

LA-UR-16-25367

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Title: THE SAVY 4000 CONTAINER STORAGE PROGRAM AT LOS ALAMOS NATIONAL LABORATORY

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Intended for: Institute of Nuclear Materials Management, 2016-07-24/2016-07-28 (Atlanta, Georgia, United States)

Issued: 2016-07-25 (rev.1)

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THE SAVY 4000 CONTAINER STORAGE PROGRAM AT LOS ALAMOS NATIONAL LABORATORY

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Institute of Nuclear Materials Management 57th Annual Meeting

July 24-28, 2016

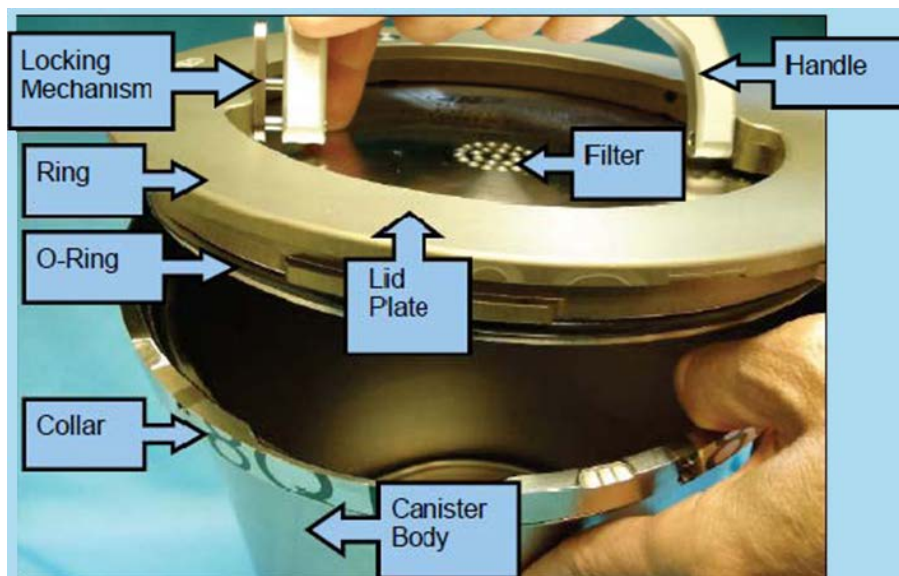
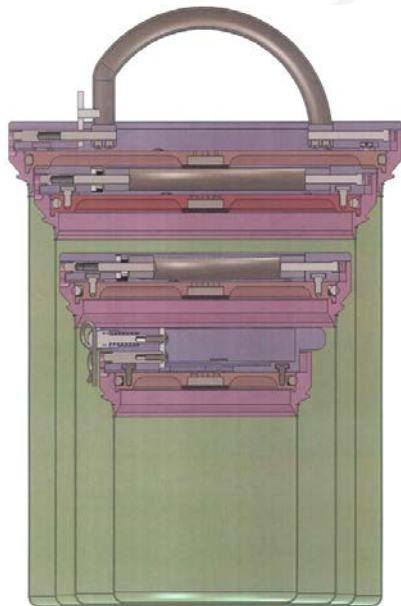
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Outline

- The SAVY 4000 Container
 - Design, Testing, Improvements, Production
- Surveillance
 - Approach, Plan, Results, Implications
- O-ring Lifetime Extension
 - Approach, Preliminary Results
- Summary and Conclusions

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SAVY 4000 Design



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2-Quart SAVY 4000 Container

- 4.77 inch diameter
- 10 inch Length
- Two containers fit within the 9977 (as long as the wattage limit is not exceeded)



2 Quart Design Qualification
12' drop tests completed, and container passed testing required for Manual compliance (drop in 7 orientations, leak checked, and filter tests)

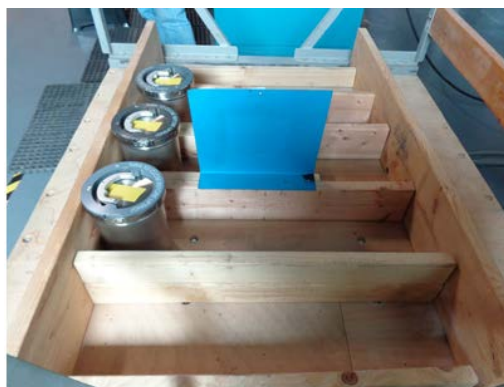
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Extending utility of container design

DOT Type A Testing for Solid and Liquids

Primary goal is to develop an approved Type A container for on site material transfers

- Initiated testing for solids and liquids.
 - Bar Penetration*; Vibration; Stack test; 30' Drop test; water spray;
 - *The He leak rate was determined to be $9.1\text{E-}08$ atm-cc/s at 32 Kpa differential pressure after the bar tests and the filter demonstrated 99.999% efficiency for DOP @ 200 ml/min @ 0.41" WC
 - Further testing for low temperature evaluation on O-ring seal and bar penetration with capped filter for liquid only option.
 - Results to date are promising



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Filterless / Capped SAVY Option for Manual Complianceunder consideration

- A filterless/capped SAVY without major container modifications
 - doable, but not necessarily easy
- A new Maximum Normal Operating Pressure (MNOP) evaluation will be necessary
 - Requires analysis of the desired content materials
 - Requires content control through procedure controls
- Gas generation
 - Container testing would be required to demonstrate the new MNOP
 - testing of bagout bags and materials under bounding loading conditions may be necessary



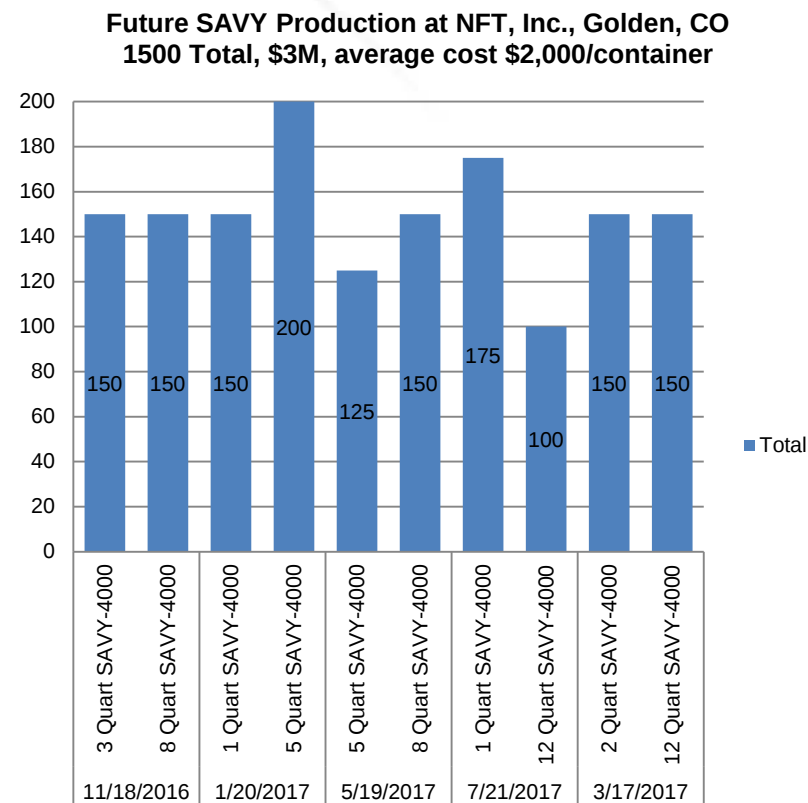
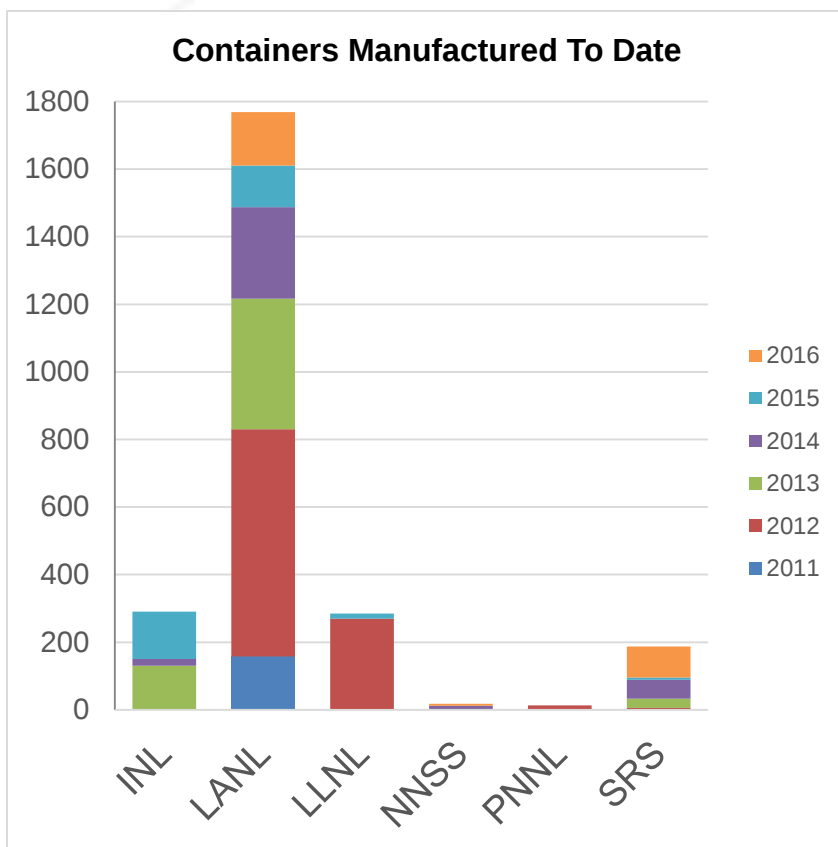
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Planned Safety Analysis Report Amendments

- 2 Quart container:
 - Provided a maximum loading efficiency in 9977 Type B shipping container, and to accommodate longer material contents.
- Life Extension:
 - Initial Design Life 5 years (clock started April, 2014 with SAR approval)
 - Expect to request at least 10 year extension
- Extended material authorized contents
- Under Consideration
 - Drop Tests: increased storage height to 16'
 - Hermetic Capped SAVY

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SAVY 4000 Production for DOE Sites (2562 Manufactured, 1500 in Production)



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SAVY 4000 Surveillance Approach

- No maintenance program (like a transportation container) required within the design lifetime, currently five years for all components
- Surveillance includes:
 - *Lifetime extension* efforts also apply to all components of the container, and no maintenance of in-service containers will be required during the extended lifetime
 - *Field Shelf Life NDE/DE tests*
 - *In Service Inspections:*
 - Prior to each use, containers and O-rings are inspected.
 - Defects found with the container will result in removal from service and provided to the Surveillance Program for evaluation
 - If defects are found with a component such as the O-ring, the O-ring is replaced and the defective O-ring is provided to the Surveillance Program for evaluation
- The goal is to have sufficient data from the surveillance and lifetime extension studies, within the 5-year design life, to gain confidence the design criteria will be met by all components over an extended lifetime as justified based on the data
- Complex Wide option available through MOUs with each site. LANL conducts a gap analysis such that the material, usage (T, height, weight) are bounded by LANL SAR.

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Surveillance Program Implementation

Sample Group	2015	2016	2017	2018	2019	Total
SAVY Field Shelf-Life, NDE-only	4 from 2014 plan	4 from 2015	6 total: 4 from 2015, + 1 BLO, + 1 HATCH/3	6	6	26
SAVY Field Shelf-Life, NDE/DE	6 (from 2014 plan)	9	6	6	6	33
SAVY I-of-O, NDE-only or NDE/DE if needed	10 (transfer containers)	10	10	10	10	50
SAVY EJ, NDE/DE	0	2 total: HATCH container and Transfer container	TBD ²	TBD	TBD	2+TBD
Hagan EJ NDE/ DE	4 (EJ NDE/DE - Heat Load items)	3 ³ (Table 3-1-b)	5 Pu-238 Residue Items (Table 3-3-b) (possibly examined after 2019)			4+TBD
Hagan I-of-O NDE/DE (up to 6 each year)	0	0	6	6	6	18
Total	24	25/28	27 + EJs	28 + EJs	28 + EJs	133/136 ³ + EJ TBDs

- Intent is to ensure that the SAVY-4000 containers function properly throughout their design life
- The different material characteristics, including metal, oxide and residues, are expected to bound both the corrosive properties and the thermal characteristics of the materials in storage
- The field shelf-life surveillance consists of 33 DE / NDE containers and 26 DE only containers over 5 years.
- This sampling schedule ensures availability of surveillance data within the initial SAVY design life of five years to support design life extension
- Items-of-opportunity containers will also be evaluated to provide additional data within the overall container population

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Surveillance Results:

Hatch Material, 7% Pu-238 in Weapons Grade Plutonium Oxide, High Heat Load, ~20 Watts



Photos taken after introduction into glovebox



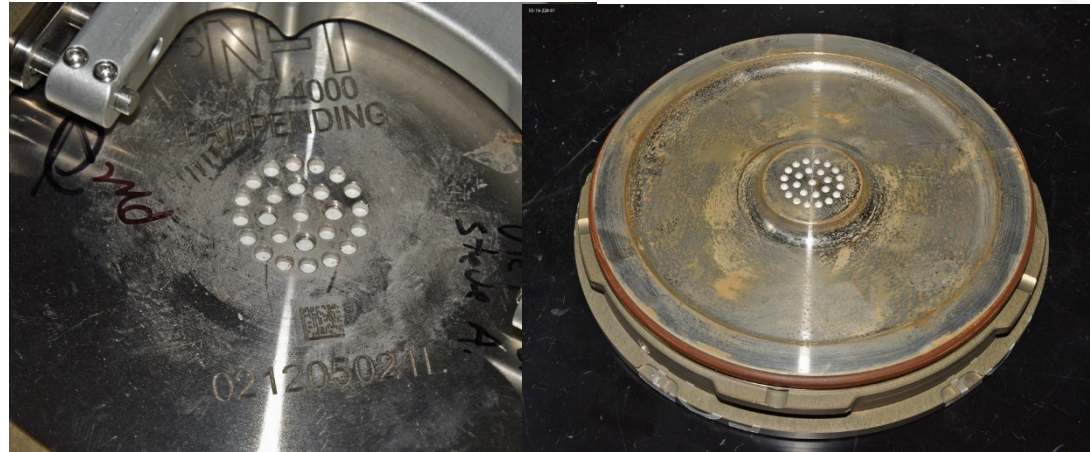
- First identified in 2015
- Significant TID wire corrosion
- No external contamination
- Identified during an In-Service Inspection
- Container Cognizant Systems Engineer issued Prompt Operability Report
 - Conclusion: Container functioning as designed
- Item is currently in glovebox line



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Surveillance Results: High Americium Molten Salt Extraction Residue

- No external contamination
- White powder on top exterior of lid
- Corrosion evident on internal surfaces of container
- Item was chosen for M441.1-1 Surveillance
 - We expected it to be a “worst case” item
 - Empty container was free of contamination
- Surveillance results
 - NDE: all tests passed except visual inspection
 - DE pending



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Surveillance Results: High Americium Molten Salt Extraction Residue in Hagan Container

- No external contamination
- Item identified during In-Service Inspection performed as part of MR&R re-shelving operation
- White powder identified as ammonium chloride
- Ammonium chloride on the container and shelf
- Vault personnel inspected vault locations and discovered other containers exhibiting similar behavior – no external contamination
- Container has been introduced into a glovebox for evaluation and testing



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Surveillance Results: 3 Molar HCl solutions (Solution Assay Instrument standards) stored for ~14 months

- No external contamination
- Items identified after unloading standard solutions into glovebox
- Items had been stored in floor location in TA-55 for approximately 14 months
- Empty containers are free of contamination
- NDE/DE examinations pending



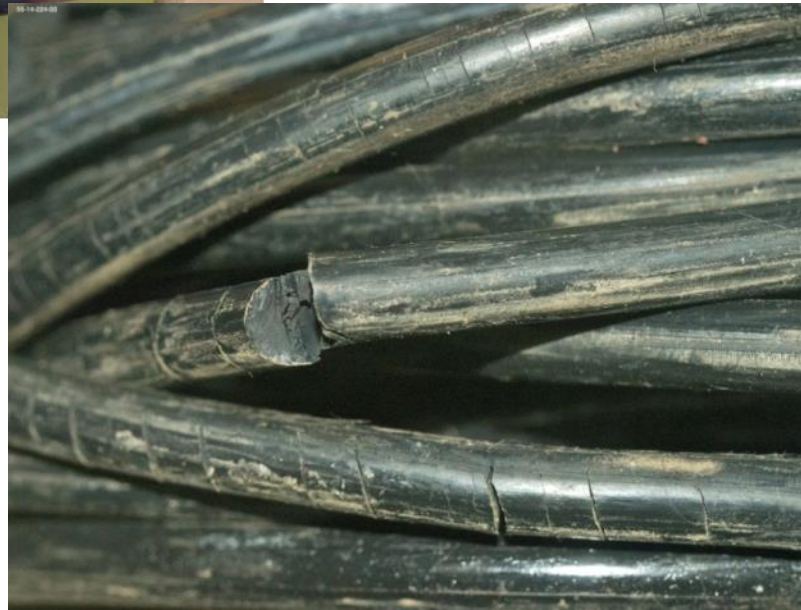
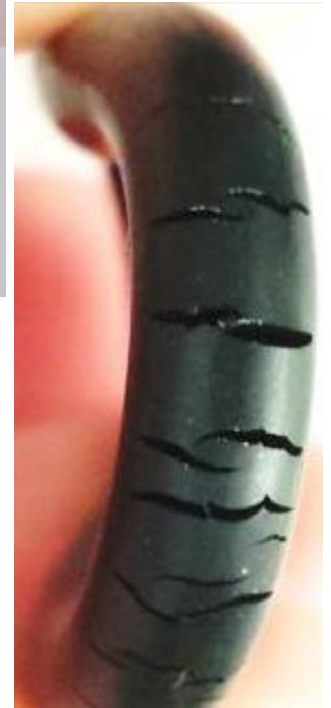
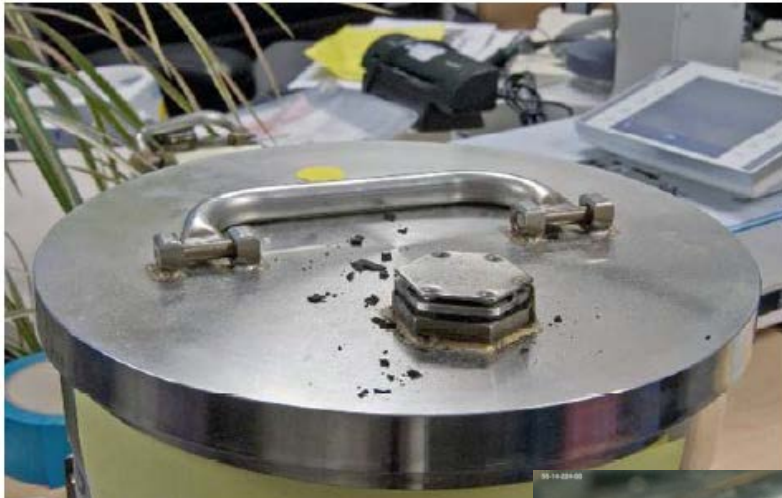
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Surveillance Implications: Corrosion of the stainless steel container

- High Wattage Materials (Hatch)
 - HCl generation from PVC bagout bags, consider replacing PVC with other plastic
- Molten Salt Extraction (MSE) Residues
 - ~250 MSE Salts at TA-55, pending aqueous americium recovery and/or discard
 - Composition likely contains hygroscopic salts, e.g., PuCl_3 , CaCl_2 , etc.
 - HCl generation likely from radiolysis of salt itself, possibly after water absorption
 - Implement Enhanced Surveillance
 - Determine bounding corrosion rate and corresponding container life
 - Increase MSE residue surveillance frequency
 - Develop new packaging configuration for MSE salts
 - Stabilization, hermetically sealed inner container
 - Justified based on gas pressurization rate
- Acid Solutions
 - Rigorous control of time in storage

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Why Polymer Lifetime is Important



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SAVY 4000 Lifetime Assessment

- Thermal Aging on samples and whole containers
 - Leak Testing
 - Compression Set
 - Durometry
 - Spectroscopy
 - Oxygen Consumption
- Radiation Aging
 - Compression Set
 - Durometry
 - Spectroscopy
- Synergistic Effects of Heat and Radiation
 - Compression Set
 - Durometry
 - Spectroscopy

Full container aging

- 1-Qt. SAVY containers in each oven (70, 90, 120, 160, 210°C)
- Periodically leak-tested.
- Difficult to remove lid after 9 months; No residue observed



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Time-Temperature Superposition Results for Compression Set for Viton O-Ring

- Results suggest two degradation mechanisms
 - High temperature (chemical) dominates at high temperature
 - Low temperature (mechanical) is not lifetime determining
- High temperature data indicates o-ring lifetime of 7,500 years at 70° C
- Represents an upper bound on the o-ring lifetime

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Evidence for Lifetime Extension Request

- High temperature data support much, much longer times than 40 years for our 50 durometer Viton O-rings
- All Viton O-rings examined after service to date at LANL have shown essentially no degradation
- Savannah River Site on 70 Durometer Viton O-rings
 - Established a lifetime of 15 years at 75 C
 - High temperature data on GLT-S support greater than 50 years
 - Results show an activation energy of 60, 81, and 90 kJ/mol
 - This is lower than the activation energy of LANL's 50 durometer O-ring of 135 kJ mol⁻¹
 - This suggests the lower durometer o-rings have an intrinsically longer life than the higher durometer o-rings

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O-Ring Lifetime Extension Conclusion

- There is no evidence at this point for a degrading mechanism that will result in a substantially shorter lifetime than 40 years
- LANL will continue its surveillance program to identify issues as they arise
- LANL will continue studies designed to uncover a lifetime limiting mechanism using
 - oxygen consumption measurements, FTIR measurements of O-rings that had been in-service to identify chemical changes in the polymers, etc.
- This will ensure that issues will be discovered early if they exist

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Summary

- SAVY 4000 containers have become the complex-wide standard for plutonium storage
- Los Alamos is saving DOE money by integrating container procurements and providing surveillance results for bounding contents to other sites
- Surveillance program is performing its intended function of identifying problem materials and ensuring container integrity
- Some materials will require special controls such as time limit, sealed inner container, extra stabilization, etc., to minimize corrosion
- Accelerated aging results on Viton o-ring provide technical basis for a significant lifetime extension

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