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Title: Analysis of the SAVY-4000 Nuclear Material Storage Container for Transportation

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Abstract:

The SAVY-4000 nuclear material storage container developed by Los Alamos National Laboratory and Nuclear Filter Technology, Inc. was designed for worker protection during handling and storage. However, the design lends itself to potential uses in transportation environments. For example, some potential customers have inquired about DOT Type A certification for use in transporting uranium within the LANL site. Other customers have stated a need to use the SAVY-4000 design as an internal container for the 9975 or 9977 Type B shipping containers. The idea is that material could be loaded into the SAVY-4000-like internal container at the shipping site, placed into the shipping container, shipped, and it would be ready for M441 compliant storage at the receiving site without subsequent repackaging or over-packing. This poster will analyze the requirements for Type A certification of the SAVY-4000 container and provide a proposed design for a SAVY-4000-like internal container for potential use in Type B shipping containers.

Introduction

The Department of Energy (DOE) issued DOE M 441.1-1, Nuclear Material Packaging Manual, hereafter referred to as the Manual, in March 2008, to protect workers who handle nuclear material from exposure due to loss of containment of stored materials. The Manual specifies a detailed approach to achieve high confidence in containers and includes requirements for container design and performance, design-life determinations, material contents, and surveillance and maintenance to ensure container integrity over time. The materials considered within the scope of the Manual include actinides stored outside an approved engineered-contamination barrier that could result in a worker exposure of greater than five rem Committed Effective Dose Equivalent (CEDE) if containment is lost. Nuclear Filter Technology, Inc. (NucFil) and LANL developed the SAVY-4000 container as a simple, robust, and reusable container for storing solid nuclear materials. The SAVY-4000 will replace the current "Hagan" style containers used for storage. The design of this container includes a filter to facilitate the release of hydrogen, thus preventing flammable gas mixtures from forming. The filter ensures that only minimal pressure (1 kPa) is possible within the container during use. In this respect, the container is not a pressure vessel but a lightweight, worker-friendly container (See Figure-1).

Figure 1. The SAVY-4000 Nuclear Material Storage Container

This paper describes the requirements and some initial scoping tests that demonstrate that the container can be certified as a DOT Type A shipping container and as an inner container for the 9975/9977 DOT Type B container. The SAVY-4000, if properly qualified to DOT requirements, will help simplify and minimize the steps taken in the shipping and storage process of solid nuclear material.

Container Design

The SAVY-4000 container is composed of two primary sub-assemblies; the body and the lid (see Figure-2). The body and lid are attached to one-another with a bayonet style closure such that the lid fits tightly within a collar attached to the body. The user achieves a leak tight seal by pushing the lid downward into the collar resulting in radial compression of a soft durometer Viton O-ring in a "piston groove" configuration between the body collar and the lid. The lid locks into place with a positive mechanical engagement made of aluminum and a stainless steel pin. No tools are required to open or close the container, which makes it possible for a single worker to open and close the container. The lid has a built-in filter made up of ceramic fibers that prevent hydrogen build-up inside the container and prevents particulate release. The filter is protected on the outside by a membrane that allows gases to pass but blocks out liquid water, thereby facilitating shedding of water in the event of a design basis accident. The containers and lids are interchangeable within a given container size, and the container is designed in such a way that it does require a leak test at each closure. Four of the filter vent holes are threaded for attaching a fitting for a helium leak test fixture at the time of manufacture and during surveillance. An aluminum handle is attached to the lid with stainless steel pins for manual handling and lifting. Holes in the collar allow water to drain off the lid in the event of facility sprinkler activation and allow for the installation of a tamper indicating device (TID). The internal components that form the containment boundary are made of 316L stainless steel for corrosion resistance.

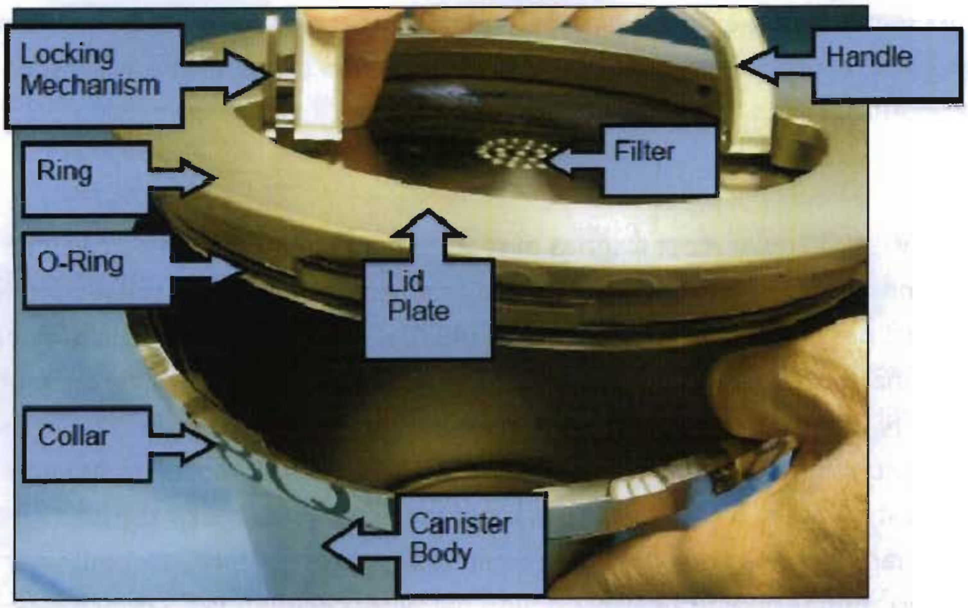

Figure 2. The Closure Mechanism of the SAVY-4000 Storage Container

The SAVY-4000 is manufactured in seven different sizes with nominal storage volumes of 1-, 3-, 5-, 8-, and 12-quarts and 5- and 10-gallons (See Table 1). Each container is built to fit into the next larger model. This design is useful when, if a container (for whatever reason) loses its ability to contain hazardous material in accordance to the safety regulations, it may be placed into a larger container eliminating the need to re-pack the material and dispose of the obsolete container. The initial design life for the container is 5 years, and it is expected to be extended to 40 years based on surveillance information gathered during the first 5 years in storage. Extending the storage service life will substantially reduce the number of containers requiring periodic repackaging and/or container maintenance.

Table 1. SAVY-4000 Overall Primary Dimensions, Container Weights and Payload Limits

Size	Overall Ø (in)	Overall Height (in)	Inner Ø (in)	Usable Inner Height (in)	Gross Weight (lb)	Tare Weight (lb)	Payload Max Weight (lb)
1 QT	4.770	5.980	3.670	4.38	22	3.3	18.7
3 QT	6.550	7.950	5.450	6.76	33	5.6	27.4
5 QT	7.700	9.950	6.600	8.76	40	7.4	32.6
8 QT	8.850	11.450	7.750	10.26	44	9.3	34.7
12 QT	10.000	13.950	8.900	12.76	49	11.9	37.1
5 GAL	11.750	15.665	10.250	14.06	55	18.9	36.1
10 GAL	15.469	17.635	13.969	15.87	88	26.2	61.8

In the area of transportation, the SAVY-4000 has shown many characteristics that are ideal for a DOT Type A container as well an inner container for the 9975/9977 DOT Type B container. The primary advantage of the SAVY-4000 is the fact that the user will be able to ship and store the material in the same container, minimizing the need to re-pack the hazardous material into a new container and keeping worker radiation doses as low as reasonably achievable (ALARA).

Requirements

The SAVY-4000 must meet a series of requirements before it can be certified for use in shipping environments. In order to be qualified as an acceptable DOT Type A container, the SAVY-4000 must pass four major integrity tests (49 CFR 173.465). First, the container must be "dropped in a matter that will cause the most damage" from a height that is deemed "worst case scenario" (4 feet for non-liquid contents) and still pass the required safety tests. Second, the SAVY-4000 container must pass a stacking test. The container must "be subjected for a period of at least 24 hours by 5 times the mass of the actual package or the equivalent of 1.9 pounds per square inch" and still pass the required safety tests. Third, the container must endure a penetration test where a "13.2 pound bar with a diameter of 1.3 inches and a spherical tip must be dropped from a height of 3.3 feet onto the most vulnerable part of the container." The container must not be punctured and must maintain its ability to pass all safety tests. Finally, the water spray test must be run at the beginning of testing and after each of the tests mentioned previously. In this test "the container must be sprayed with water that simulates rainfall of 2 inches per hour" and must remain watertight. If the container passes each one of these tests, it may be certified and used as a DOT Type A container. The requirements for use of the SAVY-4000 container as a convenience container inside a Type B 9975 /9977 container are that it must be the equivalent of a metal can with a crimped-seal closure, a slip lid closure, or site-specific convenience containers. Obviously, it must also fit inside the Type B inner container.

Results

The SAVY-4000 container was subjected to a series of preliminary scoping tests intended to bound the accident conditions required by the DOT Type A requirements. A series of drop, penetration and a water spray test were performed (the stacking test was not performed). The pass/fail criteria for both material release and water penetration was a helium leak test of 1.47×10^{-5} std cm3/s at 10kPa which corresponds to a worker dose rate of <5 Rem CEDE.

Drop Testing. The SAVY-4000 was dropped from 12 feet in the orientations illustrated in Figure 3. This is the drop height required for storage at LANL's Plutonium Facility, and it exceeds by a factor of three the drop height required by the Type A criterion for non liquid contents. These orientations are believed to encompass the worst-case drop scenario (including the four 1 ft free drop tests required for fissile material). A single container was dropped successively in 4 different orientations, and a second container was dropped successively in the remaining orientations. For each test, the container maintained its seal and passed a helium leak test (see Table 2).

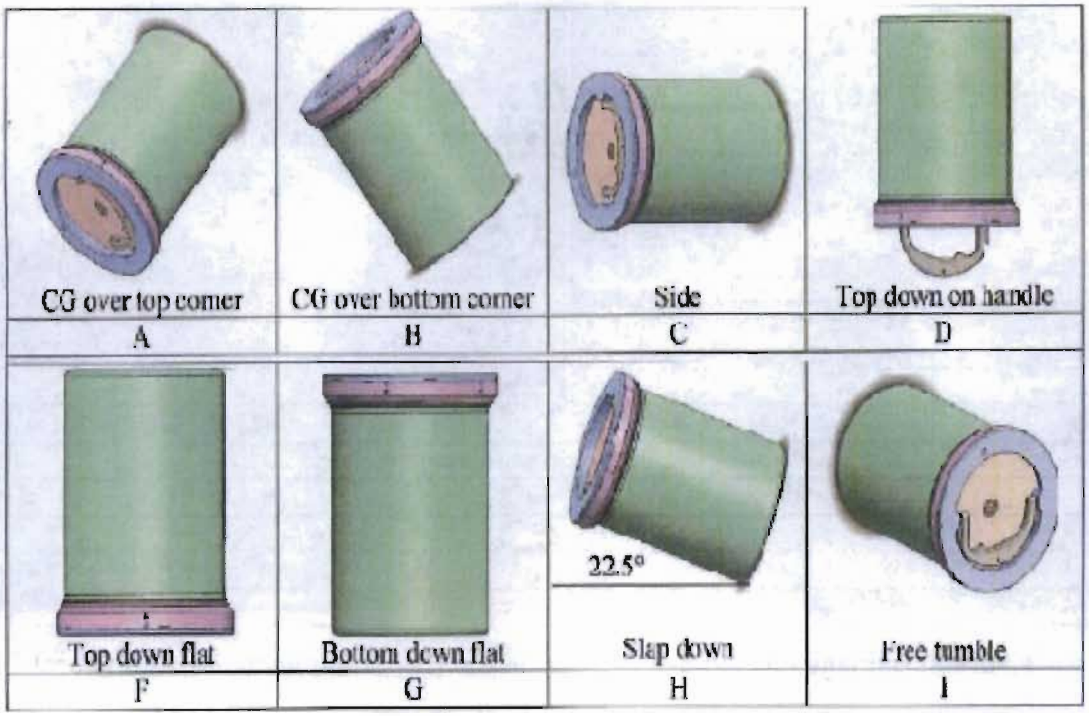

Figure 3. Drop Test Orientations

Table 2. Helium Leak Test Results After Successive 12 Foot Drops of the 5-Quart SAVY-4000

Test Article ID	Gross Weight (lbs)	Orientation	Post Drop Leak Rate (atm cc/sec)	Status
09/09-05005	42.0	CG over top corner	2.0×10^{-8}	Pass
09/09-05005	42.0	Bottom flat down	7.4×10^{-8}	Pass
09/09-05005	42.0	CG over bottom corner	3.8×10^{-8}	Pass
09/09-05005	42.0	Top flat down	4.0×10^{-8}	Pass
09/09-05003	40.5	Slap down	3.4×10^{-8}	Pass
09/09-05003	40.5	Side	4.6×10^{-8}	Pass
09/09-05003	40.5	Top down on handle	8.0×10^{-8}	Pass

Penetration Test. A 13.2 pound bar with a diameter of 1.3 inches and a spherical tip was dropped from a height of 4 feet onto 3 different points on the container (the filter, a point near the weld and the bottom, see Figure 4) that are expected to be the most vulnerable parts of the container. A helium leak test (see Figure 5) was performed on the container following the penetration and water spray test. The helium leak rate measured after the penetration and water spray tests was 9.1×10^{-8} atm cc/sec. The SAVY-4000 also passed a water spray test after the penetration insults, and no water was found inside the container.

Figure 4. Damage Caused by Penetration Bar (Left: near weld, Right: bottom)

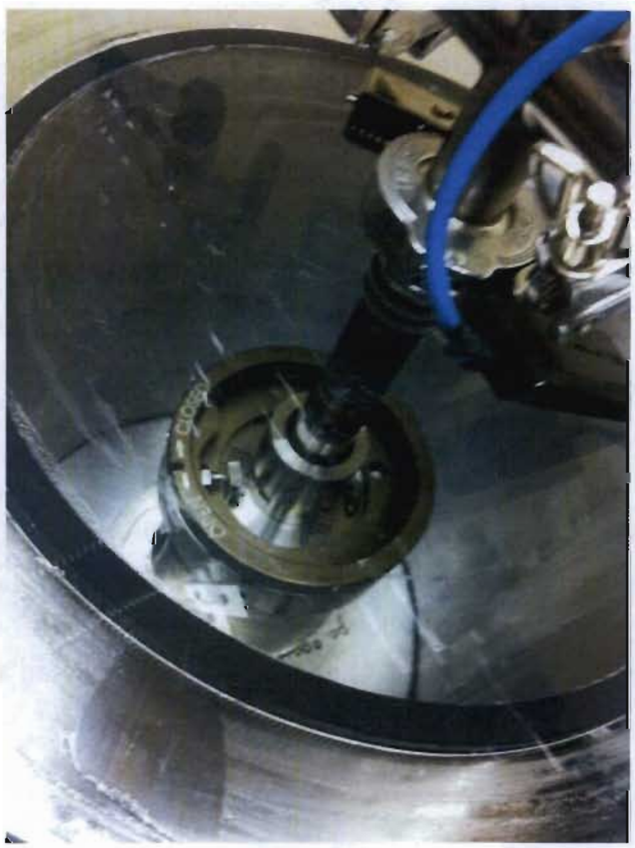

Figure 5. Helium Leak Testing of the Container After Penetration Tests

Type B Convenience Container Analysis. The one-quart SAVY-4000 (see Figure 6) will be used in the Type B shipping process. It is clear that the SAVY-4000 is the equivalent of a metal can with a crimped-seal closure, a slip lid closure, or site-specific convenience containers. The one-quart SAVY-4000 has been designed to fit into the inner containment vessel of both the 9975/9977 Type B containers. Because of the 4.77-inch radius of the one-quart SAVY-4000, it is a perfect size to fit into the 5-inch inner diameter of the 9975/9977. Because DOT Type B containers are used to transport relatively large quantities of plutonium, the benefits of using a container that is approved for storage (thus minimizing repackaging upon receipt) are most pronounced. The ability to ship the materials in the container that they will be stored in will significantly minimize the number of steps needed to safely handle the material, and it will make the overall job of the workers handling these materials easier and safer.

Figure 6. SAVY-4000 One Quart Container

An elongated version of the one-quart SAVY-4000 has been designed and is in the process of being manufactured to meet the requirements of several different DOE customers. A longer version of the container is needed to fit items taller than the 5.98-inch height of the container. The dimensions for a 9975/9977 are 6x15 inch and 6x20 ¼ inch respectively (see Figure 7); however, any object ever 450g must have a spacer within the container minimizing the diameter to 5 inches. The elongated version of the one-quart SAVY-4000 will allow users to ship larger materials without the need to break apart or minimize the pieces being shipped. The one-quart container will maintain the 4.77-inch diameter, but will be elongated to around 8 inches in order to fit larger materials.

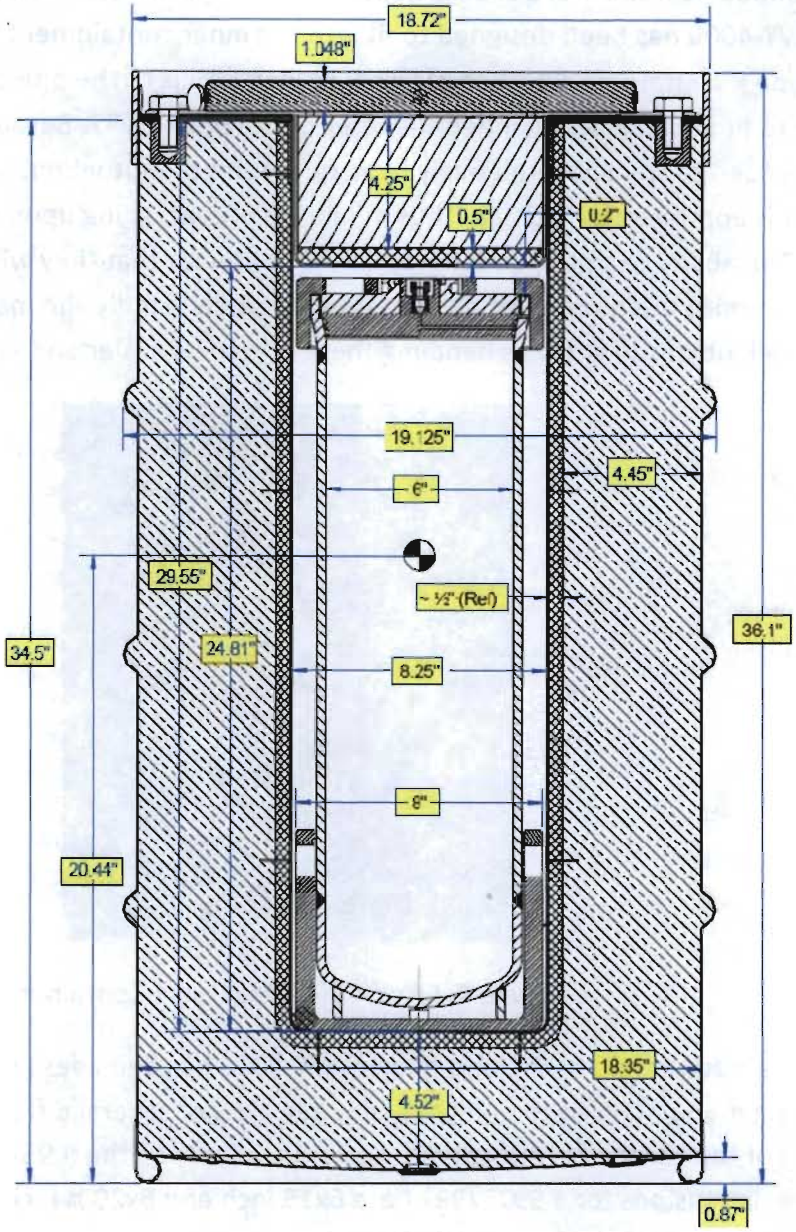

Figure 7. Type B 9977 Shipping Container

The SAVY-4000 container was initially designed for the protection of workers during the handling and storage of nuclear and radioactive material. However, because the design of the container works so successfully the idea of using it for transportation is worthy of consideration and testing. If the SAVY-4000 is approved as a DOT Type A container as well as an acceptable inner container for the DOT Type B container, it will improve how hazardous materials are shipped. This will create a safer and easier environment for the workers handling the materials as well as cut the amount of waste created from unpacking and over-packing these materials into new containers.

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