

## Design, Testing, and Certification of a Type-A Shipping Package for the Mk-18A Program

Mark Bowers and Bradley Loftin, Savannah River National Laboratory

### **Abstract:**

The Savannah River National Laboratory Packaging Technology and Transportation Engineering organization, along with Oak Ridge National Laboratory personnel, modified an existing Type-A Shipping Package for use in the Mk-18A isotope recovery project. The Mk-18A project mission is to recover rare, irreplaceable isotopes created at the Savannah River Site by processing the target materials at SRNL and then shipping the recovered materials to ORNL for future use. The modified Type-A package will be utilized to ship some of these recovered materials. The modified design was tested to show its ability to withstand the accidents required by the code of federal regulations, and then the design was certified by SRNL for shipment. This paper will discuss the design of the Type-A package, the testing program, the results of the testing, and the Type-A package certification process.

### **Background:**

The Savannah River Site operated five production reactors in support of United States nuclear defense programs producing mainly plutonium and tritium. However, there were a few cases where multi-year irradiation campaigns placed special targets in the core of production reactors for scientific research programs and in some cases for extended periods of time. One such campaign, begun in 1969, was a high-flux campaign to irradiate  $^{242}\text{Pu}$  to produce  $^{252}\text{Cf}$ . The initial irradiation ended 15 months later, but 65 of the Mk-18A targets remained in the reactor core until discharged in 1979.

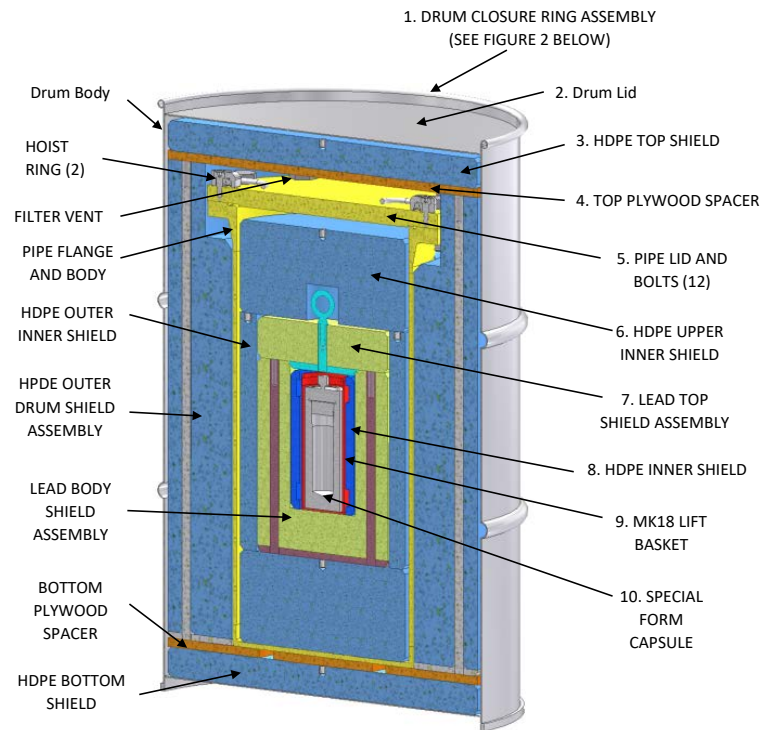
The extended high-flux irradiation of the Mk-18A targets resulted in various rare isotopes being produced in the target. Some of these isotopes include  $^{244}\text{Cm}$ ,  $^{246}\text{Cm}$ ,  $^{248}\text{Cm}$ , and  $^{244}\text{Pu}$ . Of particular interest is the  $^{244}\text{Pu}$  since it is virtually impossible to replicate this production, at this same scale, using existing high-flux reactors and, since the early 1990s, the reactors at SRS have not been in production nor operated. Thus, it was decided to explore options for recovery of these targets to preserve the valuable isotopes contained within them.

Each Mk-18A target contains more than 1 A<sub>2</sub> of contents per 49 CFR and would be required to be shipped, in commerce, in a Type B package. Once processed the plutonium will indeed be packaged and shipped within a Type-B package, however, the remaining product will be split into aliquots, packaged into special form capsules, and shipped in a Type-A Shipping Package.

### **Mk-18A Type A Package Design:**

To meet the applicable requirements of 49 CFR 172, 49 CFR 173, and 49 CFR 178, the design of an existing drum, the Los Alamos National Laboratory S-300, was modified to incorporate the necessary shielding for the Mk-18A contents. The design consists of an outer 55-gallon open head carbon steel drum having a lid with a gasket, and closed with a 12 gauge bolt ring utilizing a single bolt. Internal to the drum is High Density Polyethylene (HDPE) neutron shielding and within that is a robust cylindrical stainless steel (SS) 12-inch Pipe Component (PC) centered within the HDPE shielding. Plywood spacers are located above and below the PC. The PC has a cylindrical body with a welded bottom and a bolted stainless steel lid having an O-ring seal, a filter vent, two hoist rings, and is closed using 12-heavy hex head bolts. Internal to the PC is HDPE neutron shielding and within that is a Lead Shield Assembly (LSA).

The LSA is a right circular cylinder having a body with an integral bottom and removable lid. The internal cavity of the LSA has an annular HDPE Inner Shield, a SS lift basket and the special form capsule (SFC). The HDPE inner shield, lift basket and SFC are considered content components. The MK-18A packaging utilizes a qualified special form capsule (SFC) to provide containment.[1] The approximate weight of the Mk-18A Type-A Shipping Package is 910 pounds. A representation of the design is shown in Figure 1.



Note: Components (1-10) on right side of Figure 1 are typically removed and re-installed during opening and closure operations.

Figure 1: Mk-18A Type-A Shipping Package (Representation)

This design, after the completion of successful testing, will allow the Mk-18A Type-A Shipping Package containing a LANL Model-III Special Form Capsule [2] to remain within all of the requirements of 49 CFR 172 for the shipment of Class 7 materials from the Savannah River National Laboratory (SRNL) to the Oak Ridge National Laboratory (ORNL).

#### **Mk-18A Type-A Package Testing:**

Two test units were prepared for testing. The testing was performed in accordance with 49 CFR 173.465. The two test units were labeled Test Units 1 and 2; TU-1 and TU-2.

TU-1 was loaded with a stainless steel (SS) billet to simulate a special form capsule. The SS billet was approximately 7.2 Kg (15.9 lbs). TU-1 was subjected to the water spray test, the stack test and a free drop test. TU-2 was loaded with material to simulate normal form including a SS billet which

weighed approximately 4.5 Kg (9.9 lbs), ¾" bung plugs and numerous ¾" diameter x 20 gage metal coupons. The HDPE Inner Shield (Dwg. N3E020995A556 R/0 Item 1-10) was removed from TU-2 during the testing to better simulate the configuration during shipment. TU-2 was subjected to the water spray test, the penetration test and a free drop test. Testing was performed at Skolnik Industries, Chicago, IL. Each test unit was inspected by ORNL Fabrication to the production drawing, N3E020995A556, Rev. 0. Upon inspection of the drums, per 49 CFR 173.462, a determination was made that both test units required the gasket to be reinstalled due to improper seating of the drum lid during assembly of the components by Fabrication. Other than superficial paint scuffing on the side of each test unit, no other discrepancies were identified with either unit and testing proceeded. [3]

TU-1 loaded gross weight was 420.5 Kg (927 lbs.) with the SS billet [7.2 Kg (15.9 lbs)] used as lading. TU-2 loaded gross weight was 421.5 Kg (929 lbs.) with a SS billet which weighed approximately 4.5 Kg (9.9 lbs) in addition to bung plugs and various metal coupons used as lading to simulate forms 1, 2 and 3 as defined in DOE documents. For TU-1, the HDPE Inner Shield was left in place per the expected configuration when shipping a special form capsule of the MK-18A material. The HDPE Inner Shield was removed per the expected configuration when shipping material for TU-2. For both TU-1 and TU-2, plastic sheeting was placed on top of the HDPE Upper Inner Shield Assembly (Dwg. N3E020995A556 R/0 Item 1-6). The fluorescein/flour test media/indicator mixture was placed on top of the sheeting. The lid of the inner pipe component (PC) was placed without the use of the alignment pins, and the inner PC was closed in accordance to the ORNL/SRS developed closing instructions (attached to the test report). The PC bolts retained adequate lubricant and no additional lubricant was added. Inspections were made to determine that no loose fluorescein remained on the outside of the PC sealing surface. The remaining steps of the closing instructions were completed including the NucFilter and drum head cover/ring torque closure. [3] The water spray, stack, and free drop tests were performed on TU-1 and the water spray, penetration, and free drop tests were performed on TU-2.

#### **Mk-18A Type A Package Test Results:**

Mk-18A test units, Test Unit 1 (TU-1) and Test Unit 2 (TU-2), were returned to ORNL after Type A testing was conducted at Skolnik Industries on 8/15-16/2017. The drums were initially opened and inspected at Skolnik after testing to evaluate loss of content and visible shielding. There was no loss of content or shielding. Upon return to ORNL, the drums were disassembled to better evaluate the shielding damage caused during the Type A testing process. TU-1 was the test unit that was dropped on the side. All HDPE shielding was intact with no visible damage. However, upon opening the pipe component and removing the lead shield lid, it was noted that the lead shield was out of round. The post-test dimensions are 9 160/1000" by 9 330/1000 ". Although the shield is slightly out of round, this does not pose an issue for the overall capability of the package to provide adequate shielding. Additionally, the remainder of the package internal components showed no discernible damage. TU-2 had no visible damage upon disassembly. ORNL and SRS representatives determined that no loss of content was observed due to the sequence of tests performed on TU-2.

Pictures of the test units and descriptions of the testing and results are listed below.



TU-1 Water Spray Test



TU-1 Post Water Spray Test



TU-1 Horizontal Drop Test



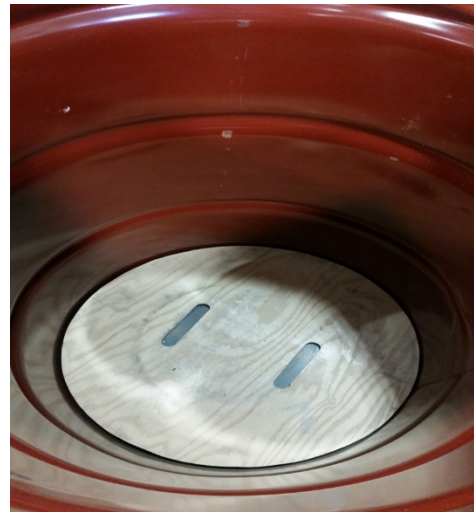
TU-1 Post Drop



TU-1 Post Drop Damage



TU-1 Lead shield deformation



TU-1 Inside look with HDPE removed



TU-2 Penetration Test



TU-2 Post Penetration Test Damage



TU-2 Drop Test



TU-2 Post Drop Test Damage

**Mk-18A Type A Package Certification:**

The Mk-18A Type A Shipping Package contains a LANL Model-III Special Form Capsule (SFC). Under DOT regulations, the SFC must be tested to ensure that it can maintain containment of the materials throughout a testing sequence. LANL performed those tests on their Model-III SFC, applied for, and was granted a certificate for the SFC. The contents in the Mk-18A are the same in form as those that are certified within the LANL SFC. Therefore, SRNL will certify the contents within the SFC for shipment to ORNL under DOT regulations. SRNL procedures require that a Compliance Summary for the package be developed to ensure that the appropriate sections of 49 CFR are met by the SFC and the Type-A Shipping Package. The package will be loaded per the closure instructions developed at SRNL, will be shipped to ORNL, and will then be unloaded for return to SRNL to be loaded with another processed mk-18A Target.

**References:**

1. Opperman, Bowers, et.al., Summary of Compliance of the Mk-18A Type A Package Design with the 49 CFR 178.350 Specification 7A General Packaging Type A for Radioactive Materials
2. LANL Special Form Capsule Design
3. Skolnik Testing Notes, Mk-18A DOT 7A Type A Shipping Container, August 15-16, 2017