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Los Alamos National Laboratory SAVY-4000 Field Surveillance Plan Update for 2017

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Prepared for: U.S. Department of Energy/National Nuclear Security Administration Los Alamos Field Office

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1.0 INTRODUCTION

The Packaging Surveillance Program section of the Department of Energy (DOE) Manual 441.1-1, *Nuclear Material Packaging Manual* (DOE 2008), requires DOE contractors to "ensure that a surveillance program is established and implemented to ensure the nuclear material storage package continues to meet its design criteria." The Los Alamos National Laboratory (LANL) SAVY-4000 Field Surveillance Plan was first issued in fiscal year (FY) 2013 (Kelly et al. 2013). The surveillance plan is reviewed annually and updated as necessary based on SAVY-4000 surveillance findings, as well as results of the lifetime extension studies. Two surveillance plan updates have been issued, one in 2014 (Kelly et al. 2014) and one in 2016 (Kelly et al. 2016). This 2017 update reflects changes to the surveillance plan resulting from surveillance findings as documented in Reeves et al. 2016. These findings include observations of corrosion in SAVY and Hagan containers and the indication (in one SAVY container) of possible filter membrane thermal degradation.

This surveillance plan update documents the rationale for selecting surveillance containers, specifies the containers for 2017 surveillance, and identifies a minimum set of containers for 2018 surveillance.

This update contains important changes to the previous surveillance plans. These changes include new guidance for corrosion examinations and for evaluating the filter membrane using water ingress testing. Another important change results from the recognition that (1) all surveillance containers that do not require destructive examinations (DE) can be examined multiple times and (2) only containers with compromised performance require DE. Therefore, the majority of surveillance containers can have ongoing non-destructive examinations (NDE). Previously there were only four containers identified for ongoing examinations, so this group is now expanded to include all surveillance containers that do not require DE. The previous ongoing group of four containers had NDEs planned annually. The period between examinations can be increased based on engineering judgment as more containers are examined multiple times. It is anticipated that expanding the group of ongoing examinations will reduce variability, resulting in improved assessment of aging impacts.

2.0 BACKGROUND

2.1 Surveillance Focused on Worst-Case Materials

In 2013, the Field Shelf-Life surveillance sample consisted of first identifying a set of "worst-case" materials that were packaged in non-standard containers, Hagan containers, or SAVY-4000 containers (Kelly et al. 2013). The worst-case materials packaged in non-standard or Hagan containers were repackaged into SAVY-4000 containers. The parameters used to determine worst-case materials were (1) for the O-ring, those materials with the potential for a high gamma dose to the O-ring, (2) for the container body, those materials containing potentially corrosive salts and with high radiation fields of all types, and (3) for the filter, those materials with the potential to generate corrosive gases and the potential for a high gamma dose to the filter. Figure 2-1 shows plots of dose versus item description codes (IDCs). The 12 IDC groups considered to encompass the worst-case materials are identified with blue stars. These groups were selected because they had a reasonable number of containers with the highest calculated doses and they encompassed the salt-bearing residues. (The doses are estimates used for ranking purposes only and do not represent actual dose to the components.) Since worst-case conditions are targeted by the surveillance program, the results are not representative but bounding.

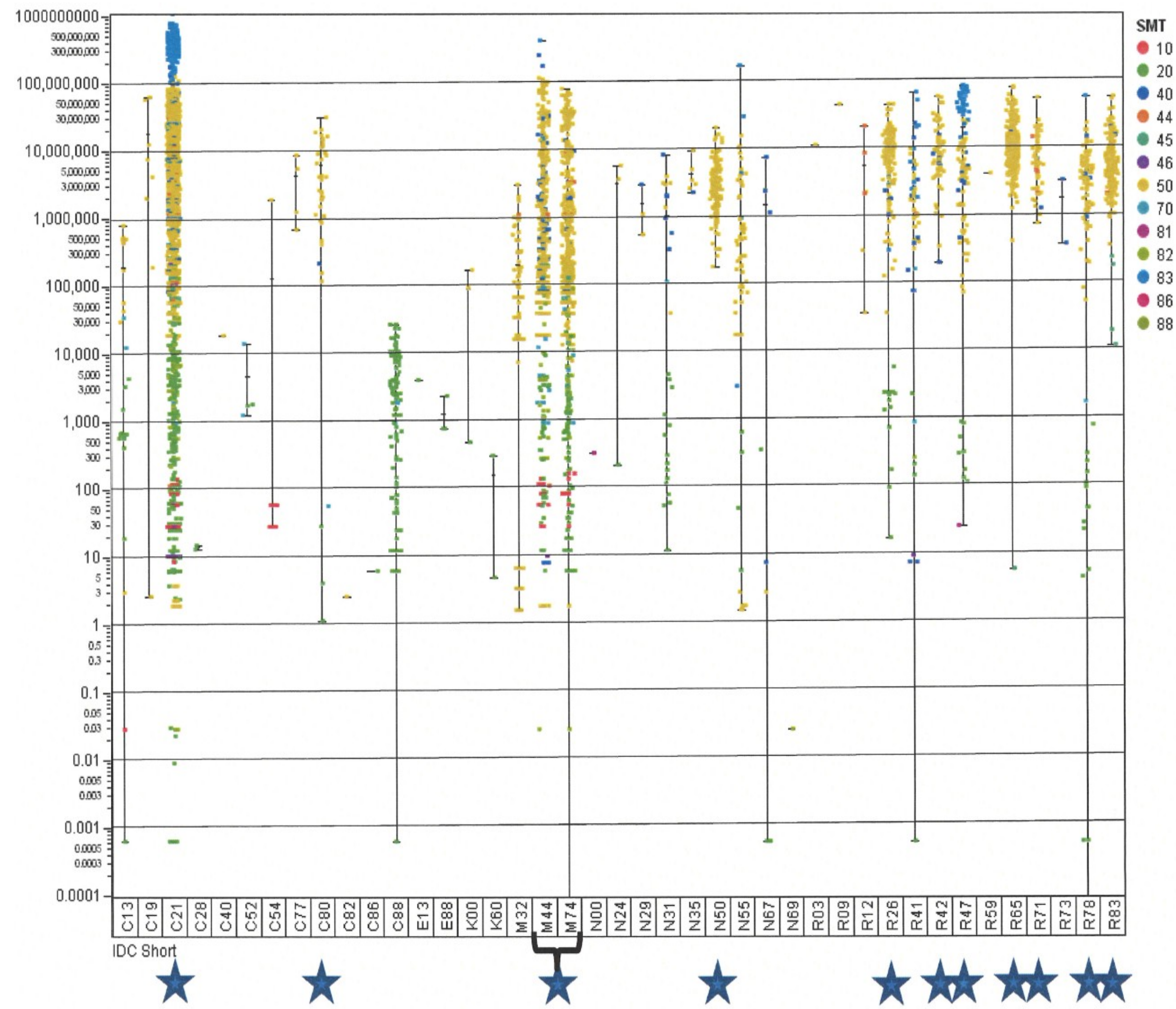

Figure 2-1. Calculated dose for each IDC (see Appendix A for IDC definitions).

A new IDC category will be added in FY 2017, Plutonium chloride (C19). This IDC is added because of its high likelihood of causing corrosion and due to the corresponding recognition of the increased importance of corrosion. The color of the dots on the graph indicate the isotopic composition (material type [MT], also known as summary material type [SMT]) of the nuclear material, e.g., weapons-grade plutonium, highly enriched uranium (see Appendix B for MT definitions).

2.2 Surveillance Results to Date

In 2015 and 2016, a total of 43 unique SAVY-4000 and 21 Hagan containers were examined as part of the SAVY surveillance program. Four of the SAVY-4000 containers were examined twice for a total of 47 tested with an age range of 0.4 to 4.9 years. The 21 Hagan containers had in-service usage ages ranging from 4.8 years to 14.4 years. The 43 SAVY containers were comprised of 21 field shelf-life containers and 22 items-of-opportunity (I-of-O) (transfer containers). There were four SAVY NDE-only containers, which were examined each year (the ongoing group), for a total of 47 SAVY surveillance examinations during 2015 and 2016.

The containers, O-rings, and filters were examined for all 47 SAVY containers. The details of the surveillance results are presented in Reeves et al. (2016). All O-rings passed a helium leak test and durometer measurements. All filters passed the criteria for efficiency and pressure drop. One SAVY surveillance item had a pressure drop that was 30% below the measurement made at the time of manufacture. This SAVY item contained a welded heat source, which may have caused thermal degradation of the membrane. This finding, along with preliminary life-extension results (Weis et al. 2016) indicates the potential for polytetrafluoroethylene (Teflon; PTFE) membrane degradation. Future SAVY surveillance items will undergo water ingress testing to evaluate the PTFE membrane.

Seven of the SAVY surveillance containers were found to have corrosion inside the container. No corrosion had passed the O-ring sealing surface. Of the seven containers found, four were part of the Field Shelf-Life program and three were I-of-O transfer containers, which were brought in for maintenance.

All 21 Hagan containers performed their primary function of containing particulate nuclear material; all containers were found to be free of external contamination. However, nine Hagan containers (43%) were found to have corrosion on the inner surfaces.

All SAVY containers and a selection of the Hagan containers that were found with corrosion have been saved for future testing. A test plan for assessing corrosion on these containers is being developed.

Section 4.0 of this update provides new guidance for surveillance corrosion examinations.

3.0 CURRENT SURVEILLANCE PLAN

The previous surveillance plans (Kelly et al. 2014 and Kelly et al. 2016) used several categories for identifying containers for examination including the:

- Field Shelf-Life surveillance sample, which includes both (1) only non-destructive examinations (NDE-only) and (2) NDE and destructive examination (DE) NDE/DE,
- SAVY-4000 I-of-O items,
- SAVY-4000 engineering judgment (EJ) items,

- Hagan I-of-O items, and
- Hagan EJ items.

Some of these categories are no longer considered useful. They have been condensed into the following:

- SAVY Field Shelf-Life surveillance sample, which includes both (1) only NDE and (2) NDE with DE. DE is performed only if there is significant container component performance degradation that warrants destructive testing, e.g., significant visual indication of corrosion, significant filter efficiency loss, pressure drop change, visual indication of filter/membrane color change, O-ring visual inspection failure and/or leak test failure, or as determined by subject matter experts (SMEs).
- SAVY-4000 I-of-O sample. These containers undergo NDE. DE is performed only if there is significant container component performance degradation (as noted above).
- Hagan containers. These containers undergo NDE. Since they are not returned to service, they undergo DE based on engineering judgment.

Table 3-1 shows the items selected for surveillance in 2017. Specific containers identified for surveillance in this plan may be replaced with equivalent items or with higher priority items as circumstances require at the discretion of the Nuclear Material Storage and Disposition Board (the Board). The first SAVY container, BLO-39-11-16, was selected because the Hagan containing this material showed corrosion. This item has been in a SAVY container for approximately 1 year. The other SAVY items on this list were selected from the list of future SAVY containers identified in the 2016 Update (Table 3_3_a, Kelly et al. 2016), and they range in age from 3 to 5 years.

Selection criteria as currently implemented for SAVY or Hagan containers in storage takes into account the following:

- Storage container with similar/same IDC type as containers that showed corrosion.
- Worst-case IDC from the blue star groups (see Figure 2-1) that has not been tested previously.
- Specific to the Hagan population, IDCs not allowed as authorized contents per the SAVY Safety and Analysis Report (Anderson et al. 2013) but are currently loaded in Hagan containers.
- For storage containers that fall within the same IDC grouping, containers higher in age or with more nuclear material are preferred.
- Preferential selection based on known degradation mechanisms from past surveillance activities (e.g., white powder generation in Hagan containers)
- High wattage
- Size of container (preference is for smaller sizes)

- Ensure at least two of each IDC grouping have been selected for SAVY containers on an ongoing basis so that these groupings are fully and continually represented.
- Materials that are considered water soluble are limited to a maximum plutonium content of 500 g in FY 2017. This limitation is expected to be removed sometime in FY 2018.

Table 3-1 Surveillance Containers for 2017

IDC Code	IDC Description	Type	Size (QT)	Item	Watt	Pu Wt. (g)	Age (yr)
C21	COMPOUND; Dioxide	SAVY1	8	BLO-39-11-16	5	544	1
C21	COMPOUND; Dioxide	SAVY2	5	CXLOX082911	2	787	5
M44	METAL; Unalloyed Metal	SAVY3	5	XAP6	0	69	3
R26	PROCESS RESIDUE; Filter Residue	SAVY4	5	ROTRBJ-1C1	1	452	5
R83	PROCESS RESIDUE; MSE Salt	SAVY5	3	XBLSCL1217	3	178	4
R42	PROCESS RESIDUE; DOR Salt	SAVY6	3	SLTF3123A	5	1900	4
R47	PROCESS RESIDUE; Incinerator Ash	SAVY7	8	INCA-21	4	913	4
C19	COMPOUND; Chloride	Hagan1	3	ATLAMS1S1	0	75	10
C19	COMPOUND; Chloride	Hagan2	3	CASLT966	1	286	12
C21	COMPOUND; Dioxide	Hagan3	3	BMB32OXC2	2	604	17
R47	PROCESS RESIDUE; Incinerator Ash	Hagan4	5	ASHRCP-7	2	713	10
R47	PROCESS RESIDUE; Incinerator Ash	Hagan5	8	TDC59	13	27	16
R65	PROCESS RESIDUE; ER Salt	Hagan6	8	XORER6SLT2	1	457	11
R83	PROCESS RESIDUE; MSE Salt	Hagan7	3	XBLS8A	4	114	10
R83	PROCESS RESIDUE; MSE Salt	Hagan8	1	XBLSCL4051203	7	451	13

The decision to examine eight Hagan containers in 2017 was based on the following three considerations.

1. Hagan containers are likely to be more susceptible to corrosion than SAVY containers (304 L versus 316 stainless steel, http://www.penflex.com/chloride-chlorine-levels-and-stainless-steel-alloy-selection/) under the expected atmospheric corrosion conditions. Therefore, Hagan containers provide worst-case information in terms of corrosion effects.

2. Current Hagan container population is large (approximately 3,500 LANL-wide, approximately 3,000 in PF-4). It is anticipated Hagan containers will be in use for many years to come. Therefore, it is prudent to understand corrosion conditions in Hagan containers and any negative impacts to the containment function.

3 The time-in-storage for Hagan containers is generally much longer than SAVY containers for similar contents.

Table 3-2 shows containers that have been identified for 2018. Others will be added for a total of 15 containers. This table assumes that the ban on examining containers with >500 g soluble material has been lifted.

Table 3-2 Surveillance Containers for 2018

IDC Code	IDC Description	Type	Size (QT)	Item	Watt	Pu Wt. (g)	Age yr
C21	COMPOUND; Dioxide	SAVY	8	BLO-39-11-16	5	544	1
C21	COMPOUND; Dioxide	SAVY	5	CXLOX082911	2	787	5
M44	METAL; Unalloyed Metal	SAVY	5	XAP6	0	69	3
R26	PROCESS RESIDUE; Filter Residue	SAVY	5	ROTRBJ-1C1	1	452	5
R83	PROCESS RESIDUE; MSE Salt	SAVY	8	XBLSCL1306	10	649	4
C19	COMPOUND; Chloride	Hagan	8	SLT4-98B	6	2189	15
R65	PROCESS RESIDUE; ER Salt	SAVY	8	GBS059	4.9	1877	11
R83	PROCESS RESIDUE; MSE Salt	SAVY	3	CAXBL128D	13.4	835	4
R83	PROCESS RESIDUE; MSE Salt	Hagan	3	XBLSCL4050903	7	1491	13
R78	PROCESS RESIDUE; Sweeping/Screening	SAVY	8	VTB-16C1	2.7	1013	4

4.0 SURVEILLANCE MEASUREMENTS

The main focus of surveillance examinations is to evaluate O-rings, filters, and the condition of the metal surfaces, particularly for any sign of performance degradation, corrosion, or leakage. Measurements and examinations to assess potential problems are conducted on all surveillance containers. Because the previous surveillance showed corrosion in seven SAVY and nine Hagan containers, in this update there is increased emphasis on and guidance for corrosion examinations. In addition, there is additional guidance for inspecting the PTFE membrane.

Some of these evaluations provide "yes/no" data and others provide quantitative data. If there is a "yes" response and/or there are any observations that indicate a potential problem with the container, the Board is notified as appropriate.

4.1 Non-Destructive Examinations (NDE) for SAVY-4000 and Other Surveillance Containers

Examinations during the unpacking of the outer container:

- Any visual indications of pressurization (slight bulging) or corrosion? (yes/no)
- Does visual inspection show signs of any dents or gouges that may have occurred in normal handling or possibly due to dropping the container? (yes/no)
- Weight measurement: do trends indicate moisture absorption or metal oxidation? (yes/no)
- Do contamination surveys show any indication of O-ring seal failure, weld failure, or filter failure? (yes/no)

Visual examination to determine inner package condition and if the container was packaged according to procedures:

- O-ring installed improperly? (yes/no)
- Inner container not consistent with material form (e.g., not a stainless steel slip lid for oxide, not a hermetically sealed lid for metal, etc.)? (yes/no)
- Bag-out bag not present? (yes/no)
- Bag-out bag not intact (e.g., contamination found outside bag-out bag)? (yes/no)
- Any liquid observed inside the bag-out bag? (yes/no)
- Metal inner container <u>not</u> intact (e.g., holes corroding through, plutonium in contact with bag-out bag, etc.)? (yes/no)

Examination of the empty SAVY-4000 or Hagan container for leakage:

- Leakage testing shall be in accordance with ANSI N14.5. For a SAVY-4000 container, the test pass rate shall be equal to the design release rate established as 5.6 × 10-6 cm^3s-1 of air. For both SAVY-4000 containers and Hagan containers, the testing helium leak rate criterion for this surveillance plan will be 1.0 × 10-5 atm cm^3 s-1 at a differential pressure of 10 kPa.
- Does the functional check of the closure system show any impingement of moving parts impeding closure? (yes/no)
- Does the O-ring groove on the body collar show any signs of damage (e.g., scratches, burr, etc.)? (yes/no)

Examination of the empty SAVY-4000 or Hagan container for corrosion

- Do the interior and/or exterior surfaces of the container show any signs of corrosion or discoloration? (yes/no). If the response is "yes,"
  - a photograph of the affected area is taken

  - determine if container can be returned to service or further analysis for corrosion is required (in this case the container will have a DE [4.2]).

Examination of O-Ring:

- Does the SAVY-4000 O-ring need replacement based on the visual inspection: scratches, cuts or other damage on the O-ring itself that might prevent an effective seal? (yes/no)
- Shore M hardness measurements that will be evaluated using Parker O-ring manufacturer recommended tolerances. The hardness measurements will be directly compared with those measurements obtained from the accelerated aging studies and shelf-life studies.
- Compression set will be estimated from the measured thickness of the O-ring and the nominal thickness of Parker V0986-50 O-rings, 0.2100 inches ± 0.0005 inches. Initial thickness measurements will be made for SAVY containers going into the surveillance program. The estimated compression set values will be directly compared with those measurements obtained from the accelerated aging studies (Weiss et al. 2016).
- NDE will also be performed on Viton-based O-rings and Neoprene-based gaskets from Hagan containers included in the surveillance program. However, since we are not conducting accelerated aging studies on the polymeric materials used in Hagan containers, we do not have a base of knowledge for comparison to compression set measurements.

Examination of Filter Function:

- Based on visual inspection of the outside of the lid, does the area around the filter show indications of deposits on or near the filter? (yes/no)
- Based on visual inspection of the inside and the outside of the lid, does the filter material itself show indications of discoloration or occlusion? (yes/no)
- Aerosol filter test at a flow rate of ~200 ml/minute with criteria pressure drop across the filter (<1 inch water column) and % penetration (<0.03%)
- Water penetration test of the PTFE membrane, 12-inch water column pressure applied on the exterior of the lid for a minimum of 1 minute with a visual inspection on the interior side of the lid to verify no water passed through the membrane (must be performed after the filter pressure drop test, or the filter must be properly dried to avoid a misleading pressure drop result)

4.2 Destructive Examination (DE)

In addition to the NDE measurements and qualitative evaluations that will be performed, if there is container component performance degradation, e.g, significant visual indication of corrosion, significant filter efficiency loss, pressure drop change, visual indication of filter/membrane color change, O-ring visual inspection failure and/or leak test failure, or as determined by SME judgment, then the container will undergo a DE. This is true for both SAVY and Hagan containers.

DEs to evaluate corrosion will include performing drop tests on the worst-case containers to investigate if the corrosion is affecting the ability of the containers to survive a drop. The containers will have helium leak tests both before and after the drop. The thickness of the containers will be measured prior to the drop using ultrasonic measurement devices. After drop testing, the containers will be sectioned and the corrosion morphology (e.g., pitting and cracking) will be investigated. A series of mechanical property tests will also be conducted using some of the samples taken from the containers.

DE tests for the SAVY-4000 and Hagan O-rings have changed. Previously O-ring thickness evaluation was listed as a DE, but it is actually an NDE. Fourier transform infrared (FTIR) measurements previously listed under DE have not proven to reveal changes at a molecular level. So they are being discontinued. For DE containers, when determined by the SME to be required, polymer swelling measurements will be taken on a section of the O-ring in accordance using ASTM D2765–95. Swelling measurements will be compared with those obtained from the accelerated aging studies.

5.0 REPORTING REQUIREMENTS

As stated previously, if there are any “yes” responses and/or there are any observations that indicate a potential problem with the container during the NDE and NDE/DE, Nuclear Material Storage personnel and the Board will be notified as appropriate.

An annual report summarizing the surveillance and lifetime-extension studies for all containers examined to date will be delivered to the Board in December. The SAVY-4000 Project Leader shall submit the report with assistance from staff members for each tested component.

6.0 SURVEILLANCE DATABASE

A key component of the surveillance program is the surveillance database. LANL initiated the development of a database with relevant information about stored materials and containers, including material, packaging, and surveillance information for each storage container. The database will document important information for trending studies such as the age of the container, how long it has been in service, its in-service history (e.g., what materials have been loaded for what periods of time), and the dates of replacements of key components such as O-rings. The database will also provide information about the materials in these containers so that a material causing potential problems can be identified. The database will also be used to document the inspection/testing results from this plan and from the lifetime extension studies.

To make sure that items that are scheduled for future surveillance are tracked properly, these items will be assigned to the LANMAS field SubMBA of MMGT. The MMGT identifier prevents the containers from being retrieved from the vault for purposes other than surveillance.

In addition, checks of the LANMAS database will be run on a routine basis. These checks will look for inappropriate storage configurations and/or conditions such as the presence of corrosive liquids, inappropriate inner container for the material, wattage limit exceeded, allowed time-in-storage exceeded.

7.0 REFERENCES

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APPENDIX A. ITEM DESCRIPTION CODE (IDC) DEFINITIONS

IDC*	DESCRIPTION
C13	COMPOUND; Carbide
C19	COMPOUND; Chloride
C21	COMPOUND; Dioxide
C28	COMPOUND; Fluoride
C40	COMPOUND; Hydride
C52	COMPOUND; Nitrate
C54	COMPOUND; Nitride
C77	COMPOUND; Sulfate
C80	COMPOUND; Tetrafluoride
C82	COMPOUND; Trichloride
C86	COMPOUND; Trioxide
C88	COMPOUND; U3O8
E13	REACTOR ELEMENT; Carbide
E88	REACTOR ELEMENT; U3O8
K00	COMBUSTIBLE; Non Specific
K60	COMBUSTIBLE; Paper/Wood
M32	METAL; Beryllide
M44	METAL; Unalloyed Metal
M74	METAL; Alloyed Metal
N00	NON-COMBUSTIBLE; Non Specific
N24	NON-COMBUSTIBLE; Filter Media
N29	NON-COMBUSTIBLE; Glass
N31	NON-COMBUSTIBLE; Graphite
N35	NON-COMBUSTIBLE; HEPA Filter(s)
N50	NON-COMBUSTIBLE; MgO
N55	NON-COMBUSTIBLE; Non-Actinide Metal
N67	NON-COMBUSTIBLE; Plastics/Kim Wipes
N69	NON-COMBUSTIBLE; Resin
R03	PROCESS RESIDUE; Hydrogenous Salt
R09	PROCESS RESIDUE; Calcium Salt
R12	PROCESS RESIDUE; Calcium Metal
R26	PROCESS RESIDUE; Filter Residue
R41	PROCESS RESIDUE; Hydroxide Precipitate
R42	PROCESS RESIDUE; DOR Salt
R47	PROCESS RESIDUE; Incinerator Ash
R59	PROCESS RESIDUE; Oxalate Precipitate
R65	PROCESS RESIDUE; ER Salt
R71	PROCESS RESIDUE; Salt
R73	PROCESS RESIDUE; Silica
R78	PROCESS RESIDUE; Sweepings/Screenings
R83	PROCESS RESIDUE; MSE Salt

*The IDC codes used in this plan are abbreviated to the first three characters. Those used in LAMCAS are four characters.

APPENDIX B. DETAILED MATERIAL TYPES IN THE SURVEILLANCE POPULATION*

MT	DESCRIPTION
42	>60% Pu-242
52	Pu-239 with 4.00%–7.00% Pu-240
54	Pu-239 with 10.00%–13.00% Pu-240
56	Pu-239 with 16.00%–19.00% Pu-240
83	Pu-238

* DOE Manual 470.4-6, *Nuclear Material Control and Accountability* (8-26-07).