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SAVY-4000 Surveillance and Life Extension Program Fiscal Year 2013 Annual Report

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Abstract

The Packaging Surveillance Program section of the DOE M 441.1-1[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." In order to ensure continuing safe storage of nuclear material and the maximization of risk reduction, TA-55 has established a Surveillance Program to ensure storage container integrity for operations within its specified design life.

The *LANL SAVY-4000 Field Surveillance Plan*[2] defines the near-term field surveillance plan for SAVY-4000 containers as required by the Manual. A long-term surveillance plan will be established based on the results of the first several years of surveillance and the results of the lifetime extension studies as defined in the *Accelerated Aging Plan*[3].

This report details progress in positioning the Surveillance Program for successful implementation in FY14 and status of the Design Life Extension Program in terms of its implementation and data collection for FY13.

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1. Introduction

The Packaging Surveillance Program section of the DOE M 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." In order to ensure continuing safe storage of nuclear material and the maximization of risk reduction, TA-55 has established a Surveillance Program specific to the SAVY-4000 Manual-compliant storage container design. Certain aspects of the Surveillance Program will also be applied to Hagan containers because there are over 3000 still in use in PF-4, and some have been in storage for up to 13 years. They also have a Viton-based O-ring formulation that is similar to the SAVY-4000 design, and the data collected is expected to provide some additional insight into the SAVY-4000 O-ring design life.

The primary goals in establishing a surveillance program are 1) to ensure that the nuclear-material storage package continues to meet associated design criteria and 2) identify indications of package degradation early, remediate the degraded package, and identify similar packages and materials that may need remediation. Therefore, the implementation of the Field Surveillance Plan incorporates the design and fabrication specification, with associated inspections and testing accomplished during the fabrication process as the initial surveillance baseline that is utilized in validating future performance. The program evaluates appropriate attributes of stored containers to determine whether the container can continue to function properly as safe storage.

Of particular interest is the extent to which real time surveillance data will validate the keycharacteristics identified in laboratory limited life component (LLC) studies to support design life extension. Therefore, aging impacts on containers will be evaluated through a combination of a surveillance plan and laboratory accelerated aging studies. The current conservative estimate of design life established for the SAVY is five years. The initial Surveillance Program is defined over a five year period; a long-term surveillance plan will be established based on the results of the first several years of surveillance, including the field shelf-life surveillance, items-of-opportunity, expert judgment samples and the lifetime extension studies. The lifetime extension studies will be completed within two years and will form the basis for the interpretation of any observed degradation identified in the ongoing Surveillance activities.

The surveillance program, a Manual requirement which is documented in the SAVY-4000 Safety Analysis Report, includes destructive testing of O-rings to identify early signs of degradation. The accelerated aging studies are anticipated to identify degradation trends and mechanisms that would be difficult, if not impossible, to identify in the surveillance program because the rate of degradation is likely to be quite slow. Therefore, LANL is performing detailed and extensive accelerated aging studies of the SAVY-4000 O-rings in order to extend the initial 5-year service life of the O-rings and to supplement the required surveillance program. The experimental aging data will be integrated with data from field usage to refine the aging estimates as the containers age in real time.

During FY13 the Field Surveillance Plan, including both Hagan and SAVY containers, was finalized, and the core surveillance capability was established and set in place to initiate the Surveillance Program in FY14. Per the bounding parameters within the plan, the worst case materials were identified and repackaged into 24 field shelf life SAVY containers for observation over time. Major Equipment needs to support non-destructive evaluation (NDE) aspects of the Surveillance Program, including helium leak testing and filter efficiency testing have been purchased The systems integration of equipment components was completed, and draft procedures have been developed. In FY14 the procedures will be finalized, the personnel will be trained and certified, and surveillance data collection will begin on the field shelf life SAVY containers. The complete Destructive Evaluation (DE) capability, including equipment and procedures was also established and demonstrated in FY13. This capability is a key element of the Surveillance Program, focusing mechanical and spectroscopic characterization techniques on the O-ring as the key limiting life component (LLC). A quality control program has also been established as equipment/test systems have come on line to ensure data quality. This program includes user performed calibration plans (UPC), calibration through the LANL Standards and Calibration Laboratory, and third party calibration using sub vendors approved by LANL's Institutional Evaluated Suppliers List (IESL), as appropriate.

Execution of the Field Surveillance Plan will be initiated in FY14 with processing of a specified number of the field surveillance units along with processing of opportunistic SAVY and SNMC containers.

The core life extension capability is actually a year ahead of the surveillance efforts. Within FY13 the comprehensive Accelerated Aging Plan to determine service lifetime of O-rings was developed and initiated. The intent is to predict the O-ring service lifetime under expected operating conditions. As the O-ring is targeted as one of the LLCs of the design, a complete picture to understand O-ring degradation is underway through a series of experimental studies. These studies involve accelerated aging, elevated radiation dose absorbed, and potential oxidation effects at relatively low temperatures (e.g. 70^{o}C). The most extensive data collected to date is tied to accelerated aging studies. Oxygen consumption studies are planned to be initiated in FY14. Mechanical durability testing of the O-ring seal; as well as; environmental contaminants effects were also completed FY13.

As the Design Authority for the SAVY-4000 container design, LANL is responsible for the Surveillance Program and Life Extension Program. These programs are designed to ensure compliance with the Manual, and quality assurance program is in place to ensure that work activities meet the requirements of the SAR[4]. As the SAVY SAR, demonstrating compliance to the Manual, is anticipated for approval in March 2014; approval of LANL's methodology and approach for Surveillance and Life Extension efforts will also be formally approved by DOE. Data collected based on these methodologies will be submitted to DOE at the appropriate time to extend the SAVY design life for up to 40 years.

2. Surveillance Program

2.1. Baseline Data Collection for Surveillance

LANL has initiated and is progressing through the development of a database with relevant information about stored materials and containers, including material, packaging, and surveillance information for each storage container. An electronic database simplifies the scheduling of surveillance and repackaging of containers and evaluation of surveillance data.

Data Base development in FY13 identified the following objectives:

- Streamline surveillance processes
- Drastically reduce errors during data capture
- Improve efficiency of operations downstream

- Store data sufficient to demonstrate compliance with applicable requirements
- Provide reporting and analysis capability necessary to make improvements and adjustments to the surveillance and maintenance program

The database developed for Source Examinations and for Source Test Verifications for SAVY-4000 Containers includes modules for container-source test verification and receipt inspections. This initial set of data generated during production will form the baseline for validating container integrity under surveillance. The features include the following:

- Helium leak test
- Lid/filter Water Entry test
- Lid/filter efficiency
- Visual and Dye Penetrant Weld Inspection
- Critical Dimension Inspection
- Receipt visual inspection for damage and functionality.

A Surveillance and Maintenance Database has been progressing to provide reliable data capture for the nuclear-material container surveillance program. The database will document important information for trending studies to support program evaluation 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 and filters. The database will provide such information as well as information about the materials in these containers, so that a material causing potential problems to the inner container can be identified. The database will also be used to document the inspection/testing results from executing the surveillance plan and accelerated aging plan for lifetime extension studies.

As a subset of this activity, Table 2-1 reflects what has been developed in the MRP system to date to capture work flow and data as an electronic traveler for the Surveillance Program in processing containers. The traveler system details specific activities to be performed, departments, and what quality data is collected at each activity.

Table 2-1. MRP System Traveler for the SAVY Surveillance Program

Step	Department	Description	Quality Collected
10	**PROD ENGR**	Product Engineer Review and Approve Traveler	Z number, Procedure and Rev
20	**PROD CNTL**	Production Control Issue Material to Job	Z number, Procedure and Rev
30	**NCO-5**	Identify Surveillance Container and Verify Content	Container ID, Material Name, Weight (g), IDC, Inner Container Type, Outer Container Type, Bag out Bag present, Procedure and Rev, Z Number
40	**NCO-5**	Retrieve Container from Vault	Z number, Procedure and Rev
50	**NCO-5**	Remove Nuclear Material from Container	Material Name, Weight (g), IDC, Inner Container Type, Outer Container Type, Bag out Bag present, Procedure and Rev, Z Number
60	**NCO-5**	Compare Data	Z number, Discrepancies or No Discrepancies detected between data, Procedure and Rev
70	**NCO-5**	Survey Container for Contamination	Contamination Yes/No, Z Number, Procedure and Rev
80	**NCO-5**	Label Container	Container Labeled Yes/No, Z Number, Procedure and Rev
90	**NCO-5**	Provide Temporary Container for Nuclear Material	Container ID, Container/Material Location, Z Number, Procedure and Rev
100	**PROD CNTL**	WIP Component Issue of Temporary Container	Z number, Procedure and Rev
110	**NCO-5**	Transport to Room 6A	Z number, Procedure and Rev
120	**NCO-5**	Visual Examination of Container	Visual Inspection Pass/Fail, Z Number, Procedure and Rev
130	**NCO-5**	Helium Leak Test	**Leak Test Data:** Date Completed, Part Number, Body SN, Lid SN, Background Reading (atmcc/sec), Evacuation Pressure (torr), He Fill Pressure (torr), Test Time (min:sec), He Leak Rate (atmcc/sec), Leak Calibration Factor, Leak Test Pass/Fail, Z Number, Procedure and Rev **Leak Standard Data:** Item SN, Calibration Date, He Leak Rate(atmcc/sec)

Table 2-1. MRP System Traveler for the SAVY Surveillance Program

Step	Department	Description	Quality Collected
140	**NCO-5**	O-Ring Visual Inspection and Durometer Test	O-Ring Type (Hagan, SAVY, Replacement, etc.), Body SN, Lid SN, Defects Present Yes/No, Debris Present Yes/No, Visual Inspection Pass/Fail, Z Number, Procedure and Rev
150	**NCO-5**	Filter Testing	Filter Test Pass/Fail, Z Number, Procedure and Rev
160	**NCO-5**	Water Penetration Testing	Water Penetration Pass/Fail, Z Number, Procedure and Rev
170	**NCO-5**	Replace Temporary Container with Original Surveillance Container	Z number, Procedure and Rev
180	**PROD CNTL**	WIP Return of Temporary Container	Z number, Procedure and Rev
190	**NCO-5**	Return Container with Material to Vault for Storage	Z number, Procedure and Rev
200	**PROD ENGR**	Product Engineer Review	PE Review Pass/Fail, Z number, Procedure and Rev
210	**PROD CNTL**	Production Control Review	PC Review Pass/Fail, Z number, Procedure and Rev
220	**TRAINING**	Training Review	Training Review Pass/Fail, Z number, Procedure and Rev
230	**PROD CNTL**	Place Job in Complete Status	Z number, Procedure and Rev

2.2. Surveillance Approach

The approach to the design of the SAVY 4000 container is to have no maintenance program during the design life. The cost in terms of money and personnel dose is too high if in-service containers need to be retrieved from the vault and degraded components replaced on a regular basis. The five-year design life of the container includes every component; therefore no maintenance of containers while they are in service is required within the design lifetime. Furthermore, lifetime extension efforts will also apply to all components of the container, and no maintenance of in-service containers will be required during the extended lifetime.

Prior to each use, containers and O-rings are inspected. If defects are found with the container, it is removed from service and provided to the Surveillance Program for evaluation against inspection criteria identified in the SAR, Section 2.12. If defects are found in an O-ring, the O-ring is replaced and the defective O-ring is provided to the Surveillance Program for evaluation. Also, containers that are chosen under the surveillance program for O-ring destructive evaluation will have the O-ring replaced prior to return to service.

The goal is to have sufficient data from the surveillance and lifetime extension studies by the end of the first five years to be confident that the design criteria will be met by all components in order to extend the lifetime to a conservative value based on the data. At the end of a defensible in-service lifetime maintenance will be performed by replacing the container components determined to be at risk of not meeting the design criteria and re-qualified if needed.

2.3. Defining the Surveillance Program

With the intent to ensure that the SAVY-4000 containers function properly throughout their design life, of key interest was establishing a bounding case for worst case materials stored in containers and assess these containers over time. A Field shelf-life surveillance program was determined to be the most effective in meeting this goal. Such an approach coupled with a high confidence statistical sampling scheme formed the basis for the SAVY-4000 Field Surveillance Plan. This document was finalized 1st Quarter of FY13 and covers the specifics to be implemented for SAVY-4000 Surveillance activities over a five year period.

Worst case material parameters that are considered most challenging to the SAVY containment barrier over time were established in the Field Surveillance Plan. These parameters were determined to be gamma dose for the O-ring, high gamma dose and corrosive salt for the container body, and high gamma dose and the potential to generate corrosive gases for the filter. Materials with the highest dose were calculated across all item description codes (IDC) groups and the twelve IDC groups that encompassed the worst case conditions were identified. This same grouping captured salt-bearing residues as well which would be of most concern in terms of corrosion. The CEDE and the weight of the nuclear material are considered to be the most important factors affecting the integrity of the O-ring over time because they are likely to have the highest beta/gamma dose. The different material characteristics, including metal, oxide and residues, are expected to bound both the corrosive (high salt impurities such as R26, R42, etc.) properties and the thermal characteristics (high americium content such as R83) of the materials in storage. The criteria for selecting these particular containers were a combination of the following:

- Containers with the highest beta/gamma dose listed in the remarks data field are preferred
- Small containers are preferred because the distance from the material to the O-ring and filter is small, and likely to cause more damage relative to a larger container
- Logistic considerations such as accessibility, probability that it would be repackaged into SAVY 4000 container for programmatic reasons, e.g., a Hagan with an NCR needing repackaging is preferred
- In the case of Hagan containers, older containers were preferred for maximum impact to the Hagan containment boundary
- A suitable material that is already in a SAVY 4000 container is preferred because no repackaging is necessary resulting in reduced worker exposures and lower cost

Once these groups were identified, expert judgment was utilized to choose two containers from each of the 11 groups totaling 24 shelf-life SAVY surveillance containers to be evaluated over a five year period in storage. The total of 24 containers is also based on statistical considerations for detecting a trend. A schedule was devised over which of the 24 containers would be pulled over the five years for non-destructive evaluations (NDE) with a subset of NDE containers also undergoing destructive evaluations (DE). In addition to the 24 shelf-life containers, an items-of-opportunity sample will also be evaluated on both SAVY and Hagan containers to provide additional data within the overall container population. Hagans were considered worth evaluating sense they are both made of a Viton based material and should exhibit some similarities in aging; all Hagan containers pulled for evaluation will go through NDE and DE.

2.4. Implementing the Field Shelf-Life Surveillance Sample

The field shelf-life surveillance consists of DE and NDE of four containers packaged with worst-case materials per year. In addition four worst-case containers will have only NDE for 5 years. At that time a decision will be made as to continued NDE's observation or DE. Surveillance will continue after the field shelf-life surveillance.

All but one of the 24 shelf-life surveillance containers have been re-packaged as needed within this fiscal year based on the 1st choice container/material selections identified in the Field Surveillance Plan with a few substitutions. Specifically IDC M74 item 63NLBF was replaced with IDC M74 item HNN5502CP. In addition IDC M44 HGO7240CP was replaced with IDC M74 item PMP328CF and is the only item yet to be re-packaged in a SAVY to complete the 24 shelf-life containers. This item will be re-packaged as soon as practical within 2014. Detailed information on the shelf life items is provided in Table 2-2 below including material characterization, historical information on the Hagan requiring re-packaging and identification of the specific SAVY repackaged into with a sense of the packaging configuration. Some of the material selections had already been packaged in a SAVY so there is no associated Hagan in the table. Only external pewter shielding was allowed for the field shelf-life SAVYs; no internal pewter shielding was allowed in these containers to ensure maximum radiation field exposure of the container to contents. The field surveillance time clock actually began back in 2011 sense one container with worst case materials identified under field surveillance was first packaged at that time. The target schedule for the twenty-four containers under the Field Surveillance Plan will be initiated in 2014 and extend through 2018.

Table 2-2. Field Shelf Life Container Information

	Item Information						Hagan Information						Hagan Unpacking Information							SAVY Packaging Information					
	Item	DMT	IDC Short	IDC Short Desc	Project	Project Description	1st Packing Date	Hagan Category and Size	Calc. Dose (mr/hr)	B/G w/o shld (mr/hr)	~ Hagan Age in Years, From 1st Use Date to Unpacking Date	Surv. Year code	Hagan Filter Serial # (Manufacture Month and Year & LANL Sequential Unique Number)	Hagan Body Serial #	Internal Shield Present & type?	Hagan Condition	Bagout Bag Condition	Inner-Most Container	Last B/G @ contact w inner-most (mr/hr)	SAVY Lid Serial #	SAVY Body Serial #	1st Packing Date	Inner-Most Container	Is Shield present & type?	As packaged weight of New Container (g)
1	CAXBL128D	52	R83	PROCESS RESIDUE, MSE Salt	345	MATLS STAGING & DISPOSITION- NON-NS	7/7/2004	SNMC-2 3Q	2E+07	NA	8.55	LT	8/02 LANL-813	030142	no	good	discolored slightly	no entry	no entry	111103026L	111103026B	1/22/2013	stainless steel slip lid	Yes- External	nothing entered
2	GBS005	52	R65	PROCESS RESIDUE, ER Salt	345	MATLS STAGING & DISPOSITION- NON-NS	12/14/2004	SNMC-2 8Q	5E+07	160	8.23	3	4/02 A-28	04/02-08028	no	good	good	Paint Can	200.0	041208025L	041208025B	3/5/2013	Paint Can	Yes- External Pewter	15477.0
3	GBS059	52	R65	PROCESS RESIDUE, ER Salt	345	MATLS STAGING & DISPOSITION- NON-NS	12/14/2004	SNMC-2 8Q	5E+07	400	8.23	5	4/02 A-207	04/02-08010	no	good	good	Paint Can	370.0	041208004L	041208004B	3/5/2013	Paint Can	Yes-External Pewter	14827.0
4	INCA-20	54	R47	PROCESS RESIDUE, Incinerator Ash	345	MATLS STAGING & DISPOSITION- NON-NS	12/16/2004	SNMC-1 8Q	3E+07	500	7.93	4	4/99 LANL-429	05/99 NMC 08000-305	no	good	good	stainless steel slip lid	3000.0	041208043L	041208043B	3/26/2013	stainless steel slip lid	Yes- External Pewter	9875.0
5	INCA-21	54	R47	PROCESS RESIDUE, Incinerator Ash	345	MATLS STAGING & DISPOSITION- NON-NS	12/8/2004	SNMC-1 8Q	3E+07	NA	8.30	3	4/99 LANL-405	04/02-08145	no	good	good	stainless steel slip lid	1800.0	041208009L	041208009B	3/26/2013	stainless steel slip lid	Yes- External Pewter	10501.0
6	ORF633956XB LC	52	N50	NON-COMBUSTIBLE, MgO	345	MATLS STAGING & DISPOSITION- NON-NS	12/2/1999	SNMC-3 8Q	5E+06	NA	13.18	2	2/99 LANL-83	080208	no	good	* good. There is a 2nd bag over bagout bag	stainless steel slip lid	280.0	041208038L	041208038B	1/31/2013	stainless steel slip lid	Yes- External Pewter	12170.7
7	PCS68B1	52	R71	PROCESS RESIDUE, Salt	345	MATLS STAGING & DISPOSITION- NON-NS	4/7/2008	SNMC-2 8Q	2E+07	200	4.82	3	4/02 A-134	08/06-08077	no	good	good	Paint Can	no entry	041208028L	041208028B	1/31/2013	stainless steel slip lid	Yes- External Pewter	10614.9
8	PHX5R4	54	C80	COMPOUND, Tetrafluoride	345	MATLS STAGING & DISPOSITION- NON-NS	10/11/2006	SNMC-2 3Q	7E+06	N/A	6.46	2	8/05 LANL-2282	08/05-03282	no	good	nothing entered	no entry	no entry	121103052B	121103052B	3/25/2013	hermetically sealed - welded	no	3131.0
9	POX4275C1	52	R78	PROCESS RESIDUE, Sweepings/Screenings	345	MATLS STAGING & DISPOSITION- NON-NS	8/16/2005	SNMC-1 5Q	4E+07	250	7.56	4	7/02 LANL-393	06/02-05183	yes- lead	good	good	no entry	180.0	091205182L	091205182B	3/7/2013	stainless steel slip lid	Yes- External Pewter	6786.0
10	RBXS5657-1A	56	C21	COMPOUND, Dioxide	345	MATLS STAGING & DISPOSITION- NON-NS	4/14/2004	SNMC-2 5Q	3E+07	N/A	8.82	1	7/02 LANL-515	06/02-05305	no	good	discolored. Some black substance in can and on bag	stainless steel slip lid	700.0	041205026L	041205026B	2/5/2013	stainless steel slip lid	Yes- External Pewter	6883.1
11	SLTF3123A	52	R42	PROCESS RESIDUE, DOR Salt	345	MATLS STAGING & DISPOSITION- NON-NS	5/5/2005	SNMC-1 3Q	5E+07	200	7.84	3	8/99 LANL-1178	07/02-03184	yes- lead	good	good	no entry	150.0	121103062L	121103062B	3/7/2013	stainless steel slip lid	Yes- Exernal Pewter	6786.0
12	SWPVTB15	52	R71	PROCESS RESIDUE, Salt	345	MATLS STAGING & DISPOSITION- NON-NS	5/2/2007	Cert05-H3Q	2E+07	70	5.77	5	08/02 LANL-897	08/05-03300	no	good	good	stainless steel slip lid	70.0	111103001L	111103001B	2/5/2013	stainless steel slip lid	Yes- External Pewter	5016.5
13	VTB-16C1	52	R78	PROCESS RESIDUE, Sweepings/Screenings	345	MATLS STAGING & DISPOSITION- NON-NS	8/9/2005	SNMC-2 5Q	2E+07	NA	7.50	5	4/02 A-164	04/02-05164	yes- lead	good	good	stainless steel slip lid	280.0	021205029L	021205029B	2/5/2013	stainless steel slip lid	Yes- External Pewter	8195.8
14	XBLC9413	52	N50	NON-COMBUSTIBLE, MgO	345	MATLS STAGING & DISPOSITION- NON-NS	10/6/1999	SNMC-3 8Q	7E+06	2300	13.35	1	2/99 LANL-80	080207	yes- lead	good	nothing entered	stainless steel slip lid	220.0	none given	041208055B	2/5/2013	stainless steel slip lid	Yes- External Pewter	12349.0
15	XBLS25	56	R83	PROCESS RESIDUE, MSE Salt	345	MATLS STAGING & DISPOSITION- NON-NS	5/24/2005	SNMC-3 8Q	2E+07	850	7.84	4	10/99 LANL-1932	080234	no	good	good	Paint Can	1400.0	041208031L	041208031B	3/12/2013	Paint Can	Yes- External Pewter	12872.0
16	XBSOX153	52	R42	PROCESS RESIDUE, DOR Salt	345	MATLS STAGING & DISPOSITION- NON-NS	11/13/2006	SNMC-1 5Q	3E+07	NA	6.33	5	3/06 LANL-296	03/06-05296	no entry	good	good	no entry	no entry	091205175L	091205175B	3/12/2013	stainless steel slip lid	Yes- External Pewter	8652.0
17	HNN5502CP	52	M74	METAL, Alloyed Metal																		3/22/2012			
18	NAB183-2	52	M44	METAL, Unalloyed Metal	311	NEST- LANL			4E+07												121103013B	6/27/2012	food pack can		4940.0
19	PMP328CF	52	M44	METAL, Unalloyed Metal				Non-Standard																	
20	PHX3F	54	C80	COMPOUND, Tetrafluoride	345	MATLS STAGING & DISPOSITION- NON-NS	4/5/2014	SNMC-1 3Qt	2E+07	300	7.60										121103121B	4/3/2013			4701.4
21	CXLOX082911	52	C21	COMPOUND, Dioxide	362	PLUTONIUM SUSTAINMENT-LANL			8E+07												031105052B	1/18/2012	stainless steel slip lid	Yes- External Pewter	6735.0
22	PBO	54	C21	COMPOUND, Dioxide	650	MATERIAL IDENTIFICAITON AND SURVEILLANCE			1E+08											031105028B	031105028B	1/10/2012	stainless steel slip lid	Yes- lead lined & external pewter	
23	ROTRB9C2	52	R26	PROCESS RESIDUE, Filter Residue	345	MATLS STAGING & DISPOSITION- NON-NS			1E+07										100.0		031105010B	8/2/2011	stainless steel slip lid	Yes- lead lined & external pewter	8911.1
24	TKS1C1	52	R26	PROCESS RESIDUE, Filter Residue	345	MATLS STAGING & DISPOSITION- NON-NS			2E+07												031105059B	8/29/2011	stainless steel slip lid	Yes- External Pewter	8232.2

The established surveillance sampling frequencies of 5 years for SAVYs and SNMCs is as identified in Table 2-3. Time T0 marks the beginning of surveillance; as a few material contents chosen had all-ready been re-packaged into SAVYs (as early as August, 2011), time T0 will be initiated within the 2nd Quarter of calendar year 2014 to evaluate containers that have been in storage for at least one year. One additional item will be pulled at this time that has reached two years in storage. The other three to be pulled at two years are scheduled for 1st Quarter of 2015. This sampling schedule ensures availability of surveillance data within the initial SAVY design life of five years to support design life extension. For the out-years, the typical number of items in the surveillance sample including opportunistic is 32.

Table 2-3. Surveillance sample frequency summary table example

	T0*	**T1**	**T2**	**T3**	**T4**	**T5**
SAVY Field Shelf Life NDE	4	4	4	4	4	
SAVY Field Shelf Life DE	5	3	4	4	4	4
SAVY Opportunistic	12	12	12	12	12	
SNMC Opportunistic	12	12	12	12	12	
Total	**33**	**31**	**32**	**32**	**32**	**4**

2.5. Surveillance Non-destructive Evaluation Activities

Specific NDE evaluation techniques have been developed and revised as needed through the SAR comment/resolution process over the course of the fiscal year. The specific requirements in processing containers identified under surveillance are discussed in detail here.

2.5.1. Evaluation of the SAVY 4000 containers during unpacking

The following data collection and inspections requirements apply; as developed and finalized in the SAVY SAR, for initial evaluation of SAVYs pulled for Surveillance just prior to and during content removal. Some aspects of this initial evaluation are to ensure container integrity; but it is also an opportunity to validate SAR compliance with regard to internal packing configuration, authorized contents, and proper closure.

- Record mass data/process knowledge to provide content description/characterization and time in storage (since last closure). In the case of cumulative content storage, a history of stored contents over time should be provided.
- Radiography as a check to validate if a given material matrix has compromised the primary convenience can (as applicable depending on subject matter expert determination for specific high-risk contents).
- 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 (trends will be evaluated to see if there is an indication of moisture absorption or metal oxidation).

- 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 package according to procedures:
  - O-ring installed? (yes/no)
  - Inner container consistent with material form, e.g., stainless steel slip lid for oxide, hermetically sealed for metal, etc.? (yes/no)
  - Bag-out bag present? (yes/no)
  - Bag-out bag intact, e.g., contamination found outside bag out bag indicates breached bag? (yes/no)
  - Any liquid observed inside the bag-out bag? (yes/no)
  - Metal inner container intact (e.g., no holes corroding through, no plutonium in contact with bag out bag, etc.) (yes/no)

2.5.2. Evaluation of empty SAVY 4000 containers

Once contents are removed, additional inspection requirements have been developed and apply as follows:

NOTE: The only solvent allowed for cleaning all components of the container is isopropyl alcohol.

- Do the interior and/or exterior surfaces of the container show any signs of corrosion or discoloration? This could indicate a reduction in service lifetime due to degradation of the containment boundary. The presence of any surface corrosion on any component shall be cause for further inspection. If the rust can be easily wiped off, no pitting is apparent beneath it, the component is acceptable. If the rust/corrosion appears to have compromised the structural integrity of the component, then the component shall be rejected.
- 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, i.e., scratches, burr, etc.? (yes/no)
- Does additional non-destructive testing of containment barrier welds (as deemed necessary by a subject matter expert) show any positive indication of weld cracking or other weld flaws? (yes/no)

2.5.3. Evaluation of the O-Ring

The one of a kind helium leak test system to evaluate container containment to established criteria has gone through various phases of design development from a conceptual to a finalized design as a compact semi-automated system for use in the surveillance program. The unit is now installed at TA-55 and ready and awaiting final Pressure Safety Officer (PSO) approval for use. A durometer to evaluate Shore M hardness and visual inspection equipment to support O-rings inspections is also in place. The containers/O-rings will have the following visual and performance based tests to confirm integrity:

- 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)
- Helium leak testing shall be in accordance with ANSI N14.5. The test pass rate shall be equal to the design release rate established as 5.6 x 10-6 cm3s-1 of fluid. The testing helium leak rate criterion is 1.0 x 10-5 atm cm3 s-1 at a differential pressure of 10 kPa. All helium leak testing shall be performed by a Level II, or higher, helium leak-test technician certified according to ASNT SNT-TC-1A. The helium leak testing shall be conducted in accordance with qualified procedures that meet the requirements of ASTM E 493-06, Standard Methods for Leaks Using the Mass Spectrometer Leak Detector in the Inside-Out Mode, and shall be approved by a Level III per SNT-TC-1A.
- The Shore M hardness will be measured and evaluated using Parker O-ring manufacturer recommended tolerances.

2.5.4. Evaluation of Filter

The one of a kind low volumetric flow filter test system to evaluate filter efficiency and pressure drop across the filter, has gone through various phases of design development from conceptual to a bench design for proof of concept then a finalized design as a compact semi-automated system within FY13 for use in the surveillance program. Details of the integrated filter test system design, specifications, and system operation are provided in *Filter Measurement System for Nuclear Material Storage Containers*[5] Annual Report for FY13. The unit is now installed at TA-55 and ready for use. The filters will have the following visual and performance based tests to confirm integrity:

- Based on visual inspection of the outside of the lid, does the area around the filter show indications of particulate escape? (Particulates could indicate that the filter is compromised.) (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/min
  - % penetration (<0.03%)
  - Pressure drop across the filter (<1 inch water column)
- Does the filter pass the water penetration test (yes/no, at 12 inches water column pressure on the outside of the lid, pass=no visual indication of water penetration on the inside of the lid for at least 60 seconds)?

2.6. Surveillance Destructive Evaluation Activities

In addition to the NDEs, which will be performed on all surveillance containers as noted above, detailed (destructive) evaluations of O-rings have been developed and finalized in the SAVY SAR to be performed on the field surveillance sample and possibly on items-of-opportunity requiring replacement of the O-ring. These data will be used to supplement ongoing accelerated aging studies. Destructive evaluation (DE) tests for the SAVY and Hagan O-rings will consist of mechanical testing, thermal properties testing, and spectroscopic measurements. Because the Hagan and SAVY 4000 O-rings are both made of Viton, they are likely to exhibit similarities in their aging behavior.

The necessary capability and M&TE required to support DE to the extent required under Surveillance are developed and in place. The mechanical testing measurements will potentially comprise Shore M hardness, compression stress relaxometry, compression set, and tensile testing. The thermal testing will consist of either Differential Scanning Calorimetry (DSC) or Thermogravimetric Analysis (TGA). Fourier Transform Infrared (FTIR) spectroscopic measurements will be used along with other techniques that provide chemical characterization of material changes. Combining these three approaches permits a more complete evaluation of the aging characteristics of the O-rings.

2.7. Surveillance Procedure Development & Documentation

The testing and measurements to be performed under the Surveillance Program will be accomplished through the use of Detailed Operating Procedures for activities within TA-55. All NDE type evaluations required per the Field Surveillance Plan will take place within TA-55 and include helium leak testing, filter testing, and O-ring visual inspection and Durometer measurements. Other aspects of Surveillance activities involving DE are of the O-ring only and will take place at the TFF. DE of O-ring samples will be carried out by subject matter experts in a research environment that typically does not use Detailed Operating Procedures. However, we still want to assure some level of consistency in procedures across the project, and this desire becomes particularly important in these surveillance measurements which may continue across decades. TFF has therefore developed a series of procedure guidelines for each measurement to be performed that are intended to be living documents. The guidelines will be maintained in MST-7 and can be rapidly modified as necessary. Although not in a formal document management system, the changes in the procedures will be tracked and archived in the project's files. Table 2-4 lists the DOPs for TA-55 and the Procedure Guidelines for TFF and their current status.

Table 2-4. Detailed Operating Procedures and Guidelines for Surveillance

DOP/Guideline	Status	Revision
Sample Preparation	Complete	0
Compression Set	Complete	0
CSR	Complete	0
FTIR	Complete	0
Helium Leak Test – PA-DOP-01143, R0	Finalized and in Review	0
Filter Test	Finalized and in Review	0
O-ring visual/durometer PA-DOP-01080, R0	Finalized and in Review	0

2.8. Laboratory Space Dedicated to Surveillance

Considering the scope and longevity of the Surveillance Program, TA-55 facility management has designated a laboratory (PF-4, 6a) that will be dedicated to NDE of field shelf life SAVYs and opportunistic Hagan or SAVY containers. This laboratory will be used for helium leak testing, filter testing, visual examinations, durometer measurements and controlled storage of items in process. The laboratory space is undergoing a final upgrade to install a new regulator and safety relief valve in line with the helium bottle which then provides the helium supply to the leak test system. The modifications required for rm. 6a have gone through the ESR process and the project has now been released for construction with anticipated completion 2nd Quarter 2014.

3. Design Life Extension Program FY13 Efforts

3.1. Life Extension Approach

The Accelerated Aging Plan completed in FY13 detailed the approach and rationale behind the ongoing life extension studies. These studies now underway subject O-ring specimens to elevated temperatures, radiation doses or oxidation then detail mechanical and spectroscopic response of the materials.

Mechanical tests have proven to be a reliable predictor of material performance, but the onset of degradation mechanisms is difficult to detect through mechanical testing alone. In addition, mechanical testing does not reveal the nature of degradation mechanisms nor allow energetic analysis of the degradation. However, spectroscopic and thermal testing are much more sensitive to small changes in a material. Unfortunately, linking spectroscopic data to a degradation mechanism is not always straightforward. Therefore, in establishing a sound methodology in predicting O-ring failure, spectroscopic and thermal measurements is being performed concurrently with mechanical testing so that spectroscopic signatures and the associated degradation mechanisms can be directly linked to mechanical deformation.

Leak rate, a phenomenon that requires some time and specialized equipment to measure, is related to the age of the O-ring in use. More specifically, we will determine how the leak rate, or the probability of leaking, increases with respect to other more easily measured mechanical or spectroscopic properties. Once the material has deformed, it will not push back against the faces of the lid and the collar, and may not provide the required seal. Knowing the rate of deformation will help predict the lifetime of the O-ring.

In summary, by taking into account the viscous flow of the material under stress, the concentration of agents in the O-ring that may be consumed over the course of its lifetime, the reaction rates of the dominant aging processes, and the relationship between chemical transformation and changes in mechanical properties, we will be able to give a justifiable lifetime for the O-ring under the specified conditions of use

Ultimately, the O-ring lifetime in the SAVY 4000 unit will be determined by changes in mechanical properties that lead to the failure of the O-ring in the leak test of a SAVY 4000 unit

3.2. Defining the Life Extension Program

With development and approval of the methodologies presented in the Accelerated Aging Plan during FY13, a specific battery of tests have been lined up to establish the relationship between sealing force and leak rate, the viscous flow of V0896-50 formulation, and the rate of chemical change. Accelerated aging studies ranging up to a three year period induce reduced sealing force at different rates based on various temperatures 70oC, 120oC, 160oC and 210oC; the compression set and compression stress relaxometry and durometer data collected from samples or assembled units will work together to establish a relationship between O-ring deformation with increasing leak rate. Spectroscopic analysis of samples is also conducted so that microscopic changes in the molecular structure can be correlated to macroscopic changes in physical properties. This effort will result in a life time prediction at maximum operating temperature through time temperature superposition. Radiation effects are addressed by subjecting the Viton based O-rings to a range of radiation doses, from 200 to 5×10^8 rads; employing a wide range of doses will all construction of dose response curves for various mechanical and spectroscopic properties for lifetime estimation and estimating the radiation dose to which a particular O-ring has been exposed. Oxygen consumption testing is capable of detecting the dominant mechanism by which the material ages at changes with temperature and with oxygen consumption the activation energy of rate-limiting reactions can be determined. Oxygen consumption studies for all accelerated aging conditions are performed to confirm O-ring lifetime predictions or adjust predictions as necessary. Synergistic effects of radiation with temperature, compression, low pH or all four are tested. Selecting a few test conditions that span the entire parametric space defined by the O-ring environmental conditions will allow for finding the combinations that synergize the most.

3.3. Life Time Extension Progress and Results

Under compression at an elevated temperature and exposed to radiation, many chemical and physical changes are anticipated to take place in the O-ring over the course of years in service. A baseline characterization study of the Parker Inc. V0896-50 O-ring compound was completed to determine basic composition and provide an accurate description of the material in pristine condition; assignments have been made to identify the chemical significance of the various regions of the spectra. This has involved infrared spectroscopy, elemental analysis and electron paramagnetic resonance spectroscopy.

Ongoing accelerated aging studies were initiated in FY13 at temperatures of 70^oC, 90^oC, 120^oC and 160^oC for periods of time of up to 1000 hours. Compression set and compression-stress relaxation data was collected at appropriate intervals and also IR spectra of some compression set samples after aging. Durometer measurements were taken of samples before and after aging.

The initial studies are showing a small amount of aging, which is difficult to interpret. The Compression Set study shows an increase in set over time, but with no definite dependence on temperature. The accelerated aging samples undergoing compression set were also analyzed by durometer and infrared spectroscopy. There is no change in durometer value or any clear change in any IR absorption during aging so far. The compression set relaxometry study shows a decrease in sealing force over time to date, but no consistent relationship to temperature is yet identifiable.

In can studies of O-rings assembled in 1 Qt SAVY containers then subjected to accelerated aging, even at 210^oC after a few months, have not shown any signs of leakage; as they are pulled and leak tested at given intervals.

FY13 Mid-Year Report *SAVY-4000 O-Ring Performance Studies*[6], primarily details the equipment, procedures, dedicated space, and documentation requirements to implement the elastomer life extension work; as well as, details of the durability studies and results.

Durability studies of the O-ring involved systematically opening and closing four SAVY containers 100 times while performing helium leak testing periodically. Given the typical usage condition of nuclear material storage containers at LANL, it seems highly unlikely that any container will be opened more than 100 times. The durability tests show that the seal is not significantly degraded after repeated opening and closing of the can, regardless of degree of compression, within specified O-ring grove tolerances, the O-ring experiences in the container.

Detailed analysis and results concerning life extension work are provided in the FY13 Annual Report *Progress on the Savy-4000 O-Ring Certification and Lifetime Extension Program*[7].

4. References

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