LA-UR-19-28823
Approved for public release; distribution is unlimited.

Title: Technical Basis: SAVY-4000 Series, 2 qt Container

Author(s): Smith, Paul Herrick
Stone, Timothy Amos
Karns, Tristan
Grow, David Isaac

Intended for: Report

Issued: 2019-08-30

Disclaimer:
Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by Triad National Security, LLC for the National Nuclear Security Administration of U.S. Department of Energy under contract 89233218CNA000001. By approving this article, the publisher recognizes that the U.S. Government retains nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy. Los Alamos National Laboratory strongly supports academic freedom and a researcher's right to publish; as an institution, however, the Laboratory does not endorse the viewpoint of a publication or guarantee its technical correctness.

Technical Basis
SAVY-4000 Series, 2 qt Container

Paul H. Smith, Timothy A. Stone*, Tristan M. Karns, and David I. Grow

Abstract
The 2 qt SAVY nuclear material storage container is the latest in the SAVY-4000 series. The 2 qt design is identical to the 1 qt container, with the exception of an extended, deep-drawn body. Here, a technical basis using engineering equivalency analysis, calculation, and test data is presented to establish that the 2 qt SAVY-4000 Container is a DOE Manual 441.1-1 compliant container and that a fifteen-year design life (as with the currently approved SAVY series) is justified.

***Corresponding author**: stone_tim@lanl.gov

Contents

1 Introduction 1
2 Design Description 2
3 Design Requirements & Adequacy Assessment 2
4 Conclusion 2
5 References 2
A Attachment 1: Design Life Extension Approval 6

1. Introduction

The SAVY-4000 Series (hereafter SAVY) nuclear material packaging system is a storage system compliant with DOE Manual 441.1-1, *Nuclear Material Packaging*, used at Los Alamos National Laboratory and across the DOE complex as the primary storage system for plutonium-containing materials not in 3013 containers. The SAVY design meets all applicable requirements of M441.1-1 and LANL Procedure P118, *Packaging Nuclear Material for On-Site Storage*.

DOE Approval of SAVY-4000 Container Series 15 Year Design Life

The SAVY-4000 Series containers initially had a design life of five years that was established in the SAVY-4000 Series Safety Analysis Report (SAR) Smith13 with clearly defined content limitations. In November 2013, the SAVY-4000 Series Safety Analysis Report [1] was submitted to DOE Los Alamos Field Office (NA-LA) for approval. The review was performed by the DOE Office of Packaging and Transportation (NA-531), and a Safety Evaluation Report (SER) [2] was transmitted to NA-LA on April 9, 2014 [3]. To quote from the Safety Evaluation Report:

> The review panel recommends the Los Alamos Field Office approve the SAVY 4000 SAR as the safety basis for the storage of solid nuclear materials in accordance with DOE M 441.1-1 for a period of five years from the date of this SER. After completion of extensive accelerated aging studies of the O-ring and non-destructive and destructive evaluations of the O-ring, filter, and other container components as described in the SAVY 4000 Surveillance Program, LANL may request an extension of the SAVY 4000 design life.

On April 16, 2014, DOE NA-LA transmitted the "SAVY 4000 Safety Analysis Report Approval" to Los Alamos [4]. On June 11-15, 2018, a DOE NA-LA Contractor Assessment was performed on LANL's DOE M441.1-1 surveillance and documentation programs [5]. On July 26, 2018, DOE NA-LA transmitted a letter to Los Alamos with the subject "Approval of Nuclear Material Storage Package Surveillance and Process for Documentation" [6]. This letter reaffirmed the existing technical basis, approved the surveillance program and the system for documentation, and requested an update to the technical basis based on surveillance results collected to date. The letter stated:

> Overall, the assessment team observed excellent performance including three noteworthy practices. Compliance was observed in all areas reviewed, there were no findings or weaknesses identified during the assessment. A few opportunities for the assessment team and the Contractor to continue to work and improve in this area were observed and documented in the report. Based on these results, NA-LA is hereby approving the nuclear material surveillance program and process for documentation. Additionally, NA-LA is reaffirming prior approvals of the technical basis for the SAVY Series and Fuel Storage Outer Containers. Please update the technical basis for the SAVY Series container design based on surveillance results collected for the past few years, and submit to NA-LA for review and approval.

On June 11, 2019, DOE NA-LA approved the request to extend the design life of the SAVY-4000 Container Series to 15 years [7].

2. Design Description

The new 2 qt SAVY container design joins seven other sizes, divided into four structural subgroups (Table 1). To achieve the deeper draw, the 316L stainless steel blank use is thicker than that utilized in 1 qt SAVY body production. The final body thickness of the 1 qt is .020–.030", whereas that of the 2 qt is 0.026–0.048". The primary dimensions of each model are listed in Table 2, and the payload parameters are given in Table 3. All sizes are intended as general-purpose, reusable containers for the storage of solid nuclear material inside a nuclear facility. A summary of allowable material contents for the SAVY is given in Table 4. Regardless of container size, the maximum heat load is 25 watts. Detailed drawings of the 2 qt container are available in Reference [9]. Additional information regarding the design, fabrication, and procurement is available in Reference [10], which includes:

1. SAVY-4000 fabrication specification
2. Acceptance test plan results
3. Final design review record
4. Final design review comment resolution
5. Weld procedure specifications
6. Example documentation package from NFT, Inc.
7. SAVY-4000 operating instructions (rev. 3)

3. Design Requirements & Adequacy Assessment

DOE Manual M441.1-1 provides detailed packaging requirements for protecting workers from exposure to nuclear materials stored outside of an approved engineered contamination barrier [11]. These requirements address: 1) stored material characteristics, 2) packaging design criteria and performance objectives, 3) packaging surveillance, and 4) documentation. Each of these requirement areas are addressed in in Table 5.

4. Conclusion

The use of the SAVY 4000 containers supports the existing nuclear material storage program at LANL. The primary purpose of this program is to protect workers from a 5 rem committed-effective-dose-equivalent inhalation of airborne contamination hazard during normal handling, storage, and in the event that a container is dropped.

The 2 qt SAVY design, material components, and operating procedures are similar or identical to those of previously approved SAVY containers. The 2 qt SAVY meets all DOE M441.1-1 requirements, based on a combination of engineering equivalency analysis, calculation, and test data presented and referenced here. Moreover, the design life of the 2 qt container should be approved to match the 15 year life of the rest of the SAVY Container Series (40 years for O-ring, filters and aluminum locking ring and 15 years for the stainless steel components (limiting factor)).

5. References

[1] Smith, PH, et al., *Safety Analysis Report for the SAVY 4000 Container Series (LA-CP-13-01502), in DOE/NNSA Review*, 2013, Los Alamos National Laboratory.

[2] Nez, DJ, *Safety Evaluation Report for the SAVY 4000 Series of Storage Containers, Revision 0,* 2014, US Department of Energy, National Nuclear Security Administration, Office of Packaging and Transportation.

[3] Al Daouk, AM, *Memorandum for Kim Davis Lebak, Manager*, 2014, US Department of Energy, National Nuclear Security Administration, Office of Packaging and Transportation.

[4] Rael, GJ, *SAVY 4000 Safety Analysis Report Approval (4771 NSM:8MH-571107)*, 2014, US Department of Energy, National Nuclear Security Administration, Los Alamos Field Office.

[5] Sipes, RR, *Evaluation of Surveillance and Documentation for the Material Recycle and Recovery, and Storage Programs (ASM-NSM-l .14.2017-766453)*, 2018, US Department of Energy, National Nuclear Security Administration, Los Alamos Field Office.

[6] Jung, JL, Goodrum, WS, *Approval of Nuclear Material Storage Package Surveillances and Process for Documentation (U1800960)*, 2018, US Department of Energy, National Nuclear Security Administration, Los Alamos Field Office.

[7] Jung, JL, Goodrum, WS, *Approval of Design Life Extension for the SAVY-4000 Container Series (MAI: 08MH-2019-001918)*, 2019, US Department of Energy, National Nuclear Security Administration, Los Alamos Field Office.

[8] Stone, TA, Reeves, KP, et al., *Technical Basis Update for the Design Life Extension of the SAVY-4000 Series Containers (Rev. 2)* (LA-UR-18-27269), 2019, Los Alamos National Laboratory.

[9] Stone, TA, *Compilation of Engineering Drawings for the 2 Quart SAVY-4000 Container* (LA-CP-19-20498), 2019, Los Alamos National Laboratory.

[10] Smith, PH, *Compilation of Design and Testing Documents for the 2 Quart SAVY-4000 Container* (LA-UR-19-28761), 2019, Los Alamos National Laboratory.

[11] *DOE M 441.1-1, Nuclear Material Packaging Manual*, Office of ES&H, DOE, on-line at www.directives.doe.gov/directives-documents.

[12] NFT Inc., *2 Qt SAVY-4000 Nuclear Material Container Acceptance Test Plan Results (Rev. 1)*, 2013.

Table 1. Structural Subgroups (SSG) for the SAVY 4000 Container Series

Structural Subgroup	Container Size	Unique Design Elements
SSG-1	1, 2 qt	Collar weld, deep drawn body, locking pin on locking ring, single lifting handle
SSG-2[a]	3, 5, 8, 12 qt	Collar weld, deep drawn body, locking lever on handle, single lifting handle
SSG-3[b]	5 gal	Collar weld, rolled body with seam weld, locking pin on locking ring, machined ribbed bottom plate welded to body, two lifting handles
SSG-4	10 gal	Collar weld, rolled body with roll hoops and seam weld, locking pin on locking ring, machined ribbed bottom plate welded to body, reinforcing ribs on lid, two lifting handles

[a] Baseline quart design
[b] Baseline gallon design

Table 2. Dimensional Specifications for the SAVY 4000 Container Series

Size	Overall Diameter (cm)	Overall Height (cm)	Min. Inner Diameter (cm)	Usable Inner Height (cm)	Inner Volume (L)	NFT Assy Drawing[a] (#)
1 qt	12.1	15.0	9.3	11.1	0.96	20110000
2 qt	12.1	25.4	9.3	21.5	1.78	20120000[b]
3 qt	16.6	20.2	13.8	17.2	3.07	20130000
5 qt	19.6	25.3	16.8	22.2	5.19	20150000
8 qt	22.5	29.1	19.7	26.1	8.61	20180000
12 qt	25.4	35.4	22.6	32.4	13.50	20220000
5 gal	29.8	40.5	26.0	35.7	19.40	20250000
10 gal	39.3	45.6	35.5	40.5	40.95	20300000

[a] Drawings for the SAVY series (excluding the 2 qt) are in Appendix A of Reference [1]
[b] Drawings for the 2 qt. design are in Reference [9]

Table 3. Payload Specifications for the SAVY 4000 Container Series

Size	Body Mass (kg)	Lid Mass (kg)	Container Mass (kg)	Min. Payload (kg)	Max. Payload (kg)	Max. Gross (kg)
1 qt	0.6	0.9	1.5	0	8.5	10.0
2 qt	1.2	0.9	2.0	0	10.2	12.2
3 qt	1.2	1.3	2.6	0	12.4	15.0
5 qt	1.6	1.8	3.4	0	14.7	18.1
8 qt	2.0	2.3	4.3	0	15.7	20.0
12 qt	2.4	3.0	5.4	0	16.8	22.2
5 gal	3.4	5.2	8.6	0	16.3	24.9
10 gal	5.0	6.9	11.9	0	28.0	39.9

Table 4. Summary of Allowable Material Contents for Storage Containers

Contents	**Bounding Case**
Radioactive material	Any actinide material with A_2 quantity greater than 0.002 g (based on heat-source Pu 238 oxide)
Max. heat load	25 watts
Chemical form	**Allowed**: All materials unless specifically not allowed **Allowed with restrictions**: metals that can undergo expansion are required to be in hermetically sealed inner containers when exceeding 1kg **Prohibited**: Materials with IDC codes[b] C02X, C19X, C39X, C40X, C61X, GXXX, KXXX, LXXX, N69X, R12X, and R59X, MXXJ, and M76X
Physical form	**Allowed**: Solids **Prohibited**: Liquids and gases
Max. Normal Operating Pressure	Differential pressure across container boundary of 1 kPa for quart-size containers, 2 kPa for the gallon-size containers
Max. payload	See Table 3

[a] *X* is generic for any number or letter

Table 5. DOE M441.1-1 Packaging Design Criteria & Performance Objectives[11]

No.	Design	Basis for Compliance of 2 qt Design
1	Stored Material Characteristics	No change relative to other approved SAVY containers (OASC)
2.a	Corrosion resistance	As with OASC, use of 316L stainless steel, Viton™ O-ring, and ceramic filter with PTFE membrane ensure corrosion-resistant containment barrier.
2.b	Thermal degradation resistance	Limit identical to OASC (25 watts); test data show container component steady-state temperatures $\leq 80.0^{\circ}$C, and decrease monotonically with container volume; therefore, the approved 1 qt SAVY is bounding [1, §4.1].
2.c	Radiation Resistance	As with OASC, materials of construction ensure radiation resistance; MCNP simulations detailed in [1, §5.6.3] determined that dose to the filter & O-ring of the 1 qt were at least double that of the 3 qt; it is there concluded that the 1 qt is bounding for all containers in the SAVY series; therefore, the 1 qt is bounding here.
2.d	Oxidative Expansion Accommodation	Limit to accommodate expansion of Pu metal is calculated to be 3.1 kg (vs. 1.2 kg for the 1 qt & 4.9 kg for the 3 qt); therefore, an administrative limit must be set at 3.0 kg (vs. 1.0 kg for 1 qt & 4.5 kg for the 3 qt) [1, §2.4].
2.e	Pressurization	Maximum Normal Operating Pressure (MNOP) during maximal exchange of gas due to radiolysis and atmospheric changes is calculated to be 0.23 kPA (similar to other quart-size SAVYs); therefore, MNOP set conservatively at 1 kPA; as with OASC, every unit is leak tested to 10 kPa [1, §5.4]
2.f	Incompatible & Pyrophoric Materials	Identical content requirements relative to other approved SAVY containers; therefore, the restrictions listed in Table 4 must be applied administratively
2.g	Filter Performance	Identical filter relative to other approved SAVY containers
2.h	Design Life	Through use of materials common to OASC, the design life of the stainless steel components is fifteen years; a 40-year design life is justified for the O-ring, filters, and aluminum locking ring [8]
2.i	Container Closure	Included locking device identical to that used in the 1 qt design, which precludes accidental opening or breaching during normal operating conditions
2.j	Design Release Rate	Identical design release rate applies to all SAVY containers [1, §3.10.1]; testing was conducted to demonstrate required performance [12]
2.k	Design Qualification Release Rate	Identical design qualification release rate applies to all SAVY containers using a drop height of 12' [1, §3.10.2]; testing was conducted to demonstrate required performance [12]
2.l	Nondestructive Examination	As with OASC, the design allows for nondestructive contents verification, inspection, and surveillance; the wall is sufficiently thin to allow content verification using standard MC&A measurement methods and sufficiently light to allow content surveillance using weight change.
2.m	Quality Assurance	Design, testing, and procurement processes identical to those used of OASC are applied; procurement includes ensuring compliance with LANL spec. 55Y-002926 via lot acceptance.
2.n	Labeling	Serial number, 2D data matrix barcode, and container type are permanently etched on exterior surface as with OASC.
3	Packaging Surveillance Program	Identical inclusion in existing LANL surveillance program applies; surveillance evaluates overall container integrity, helium leakage rate, O-ring durometer and compression set, and filter performance [8]; the surveillance program is evaluated annually and modified, as necessary, to adjust to observations from surveillance and accelerated aging studies; LANL's surveillance program has been endorsed by DOE NA-LA [6].
4	Documentation	Identical inclusion in existing LANL programs for maintaining information on stored materials, packaging, surveillance, and technical basis; LANL's process for documentation has been endorsed by DOE NA-LA [6]

Appendices

1. Attachment 1: Design Life Extension Approval

DEPARTMENT OF ENERGY
National Nuclear Security Administration
Los Alamos Field Office
Los Alamos, New Mexico 87544

JUN 1 1 2019

Ms. Andrea N. Martinez
Prime Contract Office Manager
Prime Contract Management Office
Los Alamos National Laboratory
Triad National Security, LLC
P.O. Box 1663, MS-M722
Los Alamos, NM 87545

Dear Ms. Martinez:

References:
1. Contract Number 89233218CNA000001, Triad National Security, LLC and the Department of Energy, National Nuclear Security Administration
2. Contract Clause H-43, *Performance Direction*
3. DOE M 441.1-1, *Nuclear Materials Packaging Manual*
4. Triad letter ALDWP 19-010 to W. Goodrum, NA-LA from David Eyler, Triad, Subject: *Request for Approval of SAVY-4000 Technical Basis Document Amendment*, dated March 29, 2019
5. Triad report LA-UR-18-27269 from Timothy Amos Stone, Kirk Patrick Reeves, Tristan Karns, Paul Herrick Smith, Kirk Douglas Veirs, Triad, Subject: *Technical Basis Update for Design Life Extension of the SAVY-4000 Series Containers*, dated March 11, 2019.
6. Triad report LA-UR-19-22133 from Paul Herrick Smith, Triad, Subject: *SAVY-4000 Technical Basis Document Comment Resolution*, dated March 8, 2019

Subject: Approval of Design Life Extension for the SAVY-4000 Container Series

Triad National Security, LLC (Triad) requested that the Los Alamos Field Office (NA-LA) review and approve the design life extension for SAVY-4000 series storage containers and approve the addition of a new design (2-Qt size) to the series of containers as stated in Reference (4). The supporting technical basis document Reference (5) has been reviewed by NA-LA subject matter experts in accordance with the requirements in Reference (3). Based on resolution of comments stated in Reference (6) and reviews of supporting documentation, NA-LA approves the design life extension from 5 years to 15 years as requested in Reference (4). NA-LA requests Triad to update its technical basis documents to include the 2 quart container along with any other changes and submit the updates to NA-LA for review and approval of the 2 quart container.

It is the position of the National Nuclear Security Administration that this direction is within the scope of the contract. If you have any questions regarding this direction, you may contact the undersigned at (505) 606-0249, or for technical questions you may contact William Gordon at (505) 665-6437 or Michael Heil at (505) 665-5920.

Jennifer L. Jung
Contracting Officer

for
William S. Goodrum
Manager

Enclosure

cc w/enclosure:
M. Fritts, NA-192.4, monty.fritts@nnsa.doe.gov
R. Verhaagen, OOM, NA-LA, richard.verhaagen@nnsa.doe.gov
G. Pugh, OOM, NA-LA, gabriel.pugh@nnsa.doe.gov
M. Miera, OOM, NA-LA, mark.miera@nnsa.doe.gov
J. Pugh, MAI, NA-LA, jody.pugh@nnsa.doe.gov
J. Sanchez, MAI, NA-LA, juan.sanchez@nnsa.doe.gov
M. Heil, MAI, NA-LA, michael.heil@nnsa.doe.gov
W. Gordon, FO, NA-LA, william.gordon@nnsa.doe.gov
P. Moss, DAMFO, NA-LA, patrick.moss@nnsa.doe.gov
J. Jung, BCM, NA-LA, jennifer.jung@nnsa.doe.gov
D. Svatos, BCM, NA-LA, dennis.svatos@nnsa.doe.gov
D. Eyler, ALDWP, Triad, deeyler@lanl.gov
R. Margevicius, ALDWP, Triad, margevicius@lanl.gov
L. Worl, PP-SMP, Triad, lworl@lanl.gov
C. Abeyta, PP-SMP, Triad, cabeyta@lanl.gov
P. Smith, SPE-2, Triad, smithp@lanl.gov
T. Karns, SPE-2, Triad tkarns@lanl.gov
J. Oka, SPE-2 Triad, oka_j@lanl.gov
J. Davis, SPE-2, Triad, jdavis@lanl.gov
A. Gallegos, DIR, Triad, amgallegos@lanl.gov
L. Lovato, DIR, Triad, lianaa@lanl.gov
pcm-do@lanl.gov
locatesteam@lanl.gov
Records Center, NA-LA
Official Contract File, NA-LA

MAI: 08MH-2019-001918