment boxes, referred to as hot cell liners. Cells 2 and 4 were converted to alpha-gamma cells, circa 1984. Samples were generally passed through cells for specific operations, such as sectioning, residual fission gas determination, metallurgical preparation, photography, physical measurements, etc.

The wastes in the drums were generated in cells 9, 10, 11, 13, 14 and 15 where examinations included disassembly, cleaning, de-cladding, cutting, grinding, polishing, etching and coating that facilitated microstructural, microprobe, density, burn-up, chemical analysis and other special examinations. Some fuel pins were subjected to mass spectrometry to determine burnup (fission expressed as atom percent) of the nuclear fuel.

Maintenance activities in the hot cells included decontamination and painting of tables and alpha containment boxes, cleaning and replacement of laboratory equipment, glassware, hardware, hand and power tools, radiation meters, windows, and filters. In 1986 the mission for the hot cells changed, and the CMR facility began a comprehensive cleanout campaign as part of decommissioning and decontamination (D&D) activities. None of the above-ground drums were generated as part of the D&D program.

Historical Waste Management at CMR

Waste management at CMR from the 1971 to 1987 time frame was not consolidated under one group, but was the responsibility of the organization conducting the work. Therefore personnel responsible for waste handling had direct knowledge of the activities generating the waste. The waste drums were generated as part of the hot cell operations, described above, from 1982 to 1986. The generator information for the drums included waste generator waste forms, hot cell operational notebooks and a historical standard operating procedure. Laboratory notebooks were available for review that document daily activities, generally sample preparations, but some waste management entries were included such as clean-up of individual cells, removal and packaging of trash and equipment that affected cell operations. Samples were transferred between cells for investigational purposes, but wastes were removed from individual hot cells to the

corridor for packaging. Most of the waste drums addressed in this paper originated in cells 13 and 15 from metallurgical preparations.

Highly radioactive materials were typically removed from the hot cells in 1-gallon, metal cans through a transfer port that held a clean plastic can as part of the bag out process (Fig. 2). Metal Lids were reportedly not used on metal cans until 1987. Each can was numbered and managed in accordance with the operating procedure. Plastic waste cans with relatively low activity were placed in either concrete or lead-lined, 55-gallon drums so that the surface dose rate on the outer drum was no greater than 200 mrem/hr. Plastic waste cans that would exceed this dose rate were placed in welded metal cans and sent to LANL TA 54 [2, 3]. Concrete-lined drums were created by placing two (2) plastic waste cans in a prepared 10-inch pipe in the center of a 55-gallon drum. The pipe was tack welded to a flat base, so the pipe was not sealed. Some drums had prepared slip lids for the pipes and some simply used scrap metal, or scrap lead sheets draped over the open tops. Concrete was poured and tamped into place around the pipe to reduce the dose rate on the outside container to less than 200 mrem/hr. In some situations, 10 to 15 low activity cans of “cold trash” were placed in a single 55-gallon, lead-lined drum. The lead liner is conservatively estimated to be 1/8-inch thick. The inner configuration of two (2) 85-gallon drums was not recorded on the generator waste form. These two, erroneously recorded as 55- and 80-gallon drums, were overpacked in 110-gallon drums.

Fig. 2. Typical 7-inch plastic can and 1-gallon, metal cans used to remove waste from hot cells. Lids were not used on metal cans until 1987.

Each drum from CMR was accompanied by a radioactive waste disposal record form. The waste disposal forms generally include a general description of the contents, cell of origin, whether the drum was concrete-lined or lead-lined, but not always, the count and assigned number of each of the plastic waste cans, and the radionuclide content. The lead-lined drums typically contained too many cans to record the number of each, so only the count was recorded. In all cases, the radionuclide content was recorded as 0.04 grams (g) of uranium-235 and 0.01 g plutonium, in accordance with the operating procedure, because they were known to be low in quantity associated with an uncertain fuel quantity. The mixed fission products (MFP) were calculated and recorded on the basis of measured radiation levels.

Historical Characterization Activities

As part of the D&D of the CMR hot cells, conducted from 1986 to 1994, numerous containers of heterogeneous debris, considered remote-handled (RH) TRU waste were generated. These wastes were contaminated with transuranic and mixed fission products (MFP) from the destructive examination of irradiated fuel pins from the early 1970s to the mid-1980s. Approximately 364 welded, waste cans were packaged in twelve (12) canisters for disposal as remote handled TRU waste at WIPP, as well as four (4) canisters with 55-gallon drums of bulk D&D waste (equipment and hardware generated during clean-up) that all exhibited over 200 mrem/hr. Extensive radiological and chemical waste characterization information available and evaluated for these 16 RH TRU containers and was directly applicable to the wastes in the 44 above-ground containers.

A Radiological Characterization Technical Report [3] was compiled that specifically addressed the sixteen (16) RH TRU WIPP containers. However, this report provided information relevant to both the radiological and chemical characterization of wastes generated during the 1971 to 1986 fuel pin examination program, and is therefore applicable to a significant fraction of the waste in the above-ground containers. The characterization report for the 16 RH TRU containers provided an appropriate isotopic distribution of radioactive contamination for all wastes associated with the fuel pin examination program.

The RH characterization report compiled historical information, including data forms for 1,473 fuel pins, mass spectroscopy results for 400 fuel pins, neutron measurements and fissile isotopic contents on the 364 welded waste cans, and dose information collected during waste packaging. Fuel pin burn-up modeling was performed on the 1,473 fuel pins, and adjusted according to mass spectroscopy results to determine actual burn-up. This reduced or eliminated any modeling bias and accounted for inaccuracies in original fuel compositions. The masses and activities for twelve (12) radionuclides were determined; ten (10) that were required by WIPP, as well as U-235 for criticality evaluation purposes and Pu-241 to ensure that ninety-five percent (95%) of the total radiological hazard was addressed. Based on these mass and activity determinations, scaling factors were derived (TABLE II) that represented the average composition of the entire RH TRU waste population. The scaling factors were calculated as of November 1991.

TABLE II. Derived scaling factors.

Scaling Factor	Value	Units
U-233/FG	9.65E-04	g per FG
U-234/FG	6.98E-03	g per FG
U-235/FG	7.26E-01	g per FG
U-236/FG	1.97E-02	g per FG
U-238/FG	4.05E-01	g per FG
Pu-238/FG	3.45E-04	g per FG
Pu-239/FG	2.73E-01	g per FG
Pu-240/FG	4.22E-02	g per FG
Pu-241/FG	2.58E-03	g per FG
Pu-242/FG	1.04E-03	g per FG
Am-241/FG	1.80E-03	g per FG
FG/Pu-240	2.37E+01	FG per g
Sr-90/FG	2.03E-01	Ci per FG
Y-90/FG	2.03E-01	Ci per FG
Cs-137/FG	2.82E-01	Ci per FG

Ba-137m/FG	2.67E-01	Ci per FG
FG/Cs-137	3.45E+00	g per Ci

The measured fissile gram contents of the waste in the twelve (12) canisters and application of the derived scaling factors allowed the isotopic distribution of reportable radionuclides (except for Co-60) to be determined. The Co-60 content was determined from the one-meter dose rate measurements made on each can and then subtracting the dose rate contribution from Cs-137 determined from a curie-to-dose method and assigning the remainder of the dose rate to Co-60. A dose-to-curie method was used to determine the Co-60 activity content. The scaling factors developed from the twelve (12) canisters were then used with dose-to-curies values of Cs-137 and Co-60 on the four (4) canisters (that lacked neutron assay results) to derive the isotopic distribution of reportable radionuclides for those containers. The scaling factors were calculated as of November 1991.

It was noted that although there was likely to be some spatial variation in the scaling factors among drums and waste materials, this variation was accounted for in the uncertainty analysis. The uncertainty associated with an unequal contribution from each fuel pin was considered to be relatively small. By virtue of using records from the entire fuel pin population that generated the waste, it was, in large measure, similar to sampling from the entire quantity of waste. Thus, these hot cell scaling factors are considered to be representative of the contamination associated with the entire fuel pin examination program from 1971 to 1986, as all fissile contributors were considered. U-235 and Pu-239 accounted for over 99.9 percent of the mass of fissile isotopes. U-233 was included in the calculated scaling factors, as it was one of the ten radionuclides required to be characterized for disposal at WIPP. It was calculated to account for less than 0.1% by mass.

General Waste Stream Characterization

Based on generator information, all of the forty-for (44) above-ground containers were stored as suspect TRU wastes. Due to interference caused by significant MFP activity, an accurate radioassay of the waste could not be obtained at the time of generation. As described above, the generator assigned all drums a mass of plutonium of 0.01 g. The 25-30 year storage of the 44 containers has allowed decay of much of the MFP, thereby reducing the dose on the exterior of the containers. Recent dose measurements indicate that the surface dose on all drums dropped from a high of 190 mrem/hr in 1983 to 44 mrem/hr in September 2013. Recent characterization activities, including non-destructive examination, high-efficiency neutron count, radiation surveys, gamma spectroscopy, and certified weights have been employed to resolve radiological parameters for proper waste classification.

A high-energy real-time radiography (HE-RTR) system is deployed at TA-54 Area G for non-destructive examination (NDE) of large or dense waste packages. The unit consists of a radiation generating device and audio and video recording system. All of the above ground drums have been through HE-RTR. The HE-RTR NDE results indicate that none of the containers possess free liquids, and the waste matrix and container configurations described by the generator are confirmed. The concrete-lined, 55-gallon drums appear to consist of two (2) inner metal cans packaged in plastic cans, wrapped in plastic (Fig. 3). The inner cans appear to be enclosed in a metal pipe with lid, which in turn is encased in concrete. None of the containers or metal pipes has obvious vents, but many of the lids do not appear to be securely seated, appear to be ajar, or missing entirely. Lids on the inner metal cans appear missing or ajar. The 110-gallon drums were observed to have an inner 85-gallon drum that encases a 30-gallon drum in concrete. Debris items, including equipment, metal, glassware and plastic are observable.

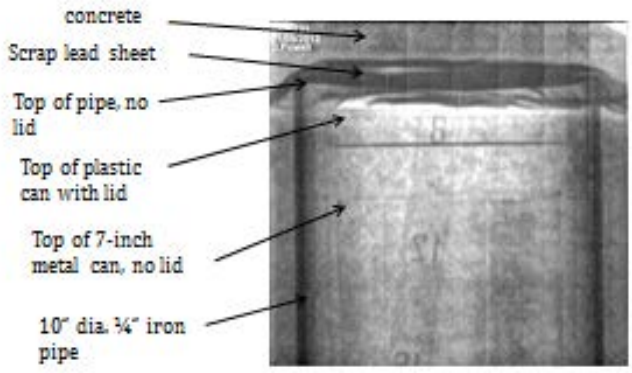

Fig. 3. Recent HE-RTR image of inner configuration of concrete-lined drum.

The multiple cans in the lead-lined drums (Fig. 4) also appear to consist of metal cans in plastic cans, each wrapped with plastic. The lead lining can be seen to be crumpled and bent down inside the drum to allow for the lid. The thickness of the lead lining is not known for certain, but appears to be less than 1/8-inch thick.

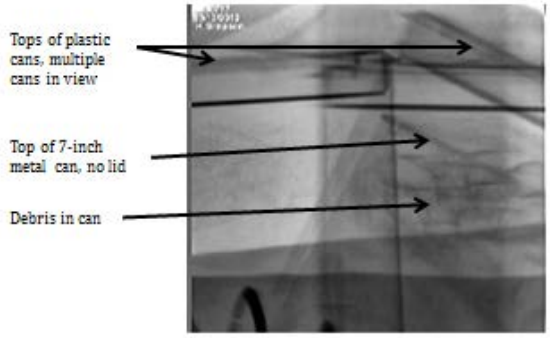

Fig. 4. Recent HE-RTR image of multiple plastic and metal cans in a lead-lined drum. The edge of the lead liner is not visible in the image.

Current Radiological Characterization using Scaling to Cs-137

Nine of the 55-gallon drums addressed in this paper were assayed by a LANL HENC system. Expert review of the data indicated that the HENC gamma data could not be analyzed (or used to verify isotopics) due primarily to high dead-time. Lacking isotopic verification gamma results for scaling, the expert analyst also determined not to use the HENC neutron data to characterize the drums. The other above-ground containers were not able to be assayed in a HENC system due to container size limits or the expectation that gamma and or neutron results would not be useable.

In order the resolve the radiological characteristics of the drums, in the 2013-2014 time period LANL employed an NDA campaign of gamma spectroscopy to acquire spectral data and processed the data in accordance with the scaling factors shown in TABLE II and isotopic distribution derived by the Radiological Characterization Technical Report [3]. The gamma assays were performed with portable far-field HPGe detectors like shown in Fig.1. Individual waste item were placed so that the detector dead time from Cs-137 in the container was with within a functional range. Counting time was generally 900 seconds because the 662 keV gamma signal was easily resolved. Standard analytical procedure was used to correct for counting geometry and matric corrections per the general container size and matrix

characteristics. The Cs-137 results were then reverse-decay corrected to November 1991 in order to properly use the derived scaling factors for the hot cell waste.

Results from the recent LANL gamma spectroscopy campaign indicate no TRU isotopes were directly detected, but the minimum detectable TRU concentrations were too high to make a direct TRU/LL determination. The TRU isotope activities as well as other expected non-detected isotope activities reported were thus calculated from the measured Cs-137 using the derived scaling factors in TABLE II. The calculated results for the scaled nuclides were then decay corrected to current activities. A few measurements showed Co-60 activity. All had strong energy peaks for Cs-137. The certified net weights of the drums, as packaged by the generator, were used to calculate the TRU concentration (nCi/g) for each container. Fig. 5 provides an example of a gamma spectrum from one of the cement line 55-gallon drums with a strong Cs-137 662keV peak and high Compton scattering continuum. Some drums were historically overpacked, (e.g., 85-gallon drum overpacked in a 110-gallon drum), but the weight of the outer drum was subtracted to yield a net weight for the concentration calculations. The maximum TRU concentration of a single drum was 93 nCi/g. The results indicate that all of the 44 above-ground waste containers possess TRU concentrations less than 100 nCi/g and have been reclassified as radioactive low level waste and disposed of at an off-site low level waste repository.

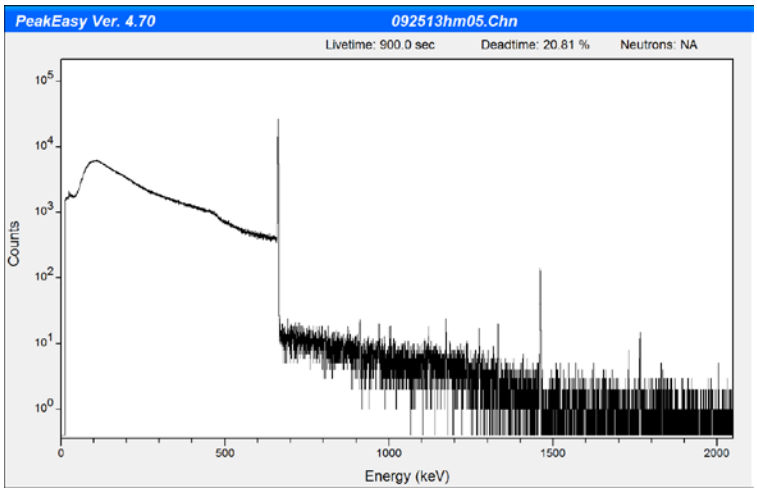

Fig. 5 Example of high Cs-137 spectrum from above ground 55-gallon concrete lined drum.

BELOW-GROUND HIGH Cs-137 WASTE ITEMS

The below-ground waste items that were characterized using the extended Cs-137 scaling technique consisted of five hot cell liners in below-ground shafts at TA-54 Area G. The five stainless steel alpha-contaminated hot cell liners were removed from cells 2, 4, 9, 13, and 14 of Wing 9 of the CMR Facility during decommissioning activities following the 1986 mission change for the hot-cells. Each of the five hot cell liners was wrapped in either 3- or 4.5-mil-thick plastic and placed into a 6 ft x 6 ft x 10 ft steel box (waste containers). Blocking was added to limit shifting during transportation and storage. The legs of some of the glovebox hot cell liners may have been removed. The five containers were placed into shafts on December 5, 1991, based on the disposal logs for shafts that received waste from August 1978 to December 1991.

Characteristics of Hot Cell Liners

Fig. 6 shows a photograph of a typical hot cell liner, which was constructed of stainless steel (top and walls 1/8 inch thick and floor 1/4 inch thick). Dimensions of the hot cell liners or "alpha containment boxes" were 5 1/2 ft square and 11-ft high with the legs.

Fig. 6 Typical Hot Cell Liner.

The waste containers are steel boxes approximately 6 ft x 6 ft x 10 ft specially designed and built to hold the decommissioned stainless steel hot cell liners for transportation to and storage at TA-54 Area G. The steel boxes have lifting lugs at each corner of the top of the box to facilitate ready emplacement and retrieval. Fig. 7 shows photographs of a steel box used to contain one of the hot cell liners. The photo on the left shows the box with the top in place and cables attached to the lifting lugs. The photo on the right shows the box with the top steel panel removed.

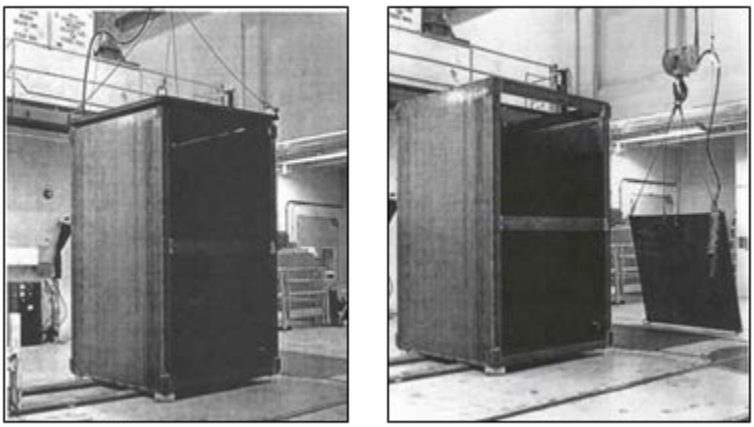

Fig. 7. Steel Box used to Contain Hot Cell Liners.

Each of the five containers contains a single decommissioned stainless steel hot cell liner, similar in configuration to a glovebox. The hot cell liners have approximate dimensions of 65 inch W x 65 inch L x 8 ft H. Gross weights of the boxes range from approximately 5,400 to 6,200 pounds, and net weights of the hot cell liners waste range from 3,800 to 4,600 pounds. Net weights for waste within each box shown in the waste profile were based on a tare weight for the steel box of 1,600 pounds.

Disposal records for the waste packages indicate that three of the hot cell liners were wrapped with one layer of either 3-mil or 4.5 mil plastic, and two of the hot cell liners were wrapped in two layers of 3-mil plastic. Blocking was added to diminish shifting during transport and storage, but no information was located on composition of the blocking material. Fig. 8 shows a photograph of a wrapped hot cell liner being placed into a steel box container.

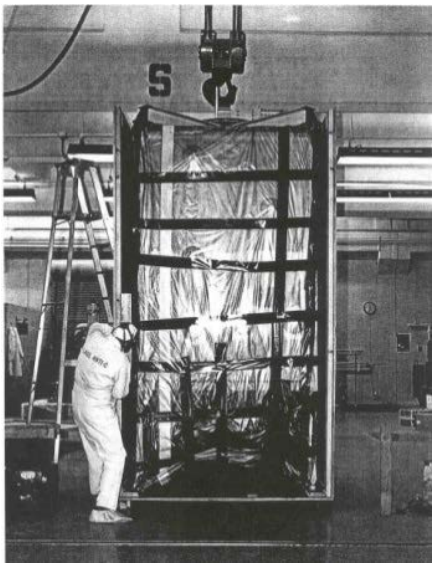

Fig. 8. Placement of Hot Cell Liner inside Steel Box Container.

Configuration of Waste Containers in Shafts

Fig. 9 is a sketch of the shaft configuration (which is not to scale), and Fig. 10 is a close-up photo of the cover over one of the shafts and the domed collar around the shaft. Lifting lugs and forklift guides on the cover are clearly visible in the photo. Each shaft contains one steel box that contains one hot cell liner. The steel boxes sit on gravel at the bottom of the shafts, and the tops of the boxes are about 12 ft from the top of the shafts. The boxes have lifting hooks at each corner of the top of the boxes.

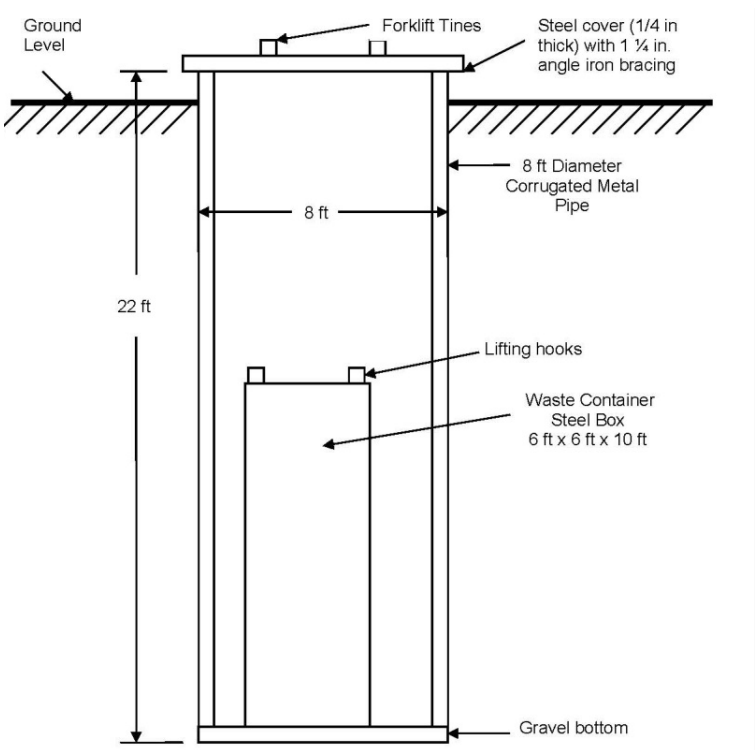

Fig. 9 Sketch of Hot Cell Liners Shaft Configuration (Not to Scale).

Fig. 10 Shaft Cover and Domed Concrete Collar at Top of Shaft.

While the development of TA-54 Area G has continued to evolve since 1991, the Hot Cell Liners shafts and the immediate surrounding area have essentially remained unchanged.

Radiological Characteristics

The LANL Waste Compliance and Tracking System (WCATS) database provides radionuclide content for each of the five hot cell liners containers based on the Radiological Solid Waste Disposal (RSWD) records and Waste Profile Request forms provided by the waste generator in 1991. The RSWD forms for the hot cell liners list amounts of nuclear Material Types U38 (approximately 93% U-235) and PU55

(approximately 84% Pu-239) and estimates of a number of mixed fission products (MFP) isotopes. The WCATS database calculates quantities of a large number of specific isotopes, as well as PE-Ci and Pu-239 fissile gram equivalents (Pu-239 FGE). Primary radionuclides listed in the WCATS database for the hot cell liners containers consist of Pu-239, Pu-241, U234, and U-235. Other radionuclides listed include Am-241, Sb-125, Ba-127, Cs-137, Eu-155, Pu-238, Pu-240, Pu-242, Pm-147, Rh-106, Ru-106, Sr-90, Te-125, U-236, U-238, and Y-90. A 2005 review of data for the hot cell liners [5] includes calculations for decay of the radioisotopes reported in the WCATS database for each hot cell liner to the year 2009. These calculations were based on use of an Oak Ridge National Laboratory computer code. Dose rates at contact of the container were also calculated as decayed to 2009. The calculated decayed dose rates were about 35% lower than the initial measured dose rates for three of the hot cell liners containers, but were considerably higher than the initial measured dose rates for two of the containers. A 2006 inspection and field study of Shafts 302-306 measured surface radiation dose on the top and each side of each of the hot cell liner boxes at several depths from the top of the shafts. These measurements all indicated doses < 200 mrem/hour [6].

Calculations on the concentration of alpha-emitting TRU isotopes using container net weights and radiological data in WCATS indicate that four of the five containers do not meet this definition and should be considered LLW while the fifth one does and would be considered TRU waste if the steel box is considered to be the payload container. However, the steel boxes are not WIPP-approved containers and are not qualified as Type A containers. They will need to be overpacked into a qualified Type A container for transport. Therefore, gross weight of the current containers hot cell liners (and steel boxes) should be considered in the concentration of alpha-emitting TRU isotopes and all five containers would be calculated to have less than TRU levels of contamination under this approach.

Current Radiological Characterization Using Cs-137 Scaling

In March 2014 gamma NDA measurement were performed on each of the five hot cell liners containers stored in Shafts 302-306 to determine/verify/validate whether the containers should be considered LLW or TRU waste per the above definition. Due to the configuration of the hot cells in the shafts and the expected high Cs-137 signal from the hot cell liners, portable far-field HPGe detectors were used for the measurements. For each shaft, the far–field HPGe detector systems was set on the metal shaft cover and pointed down toward the hot cell liner waste container. Counting time was generally 3-4 hours and because of the high levels of Cs-137 the 662 keV gamma signal was well resolved. Standard analytical procedure was used to correct for counting geometry and matrix corrections per the general container size and matrix characteristics. The Cs-137 results were then reverse-decay corrected to order to properly use the 1991 WCATS scaling factors for the hot cell waste.

Results from the recent LANL gamma spectroscopy campaign indicate no TRU isotopes were directly detected, but the minimum detectable TRU concentrations were too high to make a direct TRU/LL determination. All had strong energy peaks for Cs-137 and small peaks from Co-60 and Eu-154. Fig. 11 provides an example of a gamma spectrum from one of the hot cell liner shafts with a strong Cs-137 662keV peak and high Compton scattering continuum. The TRU isotope activities as well as other expected non-detected isotope activities reported were thus calculated from the measured Cs-137 using the scaling factors from WCATS. The calculated results for the scaled nuclides were then decay corrected to current activities. The results of these radioassays are shown in Table III. Based on the current characterization, the hot cell liners in the shafts have been classified as LLW and are currently held in place while retrieval and off-site disposal options are being evaluated. Further information and details can be found in a LANL 2014 comprehensive report on the hot cell liners [7].

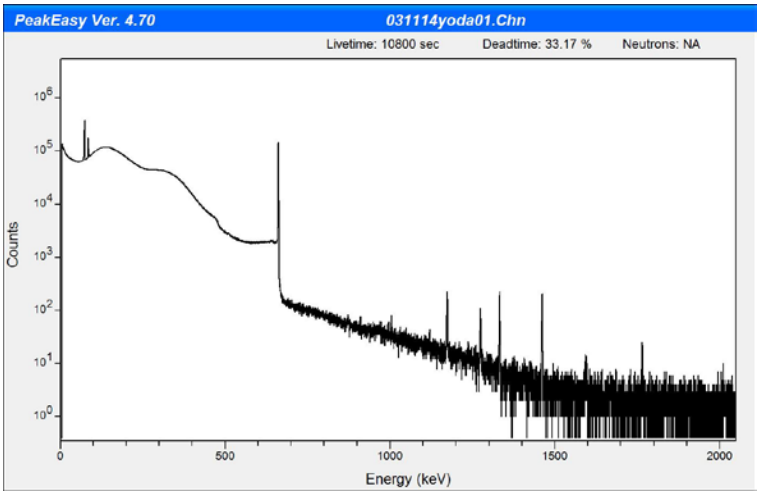

Fig. 11 Example of high Cs-137 spectrum from a hot cell liner shaft.

TABLE III March 2014 Hot Cell Liner Radioassay Results.

Shaft #	Waste Package or Container ID #	TRU Alpha (nCi/g)
302	S910321	14.1
303	S910322	39.6
304	S912719	29.7
305	S912717	92.9
306	S910327	33.4

CONCLUSION

Radioactive waste at LANL that has elevated levels of non-TRU nuclides such as Cs-137 can cause technical complications using gamma and or neutron NDA systems typically used for radiological characterization. Two such groups of waste items that contain high Cs-137 were identified at LANL TA-54 Area G in the 2013-2104 time period – one above-ground and one below-ground. Both groups were from waste streams related to the CMR facility at LANL where work included evaluation of irradiated fuel pins. The above-ground group consisted primarily of drums generated during Wing 9 operations at CMR while the below-ground group consisted of hot cell liners generated during the D&D of Wing 9 hot cells. To characterize these waste items so that a TRU/LLW determination could be made, an extended scaling technique was applied to far-field HPGe gamma spectroscopy measurements. Far-field HPGe detector systems were used because the measurement distance from the high Cs-137 waste items could be adjusted to manage detector dead time. The scaling technique used Cs-137 as the key nuclide and applied established AK/PK to scale non-detected radionuclides to the detected Cs-137. The AK/PK developed for these waste items by reviewing and documenting years of historical information was important in applying this technique. Both groups of waste items were able to be successfully characterized and classified as LLW using this technique. The above-ground waste was successfully dispositioned and disposed of at an off-site LLW repository while the below-ground waste is for the time being held in place as LLW. This scaling technique will continue to be considered for characterizing difficult gamma interfering waste streams in LANL's ongoing efforts to manage its radioactive waste.

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