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Surveillance Report on SAVY-4000 and Hagan Nuclear Material Storage Containers for FY 2017

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Executive Summary

In accordance with the SAVY-4000 Surveillance Plan [1] and DOE M441.1-1 requirements, storage container surveillance continued through fiscal year 2017 at Los Alamos National Laboratory. Surveillance items for the year consisted of 8 SAVY-4000 storage containers, 8 Hagan containers, and 39 SAVY-4000 transfer containers. The SAVY-4000 surveillance items ranged in age from 1 year to 5.6 years and the Hagan containers ranged in age from 6.3 years to 17.6 years. The surveillance containers for this year were selected primarily to better understand the extent of corrosion of the stainless steel components of the containers. Accelerated aging studies indicate that the O-ring and filter components of the SAVY-4000 will last at least 40 years under LANL storage conditions. However, the observation of corrosion on the inside of SAVY-4000 and Hagan surveillance containers has shifted the emphasis to understanding both the nature and the extent of corrosion on the stainless steel body. The restriction on handling soluble residues greater than 500 grams continued this year, delaying the surveillance of some items that was scheduled in earlier surveillance plans.

A high-level summary of the surveillance results for this year follows:

- **Container Integrity**— Visual inspections were completed on 8 SAVY-4000 containers with 4 being found to have corrosion exclusively on the inside of the containers. The corrosion was judged to be unlikely to compromise the container integrity, and these SAVY-4000 containers were returned to service with the same content for continued annual surveillance. Three Hagan containers were found with corrosion (exclusively on the inside) out of a total of 8 surveilled.
- **O-rings**—Two SAVY-4000 O-rings were found with small flaws (likely manufacturing defects), but they were not substantial enough to compromise the O-ring seal as determined by helium leak testing. One Hagan O-ring failed visual inspection due to an impression that was believed to be caused by the O-ring not being seated properly in the O-ring groove, most likely at the time of packaging. The resulting “pinch” in the O-ring caused a failure of the helium leak test. All other SAVY-4000 and Hagan O-rings met the helium leak test criteria, visual inspection criteria, and durometer specifications.
- **Filters—**No issues were found with either Hagan or SAVY-4000 filters. Both the SAVY-4000 and Hagan containers met the test criteria for capture and pressure drop. A water penetration test capability was introduced into the

surveillance testing protocol this year, and all SAVY-4000 containers that were tested passed the water ingress criterion. SAVY-4000s were the only containers tested in this year's surveillance activities due to a concern that the filter membrane could degrade with exposure to high wattage and gamma radiation.

This report builds on the previous surveillance work performed, which can be found in "Surveillance Report of SAVY-4000 and Hagan Nuclear Material Containers for FY2016" [2].

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1 Introduction

Approximately 600 SAVY-4000 containers are in use at Los Alamos National Laboratory (LANL), and although Hagan containers are being phased out, there are still ~3000 loaded Hagan containers in storage. The initial design lifetime for a SAVY-4000 container is 5 years, starting in April 2014. The lifetime extension program was initiated to determine how long a SAVY-4000 container may be used safely, potentially extending the design lifetime of the containers and avoiding unnecessary maintenance, replacement of containers or components, and handling of radioactive materials. The surveillance program was initiated to observe SAVY-4000 and Hagan containers during usage, and information from both surveillance and lifetime extension programs is integrated to build a comprehensive picture of the behavior of storage containers over time. At LANL, SAVY-4000 containers are designated as either storage containers or transfer containers as defined in TA55-DOP-091, "Nuclear Material Packaging." The primary difference is that storage containers are designed to function without maintenance over their entire design life, and transfer containers have a design life limited to 1 year and require an annual maintenance cycle to re-certify.

This work was performed for the surveillance program in accordance with the surveillance plan, "SAVY-4000 Field Surveillance Plan Update for 2017" [1]. The purpose of the surveillance plan and surveillance activities is to perform the following:

- Ensure that the containers currently in service are functioning properly
- Identify any unexpected problems in the containers or components
- Evaluate container component degradation over time against initial baseline measurements
- Contribute to the lifetime extension studies with the goal of accumulating enough data within the initial 5-year design lifetime to extend the service lifetime of the SAVY-4000 container

Containers with contents that represent upper bounding conditions have been selected for surveillance, as detailed in the surveillance plan [1]. This report includes surveillance testing results gathered over 1 year on a total of 47 SAVY-4000 containers (8 storage containers, and 39 transfer containers) and 8 Hagan containers.

2 Experimental

This section describes the experimental tests on the SAVY-4000 storage and transfer containers and the Hagan containers, along with their respective O-rings and filters.

2.1 Inspection

2.1.1 Container

Inspection of the containers begins during unpacking and includes checking for external corrosion, evidence of pressurization, and dents or gouges that may have occurred during handling. The container is weighed, and a contamination survey is conducted before the container is opened. When the container is opened, the bag-out bag is inspected for signs of compromised integrity such as discoloration, brittleness, or the presence of liquid and the interior of the outer container is surveyed for contamination. The type of inner container is checked for appropriateness to the material form, and it is checked for significant corrosion or the presence of liquid. The visual inspection continues when the outer container is emptied and then released to the package-engineering team for further evaluation. The empty container is then checked for proper function of the closure mechanism, damage to the O-ring groove in the lid or on the body collar's sealing surface, filter discolorations or occlusions, and evidence of corrosion. If deemed necessary by a subject matter expert, the weld at the collar-body interface may be tested as well, but no welds were tested during the past years. The age of the container was calculated as the time between the initial packaging and the date of the surveillance measurements.

2.1.2 O-ring

Visual inspection of each O-ring was conducted according to PA-DOP-01080, "Surveillance Inspections of O-Rings for Nuclear Material Storage Containers," using a 4-inch, illuminated magnifying lens to look for O-ring defects such as flashing; mold mismatch; damage to the O-ring, such as cuts or abrasions; and the presence of dirt, hair, or dust on the O-ring. Irregularities were noted on the inspection sheet and corrected by cleaning, if possible.

2.2 Tests

2.2.1 Helium Leak Rate

The leak rate for each SAVY-4000 container with its original O-ring installed was measured in the inside-out mode using a LACO Flexstation™ bell-jar helium mass-spectroscopy leak tester according to the procedure in PA-DOP-01143, "Helium Leak Test Procedure of the SAVY-4000." The leak tester detects the presence of a leak by analyzing for helium leakage into a bell jar held near vacuum when the container is charged with 75 torr of helium.

The O-ring passes the leak test if the measured leak rate is below a threshold value of 1×10^{-5} atm cc s^{-1}. That threshold value was determined for leak rate testing of SAVY-4000 container O-rings in Section 5.2 of the SAVY-4000 safety analysis report [3].

A single-point calibration is done before the measurements are taken each day. During FY17, the calibration standard used had a value of 1.05×10^{-7} atm. cc/s. This value is low enough to ensure that a leak at the threshold value will register on the leak detector, but it is high enough to be distinguishable from the typical background leakage rate.

The sensitivity of the measurement is limited by the quantity of helium in the ambient atmosphere, which can come from helium diffusing out of porous parts in the leak tester from prior tests. This helium contributes to an apparent background leakage rate. A background measurement was taken before each measurement.

2.2.2 O-ring Hardness

The hardness of each O-ring was measured by durometer, according to PA-DOP-01080, "Surveillance Inspections of O-Rings for Nuclear Material Storage Containers," on the Shore-M scale. The hardness value for each O-ring was taken as the average of five durometer measurements taken at arbitrary positions around the whole O-ring. The calibration of the durometer is checked before and after each day of surveillance testing, using known calibration hardness standards.

2.2.3 O-ring Compression Set

The compression set of the O-rings used in the storage containers was estimated from a measurement of the O-ring thickness several weeks after they were removed from their containers as part of the SAVY-4000 surveillance program. The initial thickness of the O-rings was 5.333-±0.045 mm, derived from the average of 85 unused O-rings, measured three times each. The compressed thickness was taken to be the gland depth of the container, which was determined by finding the best value for the difference between the lid diameter and the collar diameter, measured as part of the inspection process. If measurements were unavailable, the mean value for that particular size of container was taken from those surveyed in the receipt inspections. The final thickness measurement was taken by suspending the O-ring within the beam of a laser micrometer and averaging eight measurements at arbitrary positions around the O-ring. The uncertainty σ varied with the precision of the values available for each calculation, but generally was in the range of 5%–8%.

2.2.4 Filter Efficiency

Each filter was subjected to particle penetration testing, in which the concentration of a test aerosol is measured downstream of the filter per PA-DOP-01580. The test aerosol used was polyaphla-olefin with a concentration of 65-±15 µg/L upstream of the filter. The concentration was measured using an Air Techniques International (ATI) 2H photometer, which was modified by ATI for the test flow rate of 200 cc/min. The filters must capture at least 99.97% of the challenge aerosol. The development of this instrument and calibration information is discussed in LA-UR-16-20507, "Development and Use of a Low-Flow Filter Test System for the Filters Used in Special Nuclear Material Storage Containers".

2.2.5 Filter Pressure Drop

Each filter was subjected to pressure drop testing per PA-DOP-01580. The pressure drop tests were performed in conjunction with the aerosol tests. After the upstream aerosol concentration is measured, the instrument is switched to measure the concentration downstream of the filter, where the data system records 15 pressure drop data values in 1-second intervals. The first two data points are discarded because there is an interval with a momentary spike in the system pressure. The pressure drop must be <1 inch water column at a flow rate of 200 cc/min to be considered passing.

2.2.6 Water Penetration Testing

A selection of SAVY-4000 containers underwent water penetration testing using PA-DOP-01768, “Surveillance Inspections of Filter Water Resistance”. The water penetration testing is a new capability added this year. A pressure of water at 12” water column was applied to the filter on the outside of the lid and the pressure was held for 1 minute. The opposite side of the filter was monitored during the 1-minute interval to check for any water penetration. If no penetration was observed, the filter was considered to have passed the test. This test is comparable to the water penetration test performed at the time of container manufacture. SAVY-4000s were the only containers tested in this year’s surveillance activities due to a concern that the filter membrane could degrade with exposure to high wattage and gamma radiation.

3 Materials and Containers

For FY2017 surveillance, the selection criteria were updated based on the corrosion identified in previous years. Containers were selected based on the material form (e.g., suspected to have $PuCl_3$), wattage (e.g., high Am), container size (e.g., ≤5 Qt) and the age (e.g., as old as possible) of the containers. The history of the material form was also considered, e.g., items were included which had previously been found to cause corrosion. The 2017 surveillance plan also added Hagan containers. These containers were added to due to the age of the containers, the similar material of construction (304L for Hagan, 316L for SAVY-4000), and the fact that the containers are still in storage and likely will be for at least a decade. The 316L components of the SAVY-4000 containers are expected to be more corrosions resistant than 304L components of the Hagan containers.

The items that were stored in Hagan containers retrieved this year were repackaged into SAVY-4000 containers. The items that have corroded Hagan containers and are now in SAVY-4000’s will be surveilled in the future. The timing of this surveillance will be based on observations of similar items pulled for surveillance.

Table 1 provides a roadmap of all the containers tested. Were available, the SAVY-4000 container number that Hagan material was transferred into is included. Also included in the table are the container ages and the thermal power. The plutonium mass ranges from 4 g to 786.9 g. The physical and chemical forms cover a broad range, including compounds (Pu dioxide and Pu chloride), metals (unalloyed Pu metal, and process residues (filter residue, direct oxide reduction [DOR] salt, incinerator ash, ER salt, and molten salt extraction [MSE] salt). The isotopics of the materials range from weapons

grade Pu (MT 52) to fuel grade Pu (MT 54-57), high americium items (MT 5X+44, MSE salts), and heat source Pu (MT 83). The thermal power ranges from 0 W to 19.7 W. The age (time in service) of the Hagan containers ranges from 6.3 to 17.6 years, and the age of the SAVY-4000 containers ranges from 1 to 5.6 years.

Table 1. Roadmap for the Hagan and SAVY-4000 surveillance containers and their contents. Includes all surveillance data.

Surv #	FY	Chemical Subform	Material Type	Material Name	Hagan SN	SAVY SN	Pu-239 (g)	Container Age (y)	Thermal Power (W)
13H1	2013	MSE Salt	52+44	CAXBL128D	8/02 LANL-813, 30142	111103026	835	8.55	13.4
13H2	2013	ER Salt	52	GBS005	4/02 A-28, 04/02-08028	041208025	1875	8.22	4.9
13H3	2013	ER Salt	52	GBS059	4/02 A-207, 04/02-08010	041208004	1877	8.22	4.9
13H4	2013	Incinerator Ash	54	INCA-20	4/99 LANL-429, 05/99 NMC 08000-305	041208043	830	7.93	3.4
13H5	2013	Incinerator Ash	54	INCA-21	4/99 LANL-405, 04/02-08145	041208009	913	8.3	3.8
13H6	2013	MgO	52	ORF633956 XBLC	2/99 LANL-83, 80208	041208038	248	13.17	0.7
13H7	2013	Salt	52	PCS68B1	4/02 A-134, 08/06-08077	041208028	811	4.82	2.1
13H8	2013	Tetra-fluoride	54	PHX5R4	8/05 LANL-2282, 08/05-03282	121103052	166	6.45	0.7
13H9	2013	Sweepings/ Screenings	52	POX4275C1	7/02 LANL-393, 06/02-05183	091205182	1037	7.56	2.73
13H10	2013	Dioxide	56	RBXS5657-1A	7/02 LANL-515, 06/02-05305	041205026	751	8.81	3.8
13H11	2013	DOR Salt	52	SLTF3123A	8/99 LANL-1178, 07/02-03184	121103062	1900	7.84	5
13H12	2013	Salt	52	SWPVTB15	08/02 LANL-897, 08/05-03300	111103001	678	5.77	1.8
13H13	2013	Sweepings/ Screenings	52	VTB-16C1	4/02 A-164, 04/02-05164	021205029	1013	7.49	2.7
13H14	2013	MgO	52	XBLC9413	2/99 LANL-80, 80207	041208055	356	13.34	0.9
13H15	2013	MSE Salt	56+44	XBLS25	10/99 LANL-1932, 80234	041208031	430	7.84	12.4
13H16	2013	DOR Salt	52	XBSOX153	3/06 LANL-296, 03/06-05296	091205175	1079	6.33	2.84
15H1	2015	Dioxide	52	MOX51T	8/99-LANL-1277, 06/02-05305	121103054	2355.6	14.43	6.2
15H2	2015	ER Salt	52	XBS9455	5/01-LANL-53, 08/99NMC03-000-125	121103078	382.5	12.36	1
15H3	2015	Dioxide	57	BLO-39-11-16	3/01-LANL-209,	111308080	544	5.62	5

15H4	2015	Dioxide	56	RBXS5657-2A	LANL-441, 04/02-08049	081305197	2059	11.48	10.5
16H1	2016	Dioxide	54+44	XBPS333	U/A	N/A	80	8.1	2.9
17H1	2017	Chloride	52	ATLAMS1S1	07/02-03259 8/02 LANL-1014	N/A	75	11.10	0.2
17H2	2017	Chloride	52	CASLT966	0702-03261 LANL1061	N/A	286	12.02	0.6
17H3	2017	Filter Residue	52	CXLRES091599	05/99-NMC05-000-079, LANL-45	N/A	75	17.58	0.4
17H4	2017	Incinerator Ash	52	ASHX09	05/99-NMC03-000-192, LANL-1344	N/A	4	16.16	0
17H5	2017	Dioxide	83	10/10-01076 (Pu238)	10/10-01076 10-10 LANL-418	N/A	(blank)	6.27	19.7
17H6	2017	ER Salt	52	XORER6SLT2	0402-08245 A245	N/A	457	11.63	1.2
17H7	2017	MSE Salt	56	XBLS8A	0805/03142 LANL2139	N/A	114	10.67	3.5
17H8	2017	MSE Salt	52	XBSOX448A	08/06-01050 06/00 LANL-98	N/A	56	17.41	0.9
15S1	2015	Dioxide	52	CXLOX082911	N/A	031105052	786.9	3.03	2.07
15S2	2015	MSE Salt	52+44	XBLSCL1217	N/A	121103083	178.5	1.86	2.85
15S3	2015	Unalloyed Metal	53	XAP6	N/A	031105002	69.5	3.01	0.21
15S4	2015	Filter Residue	52	ROTRBJ-1C1	N/A	031105051	452	3.46	1.19
15S5	2015	MgO	52	XBLC9413	2/99 LANL-80, 80207	041208055	913	1.96	2.4
15S6	2015	Tetra-fluoride	54	PHX3F	N/A	121103121	479.2	1.8	1.98
15S7	2015	Tetra-fluoride	54	PHX5R4	N/A	121103052	166	2.37	0.7
15S8	2015	MSE Salt	56+44	XBLS25	10/99 LANL-1932, 80234	041208031	430	2.55	12.4
15S9	2015	Dioxide	54	PBO	N/A	031105028	1330.8	3.57	5.5
15S10	2015	Dioxide	56	RBXS5657-1A	7/02 LANL-515, 06/02-05305	041205026	751	2.65	3.8
16S1	2016	Non-Actinide Metal	53	SCRES65B	N/A	031105064	718	4.18	2.2
16S2	2016	DOR Salt	52	SLT1303	N/A	041208034	391.9	3.08	1
16S3	2016	Unalloyed Metal	52	PMP91308	N/A	111308040	3220.6	0.84	8.5
16S4	2016	MSE Salt	52+44	XBLSCL1120A	N/A	121103041	155.1	3.22	2.5

16S5	2016	Filter Residue	52	ROTRB9C3	N/A	031105039	500	4.87	1.3
16S6	2016	MSE Salt	52+44	XBLSCL1213	N/A	021205021	377.03	3.24	6.03
16S7	2016	Unalloyed Metal	52	ARIAAQ137	N/A	091205173	2456.68	3.32	6.5
16S8	2016	Dioxide	52+83	AAP02OX	N/A	041208057	509.4	3.4	21.28
16S9	2016	MSE Salt	52+44	XBLSCL1302	N/A	121103057	199.32	3.4	3.2
16S10	2016	MSE Salt	52+44	XBLSCL1301	N/A	121103044	192.6	3.4	3.1
16S11	2016	Dioxide	52	CXLOX082911	N/A	031105052	786.9	4.14	2.07
16S12	2016	Unalloyed Metal	53	XAP6	N/A	031105002	69.5	4.12	0.21
16S13	2016	Filter Residue	52	ROTRBJ-1C1	N/A	031105051	452	4.58	1.19
16S14	2016	MSE Salt	52+44	XBLSCL1217	N/A	121103083	178.5	2.96	2.85
16S15	2016	Dioxide	83	GPHS	N/A	071201061	120	2.76	60.49
17S1	2017	Dioxide	57	BLO-39-11-16	N/A	111308080	544	1.61	5
17S2	2017	Dioxide	52	CXLOX082911	N/A	031105052	786.9	5.16	2.07
17S3	2017	Unalloyed Metal	53	XAP6	N/A	031105002	69.5	5.15	0.21
17S4	2017	Filter Residue	52	ROTRBJ-1C1	N/A	031105051	452	5.59	1.19
17S5	2017	MSE Salt	52+44	XBLSCL1217	N/A	121103083	178.5	3.98	2.895
17S6	2017	DOR Salt	52	SLT1303	N/A	111308050	391.9	1.03	1
17S7	2017	Incinerator Ash	52+54	INC20602	N/A	111103020	31	4.67	0.1
17S8	2017	Unalloyed Metal	53	XAP6 (outer)	N/A	111308059	69.5	1.02	0.21

The 39 SAVY-4000 transfer containers were tested after approximately 1 year in service, and the serial numbers and maintenance dates are listed in Table 2. The time in service of the rest of the containers at the time of analysis varied from 0.8 to 2.4 years. Some of the containers are on the second or third maintenance cycle this year. Due to the way transfer containers are utilized, information about contents, dates of packaging, etc., is not recorded. For sample number 14T and 15T, the original entry in the database had a matching lid and body but at some point, the lid was exchanged with another SAVY-4000. The container was maintained twice this year due to the container being dropped after the first maintenance cycle. The second set of testing was performed to ensure that the drop did not affect the performance of the container. The container was pulled from service due to the size of the dent in the body of the container. The dropped container did still pass all performance criteria.

Table 2. Transfer containers tested in FY17.

Transfer Container Sample Number	Descriptive Identifier (if special condition found)	SAVY-4000 Serial Number	Date of Transfer Container Creation	Date of Maintenance	Age at Maintenance (years)
23T	SAI	011305020B/L			
24T	SAI	081305070B/L			
25T	Heat source	031403004B/L	1/29/16	6/27/17	1.5
26T	Heat source	031403009 B/L	1/29/16	6/27/17	1.5
27T	N/A	031403069 B/L	1/29/16	6/27/17	1.5
28T	N/A	031403088 B/L	12/4/15	12/7/16	1
29T	Heat source	031403108 B/L	1/29/16	6/27/17	1.5
30T	N/A	031403136 B/L	N/A	N/A	N/A
31T	N/A	031403160 B/L	6/16/15	12/7/16	1.5
32T	N/A	071201062 B/L	3/25/15	10/11/16	1.5
33T	N/A	071201071 B/L	11/6/15	1/19/17	1.2
34T	N/A	071201091 B/L	6/8/15	1/19/17	1.5
35T	N/A	071201108 B/L	9/30/15	1/19/17	1.3
36T	N/A	071201122B 071201048L	6/8/15	4/19/17	0.8
37T	N/A	071201122B 071201048L	6/8/15	4/18/17	1.8
38T	N/A	071201145 B/L	3/13/15	10/11/16	1.6
39T	Corroded not returning	071201164 B/L	8/25/15	4/18/17	1.7
40T	N/A	081301141 B/L	3/5/15	4/18/17	1.9
41T	N/A	081301145 B/L	8/5/14	10/11/16	2.2
42T	N/A	091205176 B/L	6/20/16	4/18/17	0.8
43T	N/A	121101053 B/L	9/30/15	4/18/17	1.6
44T	N/A	121101058 B/L	11/4/15	12/22/16	1.1
45T	N/A	121101071 B/L	11/4/15	8/22/17	1.8
46T	N/A	121103071 B/L	6/25/15	12/7/16	1.5
47T	N/A	121103094 B/L	6/16/15	4/18/17	1.8
48T	N/A	121103105 B/L	12/18/14	10/11/16	1.8
49T	N/A	121103106 B/L	1/27/16	6/27/17	1.4
50T	N/A	011303007 B/L	3/7/15	8/22/17	2.4
51T	N/A	011305018 B/L	11/4/15	8/22/17	1.8
52T	N/A	031403033 B/L	9/10/15	4/25/17	1.6
53T	N/A	031405057 B/L	N/A	N/A	N/A
54T	N/A	031403140 B/L	3/16/16	4/25/17	1.1
55T	N/A	041208002 B/L	N/A	N/A	N/A
56T	N/A	081305022 B/L	7/1/15	8/22/17	2.1

57T	N/A	081305046B 091205159L	6/8/15	8/22/17	2.2
58T	N/A	081305127 B/L	6/20/16	4/18/17	0.8
59T	N/A	091205159B 081305046L	N/A	N/A	N/A
60T	N/A	111312038 B/L	3/4/15	8/22/17	2.3
61T	N/A	121101041 B/L	11/6/15	12/22/16	1.1

4 Results

4.1 Hagan Containers

The results for the Hagan storage containers are summarized in Table 3. Results of individual tests are discussed in subsequent sections. One O-ring failed a helium leak test and two O-rings were outside the test criteria durometer measurements. All filters passed the criteria for efficiency and pressure drop.

Table 3. Surveillance test results for Hagan storage containers.

Surv Plan Sample	Container Visual Inspection	O-ring Visual Inspection	Filter Particle Penetration (%) ± 0.0002	Filter Pressure Drop (in W.C) ±0.02	Helium Leak Rate (atm cc/s)	O-ring durometer (Shore M) ± 2.15
17H1	A corrosion product distributed on interior surfaces. Corrosion in threads of filter holder up to the gasket seal. Smell of chlorine.	Removable corrosion products	0.0117	0.681	1.70E-06	75.2
17H2	Container has corrosion visible around the weld region. There is also spots that seem to be the beginning of corrosion throughout the container. Filter Gasket is also degrading. Container lid also shows beginnings of corrosion. Container is a 2-thread Hagan.	There is two significant pinched creases on the sealing surfaces of the O-ring and one minor pinched crease	0.008	0.624	2.60E-04	79.4
17H3	No issue reported	No issue reported	0.0105	0.891	1.20E-07	79.6
17H4	No issue reported	No issue reported	0.0115	0.777	3.90E-07	80.4
17H5	No issue reported	No issue reported	0.0124	0.798	2.60E-06	79.9
17H6	This has a two-thread configuration for the lid.	No issue reported	0.0125	0.599	1.50E-06	80.5
17H7	This is a 2 thread Hagan and it is corroded internally.	No issue reported	0.011	0.714	7.00E-07	78.7
17H8	Excessive tape residue on the outside of the lid. 2 thread Hagan	No issue reported	0.0091	0.822	8.30E-06	77.2

4.1.1 Visual Inspections

Visual inspections of each container revealed three Hagan containers with corrosion issues. Photographs of these containers were taken the containers are being held if further analysis is determined to be beneficial

4.1.1.1 Hagan Container, Surveillance, Sample #17H1, SN-07/02-03259, LANL-1014, ATLAMS1S1, MT52, 75g, C19, Compound; Chloride, 0.2 W, 11.1 years

Table 4. Unpacking data for Sample 17H1

Surveillance sample number	17H1
Operator	Steve Willson
Date	09/13/2017
Cont. found outside SAVY-4000	No
Cont. found inside SAVY-4000	No
Overall package weight	N/A
Body Serial	
Lid Serial	
LOT ID	ATLAMS1S1
Pewter Internal Shield	No
Pewter Outer Shield	Yes
Outer container Condition	Good
O-ring installed	Yes
Bag-out bag present	Yes
Failed Bag out bag	No
Liquid observed	Tape Goo
Condition of old bag-out bag	Stuck to Inner container
Type of inner	SS slip lid
Condition of Inner	Good, verbally said looked dirty, goo covered
Failed metal inner	No
Bag-out bag replace	Yes, Item intro'd
Inner replace	
Beta/Gamma Dose (at lid/collar of SAVY-4000)	
Beta/Gamma Dose (at 30 cm)	
Neutron Dose	
Comments	

Corrosion was found in this container. There were no visible signs that the exterior of the container was corroded. The container walls show more general corrosion than the lid with heavier general corrosion in the weld regions seen in Figure 4-1. There are markings that are likely where the bag out bag was touching the container especially on the bottom of the container seen in Figure 4-2. Upon opening, the container there was a smell of chlorine. The bag out bag was reported as being good but gooey/sticky. Photographs of the bag out bag show it as being darkened as well in Figure 4-3. Until the item was introduced, a good look at the inner container was not clearly visible. The outside of the inner container was corroded (Figure 4-4.) The inside of the inner container was also corroded (Figure 4-5,) though not as heavily as the outside.

Figure 4-1. Sample #17H1 container showing corrosion on the inside of the container. Heavier deposits in weld regions and along bottom radius.

Figure 4-2. Bottom of the sample 17H1 with markings where the bag out bag was in contact.

Figure 4-3. Bag out bag inside the glovebox after being removed from the container 17H1.

Figure 4-4. Inner container of container 17H1 with corrosion evident on the outside of the container.

Figure 4-5. Inside of the inner container of container 17H1 which had some corrosion but was not as severe as the outside of the inner.

4.1.1.2 Hagan Container, Surveillance, Sample #17H2, SN 07/02-03261, LANL-1061, CASLT966, MT52, 286g, C19, Compound; Chloride, 0.6 W, 12 years

Table 5. Unpacking data for Sample 17H2

Surveillance sample number	17H2
Operator	Steve Willson
Date	03/15/2017
Cont. found outside SAVY-4000	No
Cont. found inside SAVY-4000	No
Overall package weight	N/A
Body Serial	
Lid Serial	
LOT ID	CASLT966
Pewter Internal Shield	No
Pewter Outer Shield	No
Outer container Condition	Good
O-ring installed	Yes
Bag-out bag present	Yes
Failed Bag out bag	No
Liquid observed	No
Condition of old bag-out bag	Discolored but pliable
Type of inner	SS slip lid
Condition of Inner	Good, some rust
Failed metal inner	No
Bag-out bag replace	No
Inner replace	No
Beta/Gamma Dose (at lid/collar of SAVY-4000)	3.5
Beta/Gamma Dose (at 30 cm)	1.5
Neutron Dose	1.0
Comments	Returned to vault in SAVY-4000

Corrosion was found on the interior surfaces of both the lid and body of the container. The exterior of the container did not show any corrosion signs (Figure 4-6). There is a speckle pattern found on the inside of the container and lid (Figure 4-7, Figure 4-8) where it appears corrosion is forming. A heavier deposit of corrosion products can be found in the heat affected zone around the welds on the container (Figure 4-8). This Hagan container is also a 2-thread lid type. Corrosion was also reported on the inner container at the time of unpacking. The bag-out bag was reported as being discolored but pliable. This

container also had a pinched O-ring while in storage. There was no corrosion observed beyond the O-ring seal but the container did not pass a helium leak test due to the pinched O-ring having creases that did not relax.

Figure 4-6. Exterior of container 17H2 showing no corrosion

Figure 4-7. Underside of lid of 17H2 with spots of corrosion

Figure 4-8. Corrosion on interior of 17H2 with heavier deposits in the weld region

4.1.1.3 Hagan Container, Surveillance, Sample 17H3, SN 05/99-NMC05-000-079, LANL-45, CXLRES091599, MT52, 75g, R26, Process Residue; Filter Residue, 0.4 W, 17.6 years

There were no container or filter issues found during the inspection process. The O-ring passed the visual inspection. This was an item was an item of opportunity and the unpacking data form was not completed due to an oversight.

4.1.1.4 Hagan Container, Surveillance, Sample 17H4, 05/99-NMC03-000-192, LANL-1344, ASHX09, MT52, 15g, R47, Process Residue; Incinerator Ash, 0 W, 16.2 years

There were no container or filter issues found during the inspection process. The O-ring passed the visual inspection. This was an item was an item of opportunity and the unpacking data form was not completed due to an oversight.

4.1.1.5 Hagan Container, Surveillance, Sample 17H5, 10/10-01076, 10/10 LANL-418, MT83, 41.7g (Pu238), C21, Compound; Dioxide, 19.7 W, 6.3 years

Table 6. Unpacking Data for Sample 5H

Surveillance sample number	17H5
Operator	Kent Kramer
Date	9/8/2017

Cont. found outside SAVY-4000	No
Cont. found inside SAVY-4000	No
Overall package weight	1409 g
Body Serial	10/10-01076
Lid Serial	10/10 LANL 418
LOT ID	
Pewter Internal Shield	No
Pewter Outer Shield	No
Outer container Condition	Good
O-ring installed	Yes
Bag-out bag present	No
Failed Bag out bag	
Liquid observed	
Condition of old bag-out bag	
Type of inner	Welded inner
Condition of Inner	Good
Failed metal inner	No
Bag-out bag replace	
Inner replace	No
Beta/Gamma Dose (at lid/collar of SAVY-4000)	6.0
Beta/Gamma Dose (at 30 cm)	4
Neutron Dose	11.5
Comments	

There were no container or filter issues found during the inspection process. The O-ring passed the visual inspection. No issues were identified during the unpacking process.

4.1.1.6 Hagan Container, Surveillance, Sample 17H6, SN 04/02-08245, A-245, XORER6SLT2, MT52, 457g, R65, Process Residue; ER Salt, 1.2 W, 11.7 years

Table 7. Unpacking Data for Sample 17H6

Surveillance sample number	**17H6**
Operator	Steve Willson
Date	3/15/2017
Cont. found outside SAVY-4000	No
Cont. found inside SAVY-4000	No
Overall package weight	N/A
Body Serial	N/A
Lid Serial	N/A
LOT ID	XORER6SLT2

Pewter Internal Shield	No
Pewter Outer Shield	Yes
Outer container Condition	Good
O-ring installed	Yes
Bag-out bag present	Yes
Failed Bag out bag	No
Liquid observed	No
Condition of old bag-out bag	Good
Type of inner	N/A
Condition of Inner	Good
Failed metal inner	No
Bag-out bag replace	No
Inner replace	No
Beta/Gamma Dose (at lid/collar of SAVY-4000)	3.5
Beta/Gamma Dose (at 30 cm)	1.5
Neutron Dose	1.5
Comments	

There were no container or filter issues found during the inspection process. The O-ring passed the visual inspection. The Hagan is a 2-thread container.

4.1.1.7 Hagan Container, Surveillance, Sample 17H7, SN 08/05-03142, LANL-2139, XBLS8A, MT56, 114g, R83, Process Residue, MSE Salt, 3.5 W, 10.7 years

Corrosion was found on the interior surfaces of both the lid and body of the container. Corrosion was also found on the threads of the filter holder (Figure 4-9). The exterior of the container did not show any corrosion signs. There is a speckle pattern found on the inside of the container and lid (Figure 4-10). There are heavier concentrations of corrosion products in the weld regions of the collar weld, Figure 4-10, and the welds, which hold the TID bar on the container, Figure 4-11. A heavier deposit of corrosion products can be found in the heat affected zone around the welds on the container. This Hagan container is also a 2-thread lid type. Corrosion was also reported on the inner container at the time of unpacking. The bag-out bag was reported as being discolored but pliable.

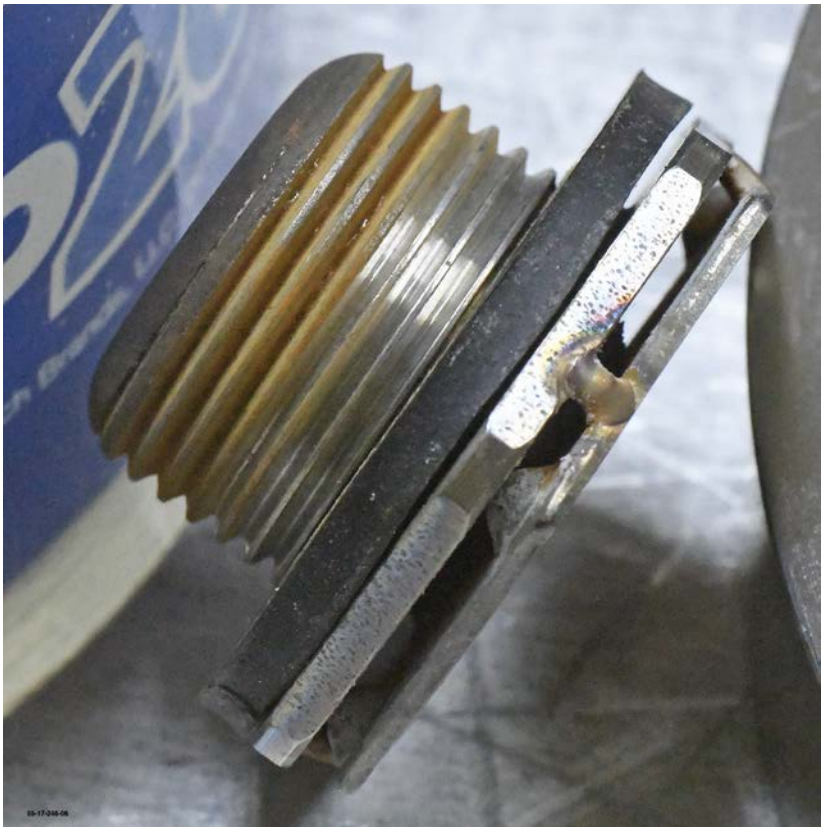

Figure 4-9. Corrosion on threads of the filter housing of container 17H7.

Figure 4-10. Deposits on the inner wall of the container 17H7

Figure 4-11. The corrosion deposits found on the heat affected zone of the welds holding the TID bar of container 17H7.

Figure 4-12. Corrosion and markings from the bag-out bag on the bottom of container 17H7.

Figure 4-13. Corrosion on underside of the lid of container 17H7.

4.1.1.8 Hagan Container, Surveillance, Sample 17H8, 08/06-01050, 06/00 LANL-98, XBSOX448A, MT52, 56g, R83, Process Residue, MSE Salt, 0.9 W, 17.4 years

Container had excessive tape residue on the outside of the lid but no filter issues were reported. The Hagan was a 2-thread design. The O-ring passed the visual inspection. The unpacking data form is unavailable.

4.1.2 O-Ring Tests

4.1.2.1 Visual Inspection of the O-rings

Inspections found one O-ring that failed a visual inspection. This O-ring was on sample #2H.This O-ring was pinched in between lid of the container and the O-ring groove on the body. The O-ring also failed a helium leak test.

Figure 4-14. Pinch visible in O-ring after ~4 weeks removed from container.

Figure 4-15. Two pinch locations visible on O-ring.

The creases in the O-ring seen in Figure 4-14 and Figure 4-15 were found prior to leak testing. The O-ring was kept to observe if the crease from being pinched relaxes, with no significant visible relaxation observed over several months. No other O-rings had any major issue reported.

4.1.2.2 Leak Rate Tests

The leak rate results for the Hagan storage containers are shown in Figure 4-16. The measured leak rate from Hagan containers ranged between 1.20×10^{-7} and 2.6×10^{-4} atm cc/s of helium at 75 torr into vacuum. One O-ring failed the leak test, with a measurement above the failure criterion of 1×10^{-5} atm cc/s due to the pinched O-ring.

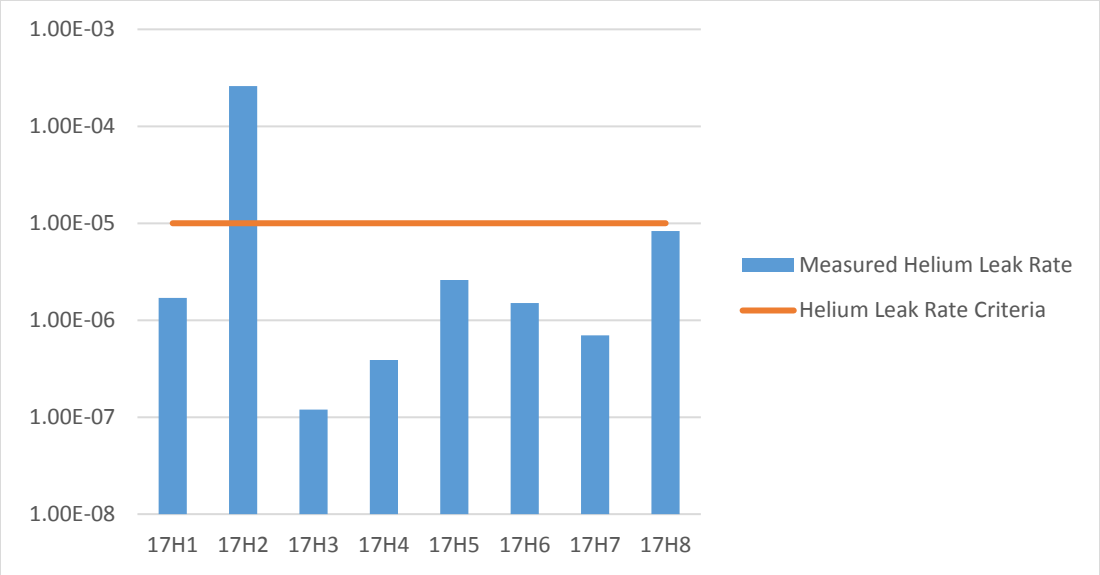

Figure 4-16. Leak rates measured for each container are shown as blue bars. The orange line shows the failure criteria. One container failed. Values on y-axis are in atmcc/sec.

4.1.2.3 O-ring Hardness Tests

The eight Hagan O-rings tested had hardness between 75.2 and 80.5, with an average of 78.9 durometer units. The measurements are graphed in Figure 4-17, and shown with the passing durometer range represented by the orange and gray bands. Two of the O-rings were slightly above the design specification. The containers are removed for service after testing and they still passed the helium leak test. The population of 20 O-rings used as a baseline in the lifetime extension studies have a hardness of 76.8 ±6.07 durometer units, with a maximum of 78.6 and a minimum of 73.9 durometer units. These baseline O-ring measurements were performed on unused Hagan O-rings that had been stored in plastic bags.

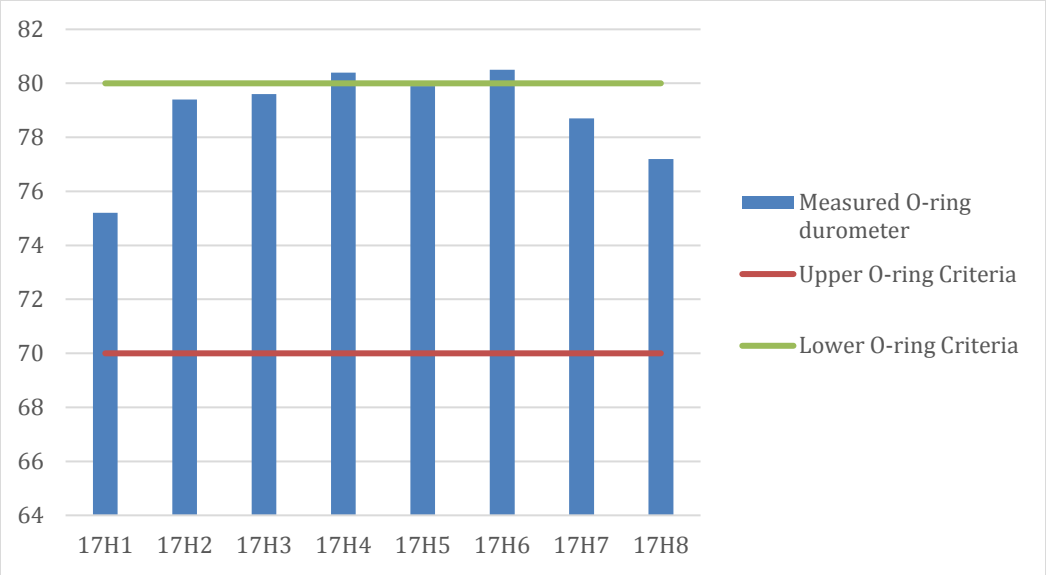

Figure 4-17. Durometer measurements, shown with an green or red line representing the criteria bounds for the hardness of O-rings.

4.1.3 Filter Tests

4.1.3.1 Particle Penetration

The aerosol data are reported as a percent penetration, also known as the percent leakage. The set of particle penetration measurements shown in Figure 4-18 is narrowly distributed and is at least a factor of 2 lower than the requirement.

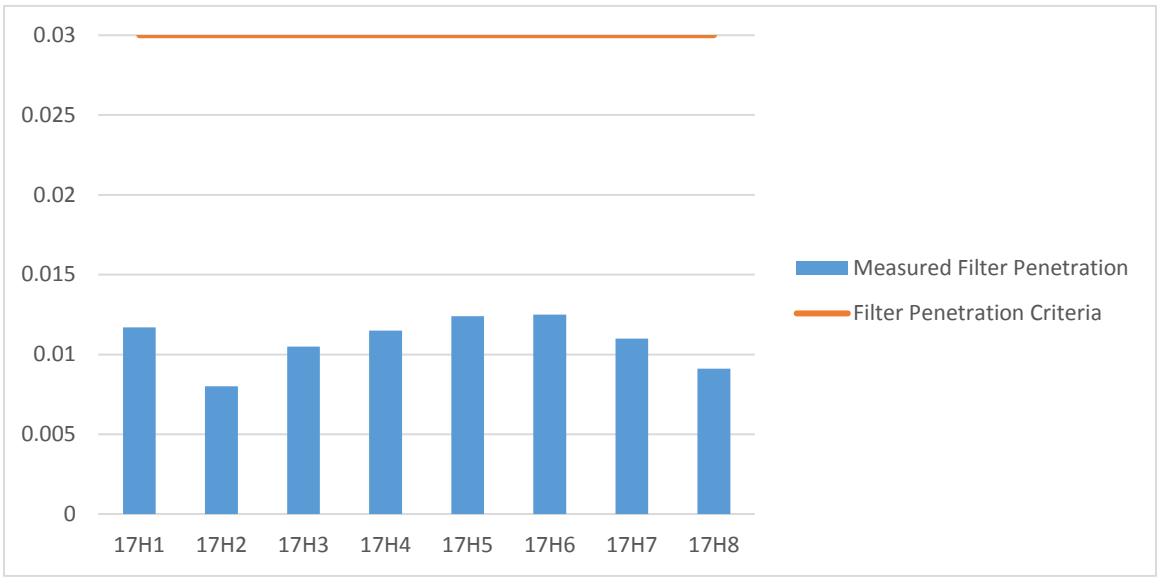

Figure 4-18. Filter particle penetration measurements. Values on y-axis are the filter efficiency.

4.1.3.2 Pressure Drop

The pressure drop measurements have an average of 0.738 in. W.C. A graph of the measurements is shown in Figure 4-19. No filters failed the pressure drop criteria.

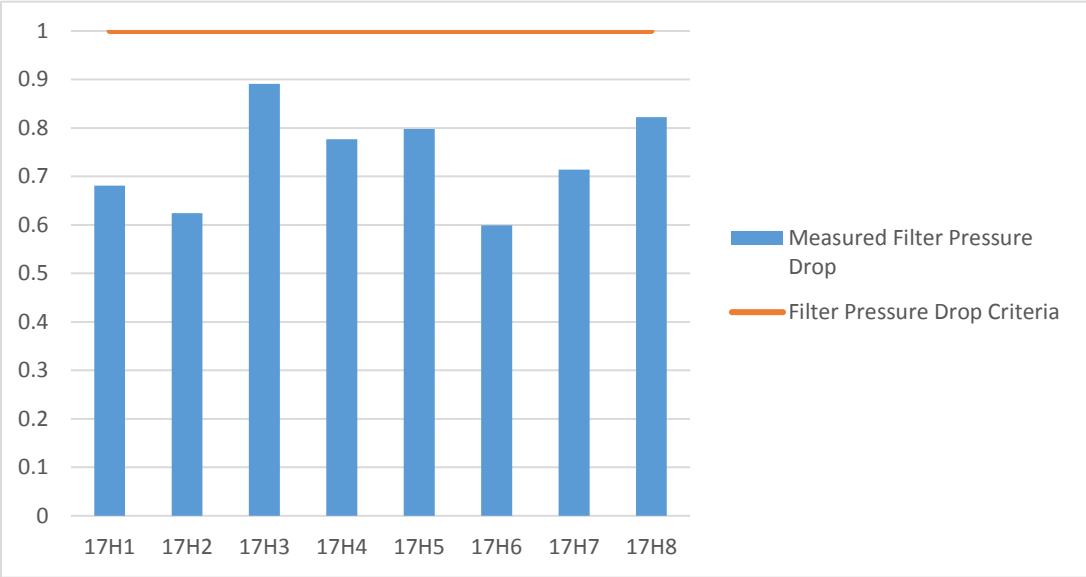

Figure 4-19. Filter pressure drop measurements. Values on y-axis are in inches W.C.

4.2 SAVY-4000

The results for the SAVY-4000 storage containers are summarized in Table 8. The results for the SAVY-4000 transfer containers are summarized in Table 9. All O-rings passed a helium leak test and durometer measurements. All filters passed the criteria for efficiency and pressure drop. A selection of surveillance containers from both FY17 and previous years were selected based on the change in pressure drop from manufacture to surveillance for water penetration testing. No container failed water penetration testing. All SAVY-4000 storage containers were returned to service with the same item packaged inside.

Table 8. Surveillance test results for SAVY-4000 storage containers

Surv Plan Sample	Container Visual Inspection	O-ring Visual Inspection	Filter Particle Penetration (%) ± 0.0002	Filter Pressure Drop (in W.C) ±0.02	Helium Leak Rate (atm cc/s)	O-ring durometer (Shore M) ± 2.15
17S1	Slight Corrosion on interior	Small nick on O-ring. Not big enough to compromise seal	0.0005	0.615	2.70E-08	56.6

17S2	No issue reported	No issue reported	0.0004	0.487	2.50E-08	57.2
17S3	Markings of bag out bag on interior of container. possibly the beginning of corrosion. small dent of bottom radius. thumb latch is sticky.	No issue reported	0.0003	0.574	3.00E-08	57.7
17S4	Markings of bag out bag on interior of container. Possibly the beginning of corrosion. Container wiped with a slight removal of the suspected corrosion.	No issue reported	0.0005	0.534	2.20E-08	58
17S5	Beginning signs of corrosion evident in the container. Mainly on bottom and lower portion of container. Container wiped with minimal change.	No issue reported	0.0001	0.634	3.00E-08	57.4
17S6	The thumb latch is a little sticky.	Small nick. Not large enough to compromise the seal	0.0004	0.622	1.90E-08	57.8
17S7	No issue reported	No issue reported	0.0003	0.527	2.60E-08	57.3
17S8	No issue reported	No issue reported	0.0001	0.67	1.40E-08	57

Table 9. Surveillance test results for SAVY-4000 transfer containers.

Surv Plan Sample	Container Visual Inspection	O-ring Visual Inspection	Filter Particle Penetration (%) ± 0.0002	Filter Pressure Drop (in W.C) ±0.02	Helium Leak Rate (atm cc/s)	O-ring durometer (Shore M) ± 2.15
23T	The inside of this container is severely corroded along with a sticky thumb latch and dull filter color on inner side of lid. Container is extremely difficult to impossible to close do to corrosion and corrosion	Along with the small hole, a dull strip runs along the sealing surface.	0.0003	0.702	8.40E-08	58.4

	residue on O-ring and O-ring groove.					
24T	The inside of the container is severely corroded and the filter has a dull color on the inner side of lid. There is also a dent at the bottom of the container.	Although there is an inclusion within the O-ring, the container still passes a helium leak test. O-ring did have corrosion residue that was easily removed.	0.0004	0.677	2.20E-08	59.2
25T	Discoloration inner bottom of the container due to heat.	No issues reported	0.0003	0.554	1.50E-08	57.8
26T	No issues reported	No issues reported	0.0004	0.658	1.20E-07	57.4
27T	No issues reported	No issues reported	0.0001	0.621	2.30E-08	57.4
28T	Thumb closure is a little sticky. There is a small crease on the lower part of the body, this has no effect on the structural integrity and is considered still functional.	No issues reported	0.0002	0.663	2.80E-09	54
29T	No issues reported	Small inclusions on O-ring due to manufacturing still passed leak test.	0.0004	0.548	1.40E-08	57.1
30T	No issues reported	No issues reported	0.0001	0.626	1.80E-08	57.8
31T	Thumb closure is a little sticky	No issues reported	0	0.661	2.00E-09	54.1

32T	No issues reported	No issues reported	0.0002	0.616	3.80E-08	55.4
33T	No issues reported	No issues reported	0.0002	0.636	5.00E-08	54.9
34T	No issues reported	No issues reported	0.0002	0.652	4.80E-08	53.4
35T	No issues reported	A small scratch/discoloration.	0.0003	0.651	5.00E-08	54.9
36T	No issues reported	No issues reported	0.0002	0.727	4.90E-08	54.2
37T	Small discoloration spot on bottom of inner part of container. There is also a small dent on bottom radius.	No issues reported	0.0003	0.73	2.60E-08	57.6
38T	No issues reported	No issues reported	0.0004	0.655	2.00E-08	54.7
39T	The interior of the container has extensive corrosion that goes past the O-ring groove on the collar. It would appear that either the lid was not used or an O-ring was not installed. There is a bit of corrosion product on the inside of the filter.	The O-ring was covered in rust from corrosion	0.0001	0.678	1.90E-08	57.9
40T	Discoloration on underside of lid.	No issues reported	0.0003	0.689	1.70E-08	56.9
41T	No issues reported	No issues reported	0	0.646	2.00E-08	55.7
42T	No issues reported	No issues reported	0.0002	0.639	1.40E-08	58.5
43T	No issues reported	No issues reported	0.0003	0.638	2.40E-08	58.2
44T	No issues reported	No issues reported	0.0003	0.595	3.30E-09	56.4
45T	There is a small dent on bottom radius and was signed by DJS on11/05/15	No issues reported	0.0002	0.594	2.70E-08	57
46T	No issues reported	Small black pit on O-ring The O-ring was replaced with a new O-ring.	0.0003	0.686	5.10E-09	n/a

47T	There is a small amount of residue at the bottom of the inside of the container. Was not fully wipe-able with a dry rag.	No issues reported	0.0004	0.663	2.80E-08	57.6
48T	No issues reported	No issues reported	0.0001	0.637	1.10E-07	53.4
49T	Small dent on bottom radius	small scratch on inner part of O-ring, passed leak test	0.0002	0.608	5.30E-08	57.8
50T	White dots on underside of lid.	No issues reported	0.0001	0.63	3.70E-08	56.4
51T	Small crease on bottom radius and residue on outside lid.	Small wavy indentions on non-sealing surface from manufacturing . O-ring still passes leak testing	0.0003	0.691	3.80E-08	55.5
52T	There is residue possibly from the bag-out-bag on the inside of the container can be wiped clean with an alcohol wipe	No issues reported	0.0001	0.653	1.10E-08	57.4
53T	No issues reported	No issues reported	0.0004	0.665	1.70E-08	57.7
54T	Thumb latch is a little sticky and there is a small dimple on bottom radius	There is small spot on the O-ring from the manufacturing process	0.0004	0.619	1.80E-08	58.3
55T	A couple of small dimples on bottom radius. Container still pass integrity	No issues reported	0.0003	0.571	3.20E-08	56.8
56T	Thumb latch is a little sticky	No issues reported	0.0004	0.676	7.50E-07	57.1
57T	Heat discoloration on the inside of the body that is also visible on the outside	No issues reported	0.0003	0.619	3.50E-08	56.1
58T	Center of bottom interior/exterior there is a brown heat effected zone.	No issues reported	0.0004	0.585	1.70E-08	58.2

59T	Scratches on the outside of the container but no impediment on the overall structure	No issues reported	0	0.599	1.60E-08	57.7
60T	There is discoloration on the inner side of the lid. Additional discoloration inner bottom that is also visible on the outside. Small dent on bottom radius and small dimples on bottom radius. The container's structural integrity is still good.	Very small dimple on the non-sealing surface area it still passed helium	0.0004	0.604	1.70E-08	56.5
61T	Handle has rubbed off ionize color on locking collar	No issues reported	0.0001	0.657	2.30E-09	56.4

4.2.1 Visual Inspections

Visual inspections of each container revealed SAVY-4000 containers with corrosion issues. Photographs of these containers were taken and the containers are held if further analysis is determined to be necessary.

4.2.1.1 SAVY-4000 Container, Surveillance, Sample 17S1, SN 111308080, BLO-39-11-16, MT57, 544g, C21, Compound; Dioxide, 5 W, 1.6 years

Table 10. Unpacking Data for Sample 17S1

Surveillance sample number	17S1
Operator	Adrian Sanchez
Date	5/16/2017
Cont. found outside SAVY-4000	No
Cont. found inside SAVY-4000	No
Overall package weight	8620 g
Body Serial	111308080
Lid Serial	111308080
LOT ID	BLO-39-11-16
Pewter Internal Shield	No
Pewter Outer Shield	Yes
Outer container Condition	Good
O-ring installed	Yes
Bag-out bag present	Yes
Failed Bag out bag	No
Liquid observed	No

Condition of old bag-out bag	Good
Type of inner	3QT Hagan
Condition of Inner	Good
Failed metal inner	No
Bag-out bag replace	No*
Inner replace	No
Beta/Gamma Dose (at lid/collar of SAVY-4000)	5.0 mrem/hr
Beta/Gamma Dose (at 30 cm)	6 mrem/hr
Neutron Dose	7 mrem/hr
Comments	*Bag out bag was placed into another bag out bag for precaution

There were no external issues found during the inspection. Corrosion was found inside the container. There were markings where it appears the bag out bag was touching the walls of the container shown in Figure 4-20. Figure 4-21 shows a potentially increased corrosion in the weld region. The bag-out bag was placed into a second bag. The bag was reported in good condition.

Figure 4-20. Bag out bag marking on the wall of the container 17S1.

Figure 4-21. Corrosion seen in the weld region of the container 17S1.

4.2.1.2 SAVY-4000 Container, Surveillance, Sample 17S2, SN 031105052, CXLOX082911, MT52, 787g, C21, Compound; Dioxide, 2.1 W, 5.2 years

Table 11. Unpacking Data for Sample 17S2

Surveillance sample number	17S2
Operator	Adrian Sanchez
Date	03/14/2017
Cont. found outside SAVY-4000	No
Cont. found inside SAVY-4000	No
Overall package weight	5199.2 g
Body Serial	031105052
Lid Serial	031105052
LOT ID	CXLOX082911
Pewter Internal Shield	No
Pewter Outer Shield	Yes
Outer container Condition	Good
O-ring installed	Yes
Bag-out bag present	Yes
Failed Bag out bag	No
Liquid observed	No

Condition of old bag-out bag	Good
Type of inner	Slip Lid SS
Condition of Inner	Good
Failed metal inner	No
Bag-out bag replace	No
Inner replace	No
Beta/Gamma Dose (at lid/collar of SAVY-4000)	5.0 mrem/hr
Beta/Gamma Dose (at 30 cm)	3.0 mrem/hr
Neutron Dose	2.5mrem/hr
Comments	

There were no container or filter issues found during the inspection process. The O-ring passed the visual inspection. The bag-out bag was reported in good condition.

4.2.1.3 SAVY-4000 Container, Surveillance, Sample 17S3, SN 031105002, XAP6, MT53, 69g, M44, Unalloyed Metal, 0.2 W, 5.2 years

Table 12. Unpacking Data for Sample 17S3

Surveillance sample number	**17S3**
Operator	Adrian Sanchez
Date	03/14/2017
Cont. found outside SAVY-4000	No
Cont. found inside SAVY-4000	No
Overall package weight	5908.6 g
Body Serial	031105002
Lid Serial	031105002
LOT ID	XAP6
Pewter Internal Shield	Yes
Pewter Outer Shield	No
Outer container Condition	Good
O-ring installed	Yes
Bag-out bag present	Yes
Failed Bag out bag	No
Liquid observed	No
Condition of old bag-out bag	Good
Type of inner	Unable to verify
Condition of Inner	Unable to verify
Failed metal inner	No
Bag-out bag replace	No
Inner replace	No

Beta/Gamma Dose (at lid/collar of SAVY-4000)	n/a
Beta/Gamma Dose (at 30 cm)	n/a
Neutron Dose	n/a
Comments	No dose rate taken on inner container after loading

Minor corrosion found on the interior walls of the container. The thumb latch was also found to be sticky on this container. The suspected corrosion was wiped and the residue was brown in color. The underside of the lid did not have much marking, Figure 4-22, compared with the container body seen in Figure 4-23. The container was found with corrosion markings, Figure 4-23 and the markings did not change significantly after wiping with an isopropyl alcohol wipe as seen in Figure 4-24 . This container is capped and placed inside another SAVY-4000 container.

Figure 4-22. Underside of lid of container 17S3 with no significant markings

Figure 4-23. Section of container 17S3 wall prior to wiping with isopropal alcohol wipe.

Figure 4-24. Section of container 17S3 wall after wiping.

4.2.1.4 SAVY-4000 Container, Surveillance, Sample 17S4, SN 031105051, ROTRBJ-1C1, MT52, 452g, R26, Process Residue; Filter Residue, 1.2 W, 5.6 years

Table 13. Unpacking Data for Sample 17S4

Surveillance sample number	17S4
Operator	Adrian Sanchez
Date	03/14/2017
Cont. found outside SAVY-4000	No
Cont. found inside SAVY-4000	No
Overall package weight	7616.0 g
Body Serial	031105051
Lid Serial	031105051
LOT ID	ROTRBJ-1C1
Pewter Internal Shield	No
Pewter Outer Shield	Yes
Outer container Condition	Good
O-ring installed	Yes
Bag-out bag present	Yes
Failed Bag out bag	No
Liquid observed	No
Condition of old bag-out bag	Good
Type of inner	Slip lid SS
Condition of Inner	Good
Failed metal inner	No
Bag-out bag replace	No
Inner replace	No
Beta/Gamma Dose (at lid/collar of SAVY-4000)	5.0 mrem/hr
Beta/Gamma Dose (at 30 cm)	1.7 mrem/hr
Neutron Dose	5.0 mrem/hr
Comments	

Minor corrosion found on the interior walls of the container seen in Figure 4-25. The suspected corrosion was wiped with an isopropyl alcohol wipe and the residue was brown in color with the pre- and post- wipe container wall being seen in Figure 4-26 and Figure 4-27. The bag out bag was reported to be in good condition.

Figure 4-25. Marks of the bag out bag on the container 17S4 wall. Appears concentration at a crease of the bag out bag touches the wall.

Figure 4-26. Container 17S4 wall prior to wiping.

Figure 4-27. Container 17S4 wall after wiping.

4.2.1.5 SAVY-4000 Container, Surveillance, Sample 17S5, SN 121103083, XBLSCL1217, MT52 + MT44, 178g, R83, MSE Salt, 2.9 W, 4 years

Table 14. Unpacking Data for Sample 17S5

Surveillance sample number	17S5
Operator	Adrian Sanchez
Date	03/14/2017
Cont. found outside SAVY-4000	No
Cont. found inside SAVY-4000	No
Overall package weight	3190.8 g
Body Serial	121103083
Lid Serial	121103083
LOT ID	XBLSCL1217
Pewter Internal Shield	No
Pewter Outer Shield	Yes
Outer container Condition	Good
O-ring installed	Yes
Bag-out bag present	Yes
Failed Bag out bag	No
Liquid observed	No

Condition of old bag-out bag	Good
Type of inner	Slip lid SS
Condition of Inner	Good
Failed metal inner	No
Bag-out bag replace	No
Inner replace	No
Beta/Gamma Dose (at lid/collar of SAVY-4000)	4.0 mrem/hr
Beta/Gamma Dose (at 30 cm)	1.5 mrem/hr
Neutron Dose	1.5 mrem/hr
Comments	

Minor corrosion found on the inner walls of the container. The corrosion appears heavier on the lower portion of the walls and the bottom of the container seen in Figure 4-28 which is unlike the corrosion concentration area seen in other containers. The container was wiped with the results being seen in Figure 4-29. The bag-out bag was reported in good condition. No other visual issues were identified.

Figure 4-28. Container 17S5 wall prior to wiping. Suspect corrosion closer to bottom of container.

Figure 4-29. Container 17S5 wall after being wiped.

4.2.1.6 SAVY-4000 Container, Surveillance, Sample 17S6, SN 111308050, SLT1303, MT52, 392g, R42, DOR Salt, 1 W, 1 year

Table 15. Unpacking Data for Sample 17S6

Surveillance sample number	17S6
Operator	Adrian Sanchez
Date	05/16/2017
Cont. found outside SAVY-4000	No
Cont. found inside SAVY-4000	No
Overall package weight	11168 g
Body Serial	111308050
Lid Serial	111308050
LOT ID	SLT1303
Pewter Internal Shield	No
Pewter Outer Shield	Yes
Outer container Condition	Good
O-ring installed	Yes
Bag-out bag present	Yes
Failed Bag out bag	yes
Liquid observed	No

Condition of old bag-out bag	Good
Type of inner	Slip lid SS
Condition of Inner	Good
Failed metal inner	No
Bag-out bag replace	No
Inner replace	No
Beta/Gamma Dose (at lid/collar of SAVY-4000)	10.0 mrem/hr
Beta/Gamma Dose (at 30 cm)	10.0 mrem/hr
Neutron Dose	1.3 mrem/hr
Comments	

There were no container or filter issues found during the inspection process. No issues found with the container. The O-ring passed the visual inspection. The bag-out bag was reported in good condition. The thumb latch on this container was slightly sticky.

4.2.1.7 SAVY-4000 Container, Surveillance, Sample 17S7, SN 111103020, INC20602, MT52/54, 31g, R47, Incinerator Ash, 0.1 W, 4.7 years

Table 16. Unpacking Data of Sample 17S7

Surveillance sample number	**17S7**
Operator	Adrian Sanchez
Date	05/16/2017
Cont. found outside SAVY-4000	No
Cont. found inside SAVY-4000	No
Overall package weight	3470 g
Body Serial	111103020
Lid Serial	111103020
LOT ID	INC20602
Pewter Internal Shield	No
Pewter Outer Shield	No
Outer container Condition	Good
O-ring installed	Yes
Bag-out bag present	Yes
Failed Bag out bag	No
Liquid observed	No
Condition of old bag-out bag	Good
Type of inner	Slip lid SS
Condition of Inner	Good
Failed metal inner	No
Bag-out bag replace	No
Inner replace	No

Beta/Gamma Dose (at lid/collar of SAVY-4000)	3.0 mrem/hr
Beta/Gamma Dose (at 30 cm)	6.0 mrem/hr
Neutron Dose	1.0 mrem/hr
Comments	

There were no container or filter issues found during the inspection process.. The O-ring passed the visual inspection. The bag-out bag was reported in good condition.

4.2.1.8 SAVY-4000 Container, Surveillance, Sample 17S8, SN 111308059, XAP6 Outer, MT53, 69g, M44, Unalloyed Metal, 0.2 W, 1 year

Table 17. Unpacking Data for Sample 17S8

Surveillance sample number	**17S8**
Operator	Adrian Sanchez
Date	03/14/2017
Cont. found outside SAVY-4000	No
Cont. found inside SAVY-4000	No
Overall package weight	10089.2 g
Body Serial	111308059
Lid Serial	111308059
LOT ID	XAP6
Pewter Internal Shield	No
Pewter Outer Shield	Yes
Outer container Condition	Good
O-ring installed	Yes
Bag-out bag present	No
Failed Bag out bag	No
Liquid observed	No
Condition of old bag-out bag	SAVY-4000 Inner
Type of inner	SAVY-4000
Condition of Inner	Good
Failed metal inner	No
Bag-out bag replace	No
Inner replace	No
Beta/Gamma Dose (at lid/collar of SAVY-4000)	15 mrem/hr
Beta/Gamma Dose (at 30 cm)	12 mrem/hr
Neutron Dose	18 mrem/hr
Comments	

There were no container or filter issues found during the inspection process. The O-ring passed the visual inspection. There is no bag out bag in this container. This container is the outer for the capped SAVY-4000 containing the material.

4.2.2 O-Ring Tests

4.2.2.1 Visual Inspection of the O-rings

Inspections revealed small amounts of dust and debris on a majority of the O-rings. It is unclear whether this dirt was introduced during the use of the container or during manipulations involved in surveillance. In either case, the dirt was easily removed with an alcohol wipe. Various flaws and pits were also found in both surveillance and transfer containers. On the SAI container O-rings, a dull stripe was found around the circumference of the O-ring. This is likely due to the HCl gas environment inside the container. These O-rings also had corrosion residue that was easily wiped away. One O-ring was found with a wavy feel in a section of the O-ring. This was likely from the manufacturing process.

4.2.2.2 Container Leak Rate Tests

The leak rate results for storage and transfer containers with O-rings installed are shown in Figure 4-30. For storage containers, the measured leak rate ranged between 1.4×10^{-8} and 3.0×10^{-8} atm cc/s of helium at 75 torr into vacuum. Tor transfer containers, the leak rate ranged between 2.0×10^{-9} and 7.5×10^{-7} atm cc/s. Every container passed the leak test, with all measurements being below the failure criterion of 1×10^{-5} atm cc/s.

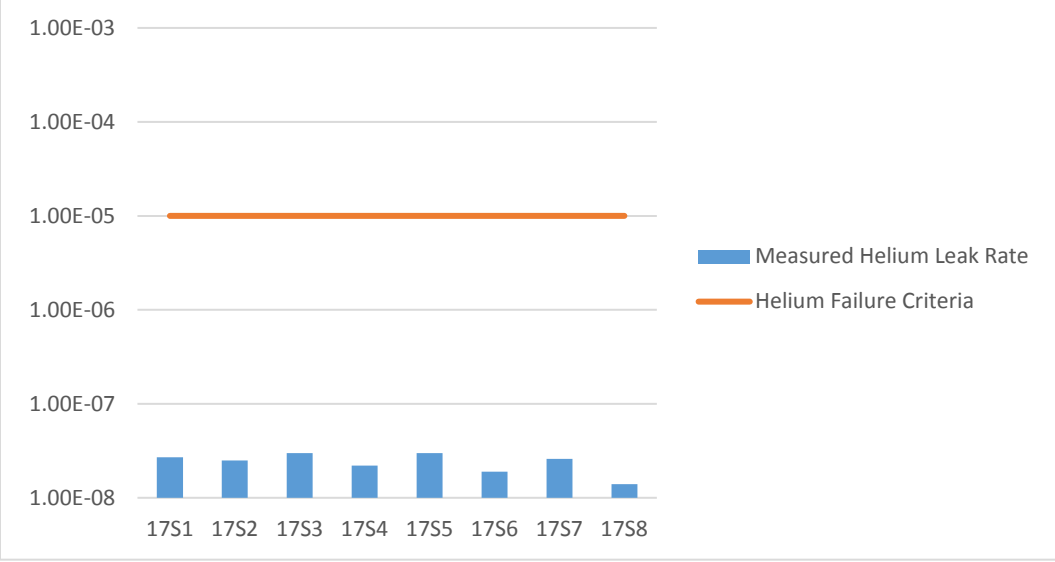

Figure 4-30. Leak rates for surveillance containers, measured for each container are shown as blue bars with the failure criteria shown with the orange line.

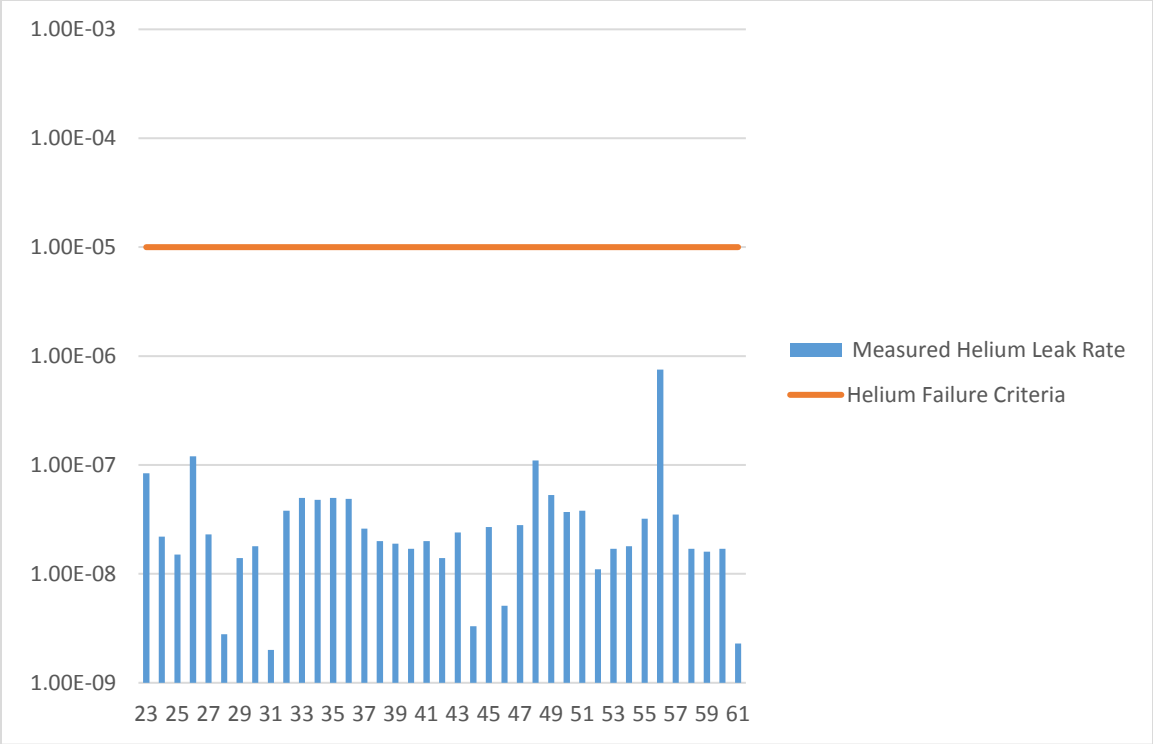

Figure 4-31. Leak rates for transfer containers, measured for each container are shown as blue bars with the failure criteria shown with the orange line.

Leak testing is done as a threshold measurement on a logarithmic scale. Only a single point calibration is done to prepare the instrument for use, though it is checked against another, known leak standard. The calibration value is chosen that is low enough to ensure that the threshold leak—the leak at which failure of a part is determined—is certain to register on the leak detector but high enough to be distinguishable from background. The value of the apparent background leak rate will always decrease during a leak test, as gas is continuously evacuated from the bell jar, so it is not unusual to see leak test measurements lower than the background. This means that the leak test measurement is indistinguishable from the background. These values show measured leak rates that are indistinguishable from the apparent background, and therefore we have confidence containment has been maintained well below the design release rate. The leak test measurement does not have a significant correlation with age, estimated dose, or item thermal power.

4.2.2.3 O-ring Hardness Tests

The 8 surveillance O-rings were found to have hardness of between 56.6 and 58, with an average of 57.4 durometer units. The 39 transfer container O-rings had a hardness between 53.6 and 60.5, with an average of 57.4 durometer units. The 28 O-rings used as a baseline in the lifetime extension studies have a hardness of 57.5 ±2.62 durometer units, so the storage and transfer O-rings are similar in hardness to unused O-rings. The 2.62 unit error is the reproducibility standard deviation as given in ASTM D2240. The measurements are graphed in Figure 4-32. None of the O-rings are especially hard or soft

compared with the baseline, and the measurement do not have a significant correlation with age, estimated dose, or item thermal power. One of the transfer O-ring measurements had a corrupt file and the data could not be found.

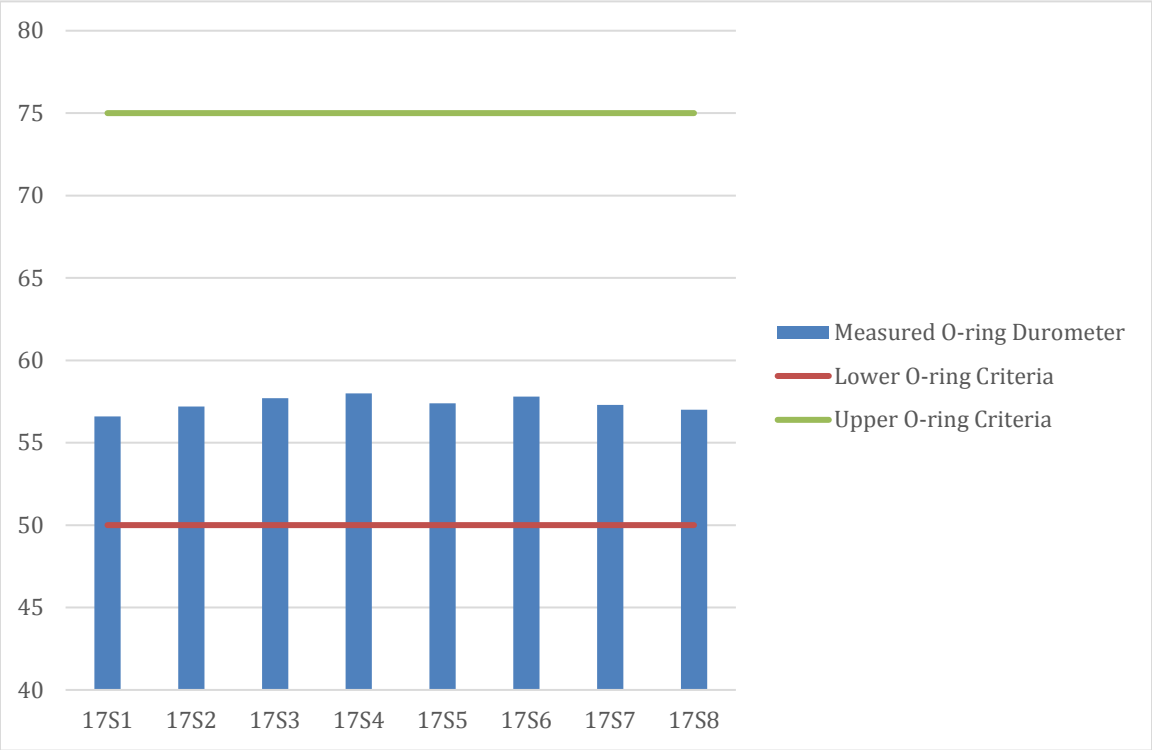

Figure 4-32 Durometer measurements of the surveillance SAVY-4000 O-ring with the red and green bands showing the upper and lower failure limits.

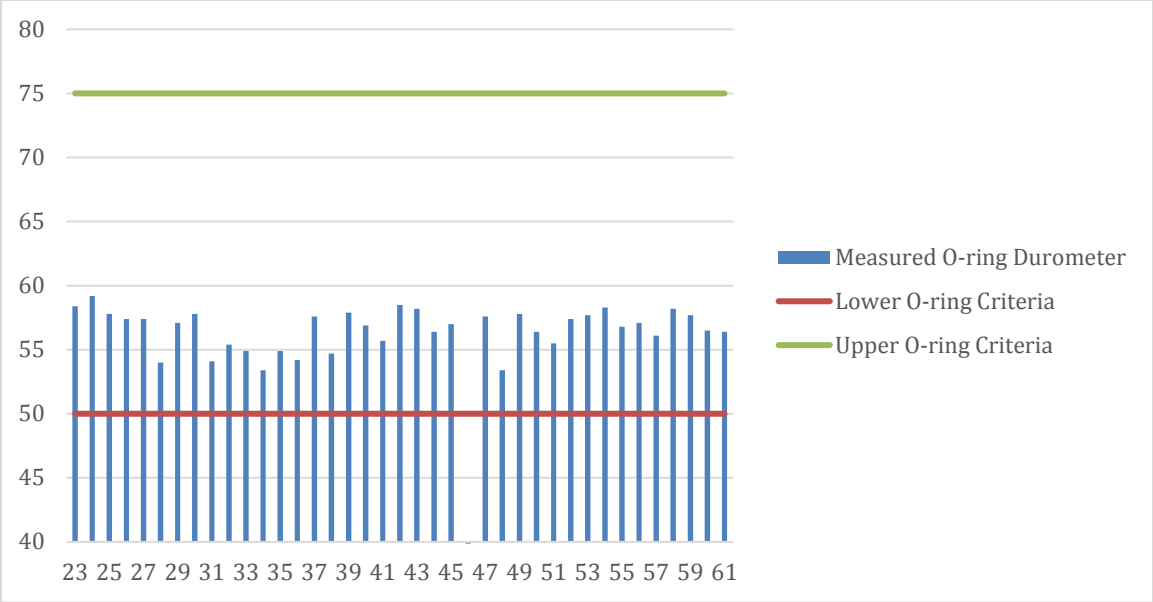

Figure 4-33. Durometer measurements of the transfer container SAVY-4000 O-ring with the green and red bands showing the upper and lower failure limits.

4.2.3 Filter Tests

4.2.3.1 Particle Penetration

The aerosol data are reported as a percent penetration, also known as the percent leakage. The set of particle penetration measurements is narrowly distributed and very far from the failure criterion as graphed in Figure 4-34 for storage containers and Figure 4-35 for transfer containers. A set of baseline particle penetration measurements does exist, but it is not clear how those measurements, taken on a different type of instrument with a different configuration, relate to the measurements taken in PF-4 with our instrument. Although we may not be able to tell how the particle penetration is changing from baseline, we will be able to track how the particle penetration changes relative to containers' peers in the sample population.

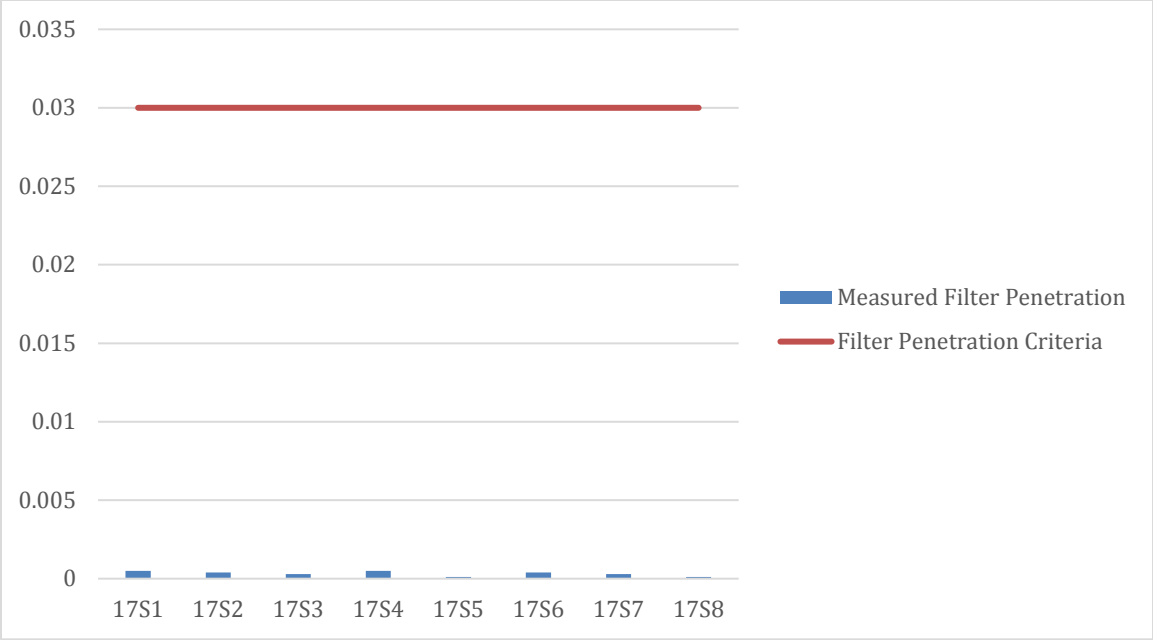

Figure 4-34. Filter particle penetration measurements for storage containers.

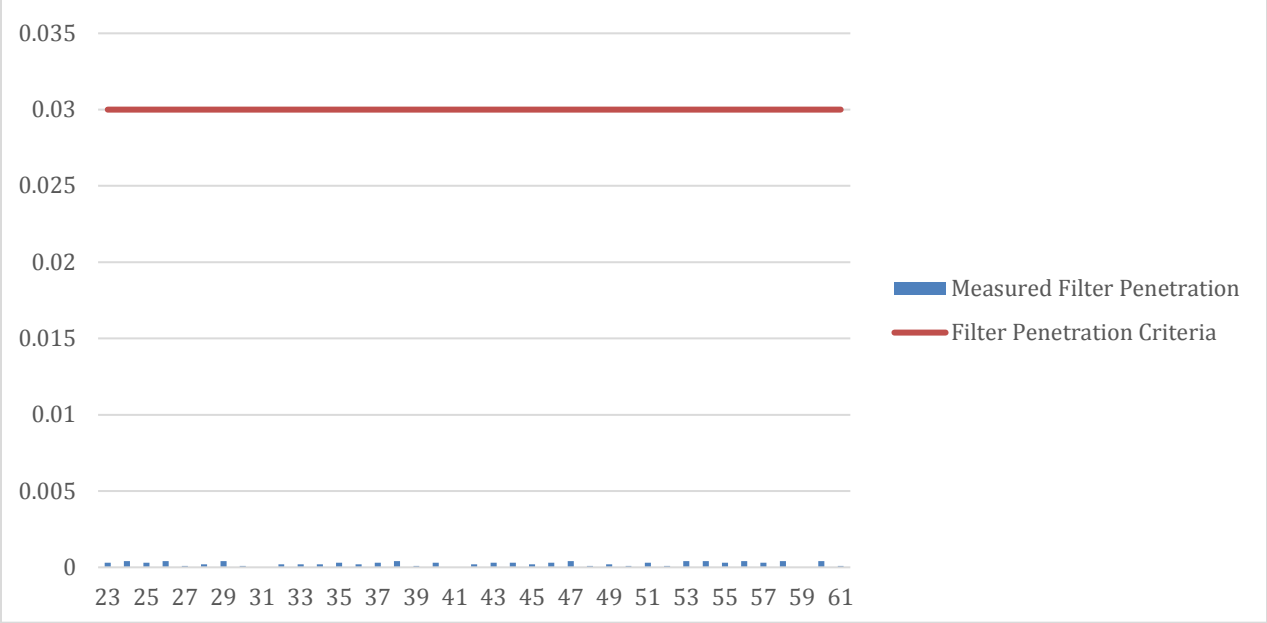

Figure 4-35. Filter particle penetration measurements for transfer containers.

4.2.3.2 Pressure Drop

The pressure drop measurements have an average of 0.58 in. W.C. ±0.09 for storage and 0.64 in. W.C. ±0.09 for transfer containers. The results are graphed below in Figure 4-36 and a graph of the measurements is shown in Figure 4-36.

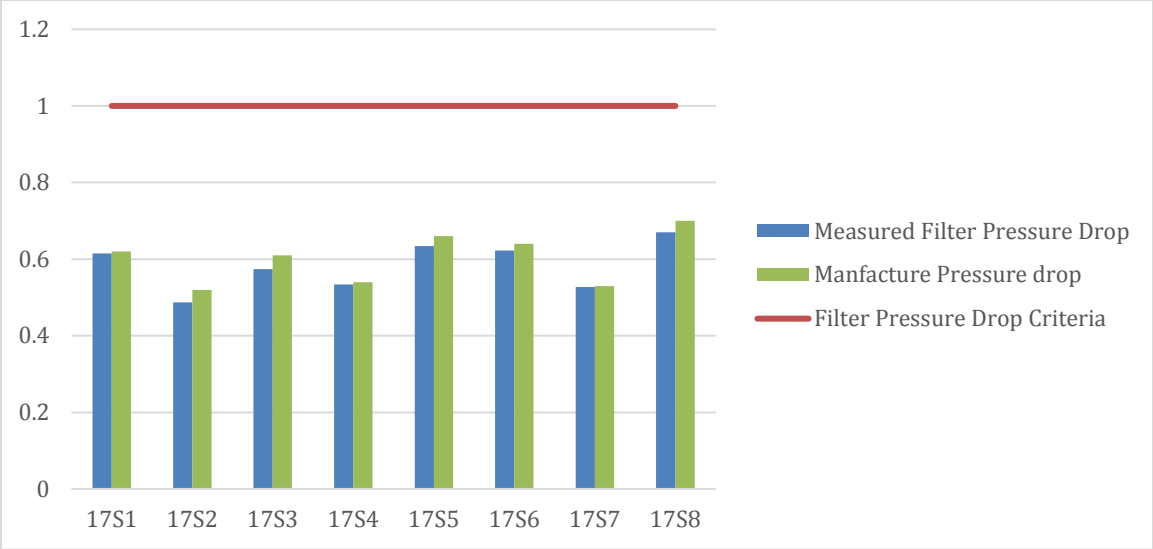

Figure 4-36. Filter pressure drop measurements for storage containers.

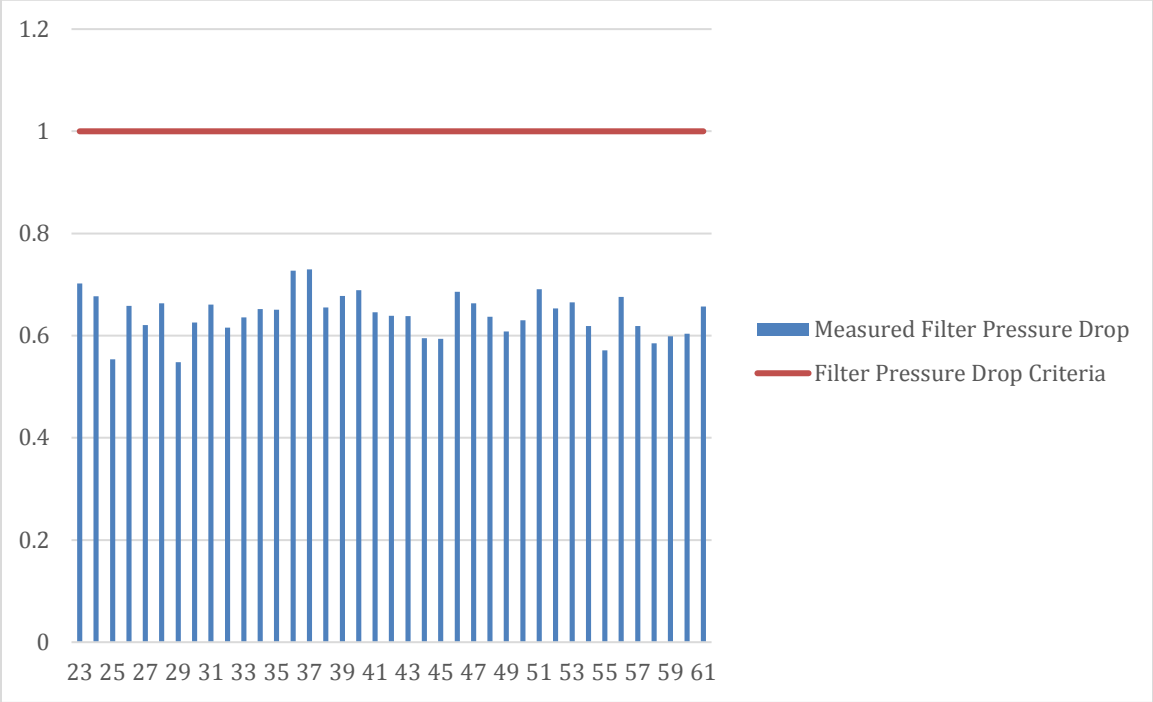

Figure 4-37. Filter pressure drop measurements for transfer containers.

The pressure drop measurement does not have a significant correlation with total dose or item thermal power or with container age. Figure 4-38 shows the pressure drop change from manufacture to the tested pressure drop versus the container age. There does not appear to be a significant correlation of pressure drop change compared with the age of the container.

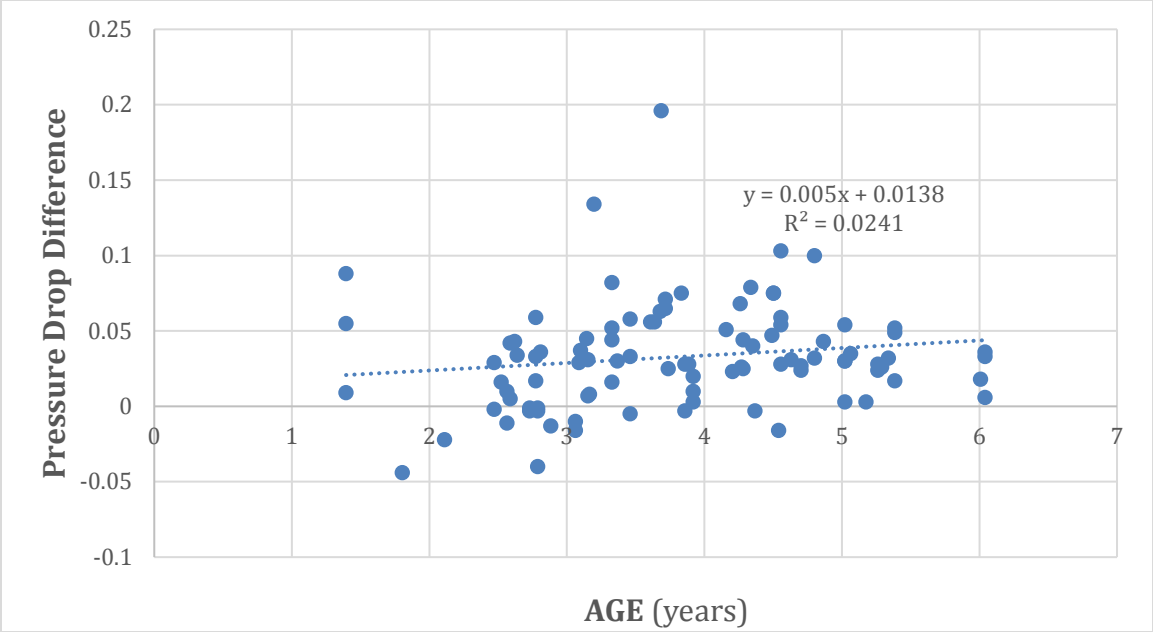

Figure 4-38. Pressure drop difference versus container age.

4.2.4 Annual Surveillance (NDE only)

Four of the containers have been designated for annual surveillance in the Surveillance Plan[1]. The relevant data for annual measurements on the four nondestructive evaluation (NDE)–only containers are reproduced in Table 18.

Table 18. Relevant data for annual measurements on the four NDE-only containers.

SAVY-4000 Serial Number	031105051(L/B)			031105002(L/B)		
LANMAS ID	ROTRBJ-1C1			XAP6		
Material Type	52			53		
IDC	R260			M447		
Chemical Form	Process Residue, Filter Residue			Metal: Unalloyed Metal		
Material Creation Date	1992-11-03			1983-07-12		
Material Mass (g)	452			69.5		
Material Wattage (W)	1.19			0.21		
Initial Packaging Date	2011-08-16			2012-01-26		
	Year 1	**Year 2**	**Year 3**	**Year 1**	**Year 2**	**Year 3**
Surveillance Completion Date	2015-01-29	2016-03-07	2017-03-14	2015-01-29	2016-03-07	2017-03-14
SAVY-4000 Age (y)	3.01	4.11	5.58	3.01	4.11	5
Leak Rate (atm cc/s)	3.1×10^{-8}	1.3×10^{-8}	2.2×10^{-8}	3.1×10^{-8}	1.3×10^{-8}	1.0×10^{-7}
O-ring Durometer (Shore M)	54.8	56.9	58.0	54.8	56.9	57.7
Filter Pressure Drop (in. W.C.)	0.59	0.58	0.54	0.59	0.58	0.57
Particle Penetration (%)	0	0.0001	0.0005	0	0.0001	0.0003
Initial Package Mass (g)	8971.5	8998.7	7616.	7262.0	7431.7	5908.6
Repackaged Mass (g)	8992.8	9193.9	N/A	7427.5	12484.4	N/A

SAVY-4000 Serial Number	031105052(L/B)			121103083(L/B)		
LANMAS ID	CXLOX082911			XBLSCL1217		
Material Type	52			52+44		
IDC	C217			R832		
Chemical Form	Compound Dioxide			Process Residue, MSE Salt		
Material Creation Date	2011-09-19			2012-10-10		
Material Mass (g)	786.9			Pu-178.5; Am-10.6		
Material Wattage (W)	2.07			2.85		
Initial Packaging Date	2012-01-18			2013-03-21		
	Year 1	**Year 2**	**Year 3**	**Year 1**	**Year 2**	**Year 3**
Surveillance Completion Date	2015-01-29	2016-03-07	2016-3-14	2015-01-29	2016-03-07	2017-03-14
SAVY-4000 Age (y)	3.03	4.13	5.16	1.86	2.96	3.98

Leak Rate (atm cc/s)	2.7×10^{-8}	2.6×10^{-8}	1.3×10-8	1.7×10^{-8}	2×10^{-8}	1.0×10^{-7}
O-ring Durometer (Shore M)	55.4	56.7	57.2	54.5	58.8	57.4
Filter Pressure Drop (in. W.C.)	0.5	0.49	0.49	0.65	0.63	0.63
Particle Penetration (%)	0	0.0002	0.0004	0.0004	0.0003	0.0001
Initial Package Mass (g)	6755.5	6758.5	5199.3	4270.1	4271.2	3190.8
Repackaged Mass (g)	6755.5	6752.3	N/A	4268.5	4266.7	N/A

The trends for the visual inspection results for the containers and bagout bags is captured in Table 19. There is no apparent trend in the condition of the bagout bag for any of the containers, but it is noteworthy that two of these items required the addition of a second bag due to a "small hole" in one and "brittle" in the other. The closing latch issue for the XAP6 item was noted each year. There were no noteworthy visual indications for any of the filters. In the third year, there were some markings on the inside of three of the four containers, which appeared to be caused by contact with the bag.

Table 19. Container and Bag Visual Inspection Result for NDE-only Containers.

	Year 1 **(1/29/2015)**		Year 2 **(3/7/2016)**		Year 3 (3/14/2017)	
SAVY-4000 SN, ID, Chem Form	**Container Inspection**	**Bag Inspection**	**Container Inspection**	**Bag Inspection**	**Container Inspection**	**Bag Inspection**
031105051(L/B) ROTRBJ-1C1 Filter Residue	no comments entered	Good, darkened	filter has no debris or discoloration	Brittle, not able to see inner container due to dark outer bag (added additional bag)	markings of bag out bag on interior of container. possibly the beginning of corrosion. Container wiped with a slight removal of the suspected corrosion. Photos taking both before and after wiping	Good (overbag)
031105002(L/B) XAP6 Metal	spring pin is hard to push	Darkened, small hole (added additional bag)	filter looks good, no debris or discoloration. Latch and pin stuck when container was being closed. Rotating the handle back and forth allowed the pin to engage. Informed	good, cannot see inner container due to dark out bag	markings of bag out bag on interior of container. possibly the beginning of corrosion. small dent of bottom radius. thumb latch is sticky. Vacuum grease applied to latch and worked into mechanism which helped to loosen it up. Container wiped with minimal change. Photos	Good

			packing team of possible issue.		taking both before and after wiping	
031105052(L/B) CXLOX082911 Oxide	no comments entered	Good	Filter has no debris or discoloration	Good	no comments entered	Good
121103083(L/B) XBLSCL1217 MSE Salt	no comments entered	Good	no discoloration of the filter or any filter damage visually	Good	Beginning signs of corrosion evident in the container. Mainly on bottom and lower portion of container. Container wiped with minimal change. Photos taking both before and after wiping	Good

Figure 4-39 contains graphs for each surveillance measurement as a function of the storage time. The graphs contain each of the 4 NDE-only items surveilled for the past 3 years. The only measurement that may show a trend over time is the O-ring durometer measurement. The O-rings appear to be getting slightly harder. Continued durometer measurements are recommended. The pressure drop and particle penetration values are also unchanged from the previous years. Over all, there is no evidence of change in the O-rings' ability to maintain a seal during their year in storage.

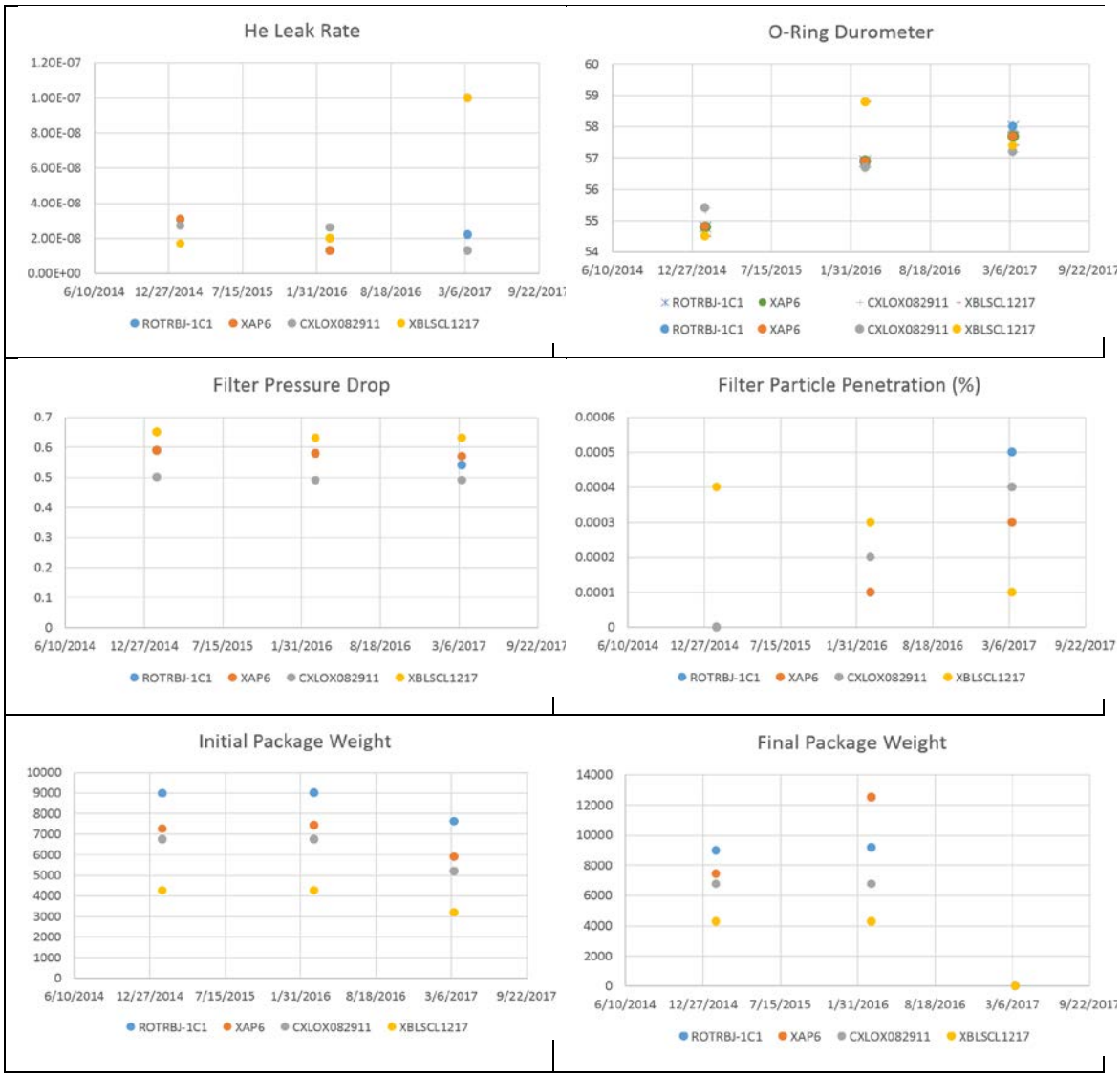

Figure 4-39. NDE-only annual surveillance data as a function of time

4.2.5 Water Penetration Testing

Six SAVY-4000 containers were tested for water penetration. No water penetration was noticed on the four containers tested. In the upcoming years, water ingress testing will be performed on all the SAVY-4000 surveillance containers.

4.2.6 Procedure Compliance

All surveillance containers were found to have the O-ring installed. One Hagan container was pulled for surveillance that had material that would have been prohibited by procedure to package in the SAVY-4000 container (this restriction did not exist when the item was packaged in the Hagan container). The container is restricted due to the IDC code, C19, being a corrosive material. The material was repackaged into a SAVY-4000 and returned to the vault due to mis-communication. For the second item a memo was

drafted and approved for C19 items to be allowed to return to the vault under the condition that it be monitored at least annually in the surveillance program.

4.2.7 Corrosion

Corrosion has been found on 4 SAVY-4000 containers and 3 Hagan containers in surveillance this year. The amount of the corrosion on the SAVY-4000 containers was minor in appearance and seemed to be concentrated were it appeared the bag out bag was touching the side of the container. The Hagan containers had more general corrosion as seen in Figure 4-10 compared to Figure 4-25. The corrosion on Hagan containers was not seen beyond the O-ring seal but there was corrosion on the threads of the filter holder in one case. This corrosion did not appear to pass the gasket, which seals the threaded filter holder to the lid, which indicates the gasket is still sealing the filter holder to the container lid.

The worst appearing corrosion was found on container 1S. The material in this container was a plutonium oxide with 8.2% americium, packaged for one year. The worst appearing Hagan container for this year held a chloride salt with an age of 12 years.

The container management team decided to form a corrosion working group, bringing together people for the 3013 studies and SAVY-4000/Hagan surveillance team members to further investigate the corrosion effects. The current finds are detailed in “Evaluating Corrosion Effects on the Stainless Steel Components of the SAVY-4000 and Hagan Nuclear Material Storage Containers.”

4.2.8 O-ring Issues

There were no significant O-ring issues found in the SAVY-4000 containers this year. There were small inclusions or scuffmarks seen but the issues did not affect the performance on the O-ring.

4.2.9 Filter Discussion

There were no significant filter issues discovered in the SAVY-4000 filters. The pressure drop measured in surveillance did not significantly change from the pressure drop measured during manufacture. The filter efficiency is within the expected values and much lower than the requirement.

4.2.10 Surveillance Issues

The container management team had the continued issue of being unable to perform surveillance on all the containers, which were selected at the beginning of the year. These containers are likely more challenging from a corrosion standpoint and we have not been able to perform surveillance on the containers due to a restriction limiting boxes to less than 500 grams of soluble material. This restriction has caused an issue for multiple years now and we have had to replace selected items for lower gram amount items, which are likely not as challenging to the stainless steel components.

5 Summary and Conclusions

This year surveillance activities continued to find corrosion inside the containers. The four SAVY-4000 containers that were found to have minor corrosion were returned to service and will be surveilled going forward. It has been noticed that there are concentrations of corrosion where we believe the bag out bag is in contact with the walls of the container.

The three Hagan containers found with corrosion have been saved. We will likely section these containers to further investigate the pitting corrosion. The first failure of a container on the helium leak test did occur this year on a Hagan container. The O-ring on this container was likely pinched while the container was in storage.

6 Recommendations

6.1 Inspection Process

Unreported corrosion found inside of the container has likely been occurring. Either this is likely due to the item being introduced to the glovebox line and then thought of as a non-issue or it was unclear that the surveillance SMEs would be interested in the found corrosion. Notifications to operators that any SAVY-4000 storage container corrosion is of interest to the surveillance SMEs is ongoing.

6.2 Enhanced Wall Thickness Measurements

Wall thickness measurements of containers entering the surveillance program would aid in making wall-thinning measurements when corrosion is found in the SAVY-4000 containers. A semi-automated system to measure the wall thickness of the container is being developed that would allow measurements to happen in a more timely manner.

6.3 Corrosion Characterization

In the upcoming surveillance years, the lack of stress corrosion cracking should be documented. If stress corrosion cracking is found, collecting photographs and information must happen. The container will also be pulled from service.

Further information on the corrosion characterization can be found in “Evaluating Corrosion Effects on the Stainless Steel Components of the SAVY-4000 and Hagan Nuclear Material Storage Containers.”

6.4 Material/Package Compatibility

Two Hagan containers were pulled this year, which held currently restricted contents. The content was restricted due to a corrosion risk. While these containers were corroded it was no worse than corrosion we have seen in other items. The material was repackaged into SAVY-4000’s and returned to storage for continued monitoring. There are other similar items which will be pulled for surveillance as well. The content may not need to be restricted in the future.

A new bag out bag material is undergoing testing to determine if it is a viable replacement for the existing PVC bags. If the testing is successful, the new material will be implemented. This will remove the main source of HCl gas generation inside the container.

7 References

1. E. J. Kelly et al., “SAVY-4000 Surveillance Plan Update for 2017” (LA-UR-17-22293, Los Alamos, NM, 2017
2. Reeves, Kirk et al,. “Surveillance Report of SAVY-4000 and Hagan Nuclear Material Containers for FY2016” (LA-UR-16-27427, Los Alamos, NM, 2016
3. L.L. Anderson et al., “Safety Analysis Report for the SAVY-4000 4000 Container Series” (LA-CP-13-00403, Los Alamos, NM, 2013)