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# Type A Fissile Packaging for Air Transport Project Overview

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## ABSTRACT

This paper presents the project status of the Model 9980, a new Type A fissile packaging for use in air transport. The Savannah River National Laboratory (SRNL) developed this new packaging to be a light weight (<150-lb), drum-style package and prepared a Safety Analysis for Packaging (SARP) for submission to the DOE/EM. The package design incorporates unique features and engineered materials specifically designed to minimize packaging weight and to be in compliance with 10CFR71 requirements. Prototypes were fabricated and tested to evaluate the design when subjected to Normal Conditions of Transport (NCT) and Hypothetical Accident Conditions (HAC). An overview of the design details, results of the regulatory testing, and lessons learned from the prototype fabrication for the 9980 will be presented.

## INTRODUCTION

The Model 9980 packaging was designed by SRNL for the Department of Homeland Security (DHS) to comply with the packaging safety requirements of Title 49, Part 173.317 of the Code of Federal Regulations[1] to receive a Certificate of Compliance for the shipment of Type A Fissile quantities of material by air. Regulatory package testing was performed by Oak Ridge National Laboratory National Transportation Research Center. The objective of the project was to develop a light-weight Type A Fissile shipping package that is in compliance with the regulatory requirements and that meets weight restrictions (<150 lbs) for overnight express courier transport.

The 9980 packaging is designed to permit overnight air transport of a 5-inch diameter special form content, USA/0783/S-96. The package is designed to confine the content within the packaging under the regulatory normal and accident conditions of transport. The following design requirements were considered in the development of the final 9980 packaging:

- A maximum gross weight of less than 140-pounds for air transport
- Only standard tools and equipment required for assembly, handling and maintenance
- A 10-gallon stainless steel drum configuration for durability and configuration that permits stacking
- A threaded overpack closure plug to secure the carrier/contents centered within the packaging cavity
- A removable carrier for the contents
- Energy-absorbing, aluminum foam packing material to secure the contents

## SRNL DEVELOPMENT TESTING

To support the design of the 9980 package five pre-prototypes were fabricated and structurally tested by SRNL at the Savannah River Site to the Hypothetical Accident Conditions required by 10 CFR 71.[2] **T**he pre-prototype design concepts evaluated different materials for energy absorption (foams, aluminum honeycomb) and puncture resistance (carbon fiber, Kevlar, fiberglass and steel). Structural testing included 30-foot drop, crush (1,100 lb plate dropped from 30-ft), and Puncture (250kg probe dropped from 3 meters). Results of these tests are illustrated in Figure 1 and Figure 2.

Aluminum Honeycomb with

Carbon Fiber Wrap (Probe test)

Dow Automotive Polyurethane Foam

Probe Test (Polyurethane filled Drum)

Figure 1 – 9980 Pre-Prototype Development and Testing

Figure 2 – 9980 Pre-Prototype Conceptual Design Test Results

**9980 DESIGN**

Based on the testing results and destructive evaluation of tested packages and the lesson learned the final design for the 9980 was developed. The final packaging configuration assembly is depicted in Figure 3. The 9980 packaging comprises a Carrier Assembly that secures the radioactive content within an insulated 10-gallon Overpack. The Overpack includes an integral Liner Weldment that separates the Carrier from the insulation materials within the Overpack. The 9980 10-gallon Overpack includes polyurethane foam, TR-19™ Block Insulation, a ceramic Insulation Cylinder, a Composite Shell and silicone covered aluminum foam Spacers that provide both structural support and thermal insulation for the package.

A threaded Overpack Plug secures the Carrier Assembly between two Spacers within the Overpack. The Carrier Assembly provides convenience handling of and positioning for the content within the Package. A Quick Lever Lock Ring is used to secure a standard Drum Cover to the top of the Package.

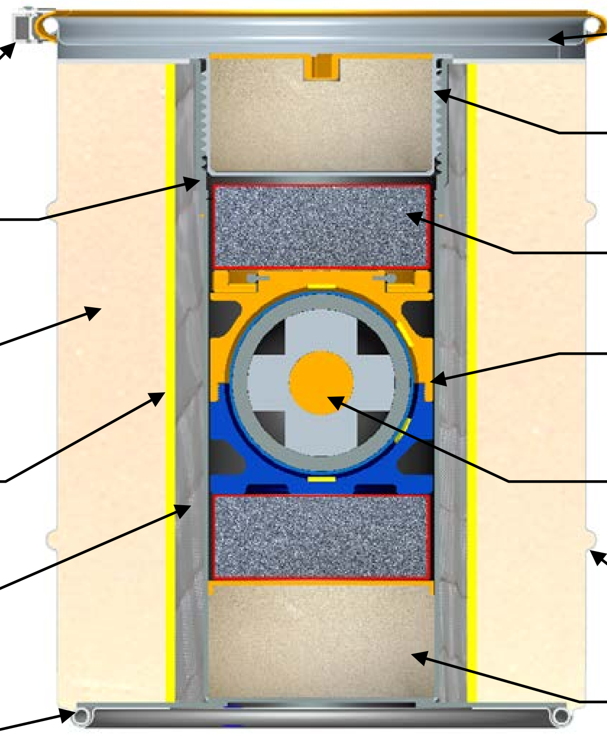



**Figure 3 9980 Packaging Configuration**

**PACKAGING DESIGN FEATURES**

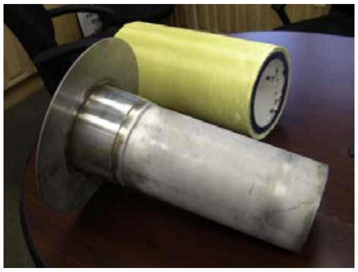
The Overpack Assembly is fabricated in accordance with 49 CFR 178.500[3], the American Welding Society (AWS) D1.6[4], and American Society of Mechanical Engineers, Boiler and Pressure Vessel Code (B&PVC), Section VIII, Division 1[5]. The Overpack Assembly consists of the Overpack Subassembly and Overpack Plug. A Carrier Assembly is centrally positioned in the Overpack by two aluminum foam spacers.

<u>Overpack Subassembly</u>

The subassembly utilizes a custom stainless steel open head sanitary style 10-gallon drum for the overpack. The Overpack is nominally 14-1/16 inches diameter measured to the outside of the wall and 19-1/8 inches high to the top of the lever-lock closure ring which includes a tab for a TID. The Drum Cover incorporates an ethylene propylene diene M-class (EPDM) closure gasket for weather protection. The outer cylinder of the Overpack incorporates two integral rolling hoops for rigidity. A formed foot-ring strengthened with an internal tube in the drum Overpack bottom facilitates package stacking.

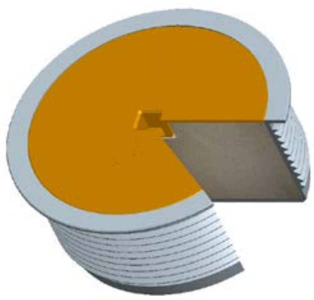
The Overpack Liner is fabricated from stainless steel tube having a nominal inside diameter of 6 inches with a 1/8-inch thick bottom wall section and ½-inch thick top wall section that is machined with a 6.375-4UN 1B thread. A 1/8-inch thick stainless steel disk is welded within the bottom section of the liner to center the installed Carrier Assembly within the package. TR-19™ Block Insulation is placed beneath the Liner Shelf and is secured in place by welding 6-inch OD, 11 gauge plate. This plate also provides puncture resistance to the bottom of the Overpack Liner. A 7-inch ID by 14-inch outside diameter 11 gauge disk fabricated from ASME SA-693 Grade 630, 17-4, heat treated to H1150, is welded to the top of the liner for joining to the drum.

A nominally ¾-inch thick ceramic fiber Insulation Cylinder is fitted to the Liner Weldment and wrapped with alternating layers of resin-infused fiberglass and Kevlar® which forms an approximately 5/16-inch thick Composite Shell for puncture resistance. The composite wrapped liner is then inserted into the 10-gallon Drum Weldment and welded to the drum wall at the top and to a 11 gauge 17-4 plate at the drum bottom. The cylindrical volume between the Composite Shell and drum wall is filled with polyurethane foam through a fill-port in the bottom of the drum. The polyurethane foam forms an approximately 2¾-inch thick radial by 14-inch OD rigid cylinder that provides thermal insulation and impact protection.



Overpack Plug

The Overpack Plug is fabricated from Armco Nitronic-60 stainless steel bar. The plug is machined with a 6.375-4UN 1A thread, with a 7-inch diameter by 1/8 inch thick top flange. The inside of the plug is machined to receive a nominally 5-7/8 inch diameter by 3-inch thick disk of TR-19™ Block Insulation. A 0.12-inch thick 17-4 plate, heat treated, is welded to the plug top to encapsulate the TR-19™ Block Insulation and to provide puncture resistance. A recessed feature is machined in the center of the 17-4 plate to receive a standard ½-inch drive socket to facilitate opening and closing the package.

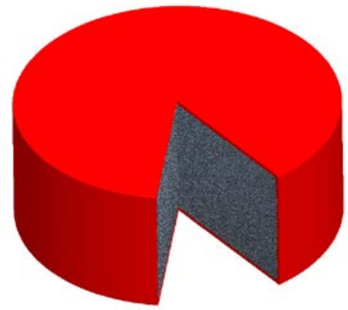


Carrier Assembly

The Carrier consists of two machined threaded caps (5.25-12 UN 2B/2A) fabricated from T6511 aluminium round bar. When threaded together the two caps form a 5.15-inch diameter spherical cavity that secures the 5-inch spherical content. The Carrier Assembly halves are hard coat anodized to prevent thread galling and to provide a durable surface. Eight ¾-inch diameter felt pads with adhesive backing are secured to the inside of each Carrier half and provide a cushion between the Carrier Assembly and the spherical content. The top half of the Carrier Assembly includes a lifting handle to allow loading and unloading of the Carrier Assembly from the package.

Spacers

Two aluminum foam Spacers are placed above and below the Carrier Assembly to center its position within the Overpack. The spacers are made from 6101-T6 aluminum open-celled Duocel® foam having a density of 9-12% (relative to the solid aluminum) and nominal crush strength of 330 psi. The spacers are nominally 5¾ inches in diameter by 2¼ inches in height, including a 1/16-inch sheet of silicone rubber bonded to the surfaces of the aluminum foam with a Silicone Rubber Adhesive Sealant. The silicone covers rough edges on the aluminum foam surface which also provides a smooth, durable handling surface. A lifting bail is attached to each Spacer to facilitate assembly into the Overpack.



**TESTING SUMMARY AND 10CFR71 COMPLIANCE**

Evaluation of the NCT and HAC performance requirements by testing at ORNL/NTRC demonstrate the 9980 complies with 10 CFR Part 71 for transportation of special-form content. Packages subjected to the series of NCT tests, e.g., water spray, free drop and penetration impacts showed no loss of effectiveness of the 10-gallon Overpack. External damage amounted to minor scuffing and denting and there was "no loss or dispersal of (simulated) radioactive contents".

The HAC testing e.g, 30-ft drop, crush, puncture, fire etc. demonstrated that the 9980 Overpack remained intact and that there was no loss of the its solid radioactive material. Thermal analysis showed the integrity of the special form content was not compromised due to the 30-minute thermal event. Criticality analysis shows a 5x5x5 array of packages would remain subcritical conservatively assuming complete radial and axial loss of the outer drum and its insulation materials. Pictures from NCT and HAC testing along with destructive examination of the packages are provided below. Damage from NCT and HAC is minor especially considering the small size of the 9980 and the tests it was subjected to (30-ft drop and 1,100 lb plate crush).

Figure 4 illustrates the NCT water spray and compression tests. Damage from the 4-foot drop and penetration testing is also shown. Damage was minimal showing no signs of losing packaging integrity or loss of content.

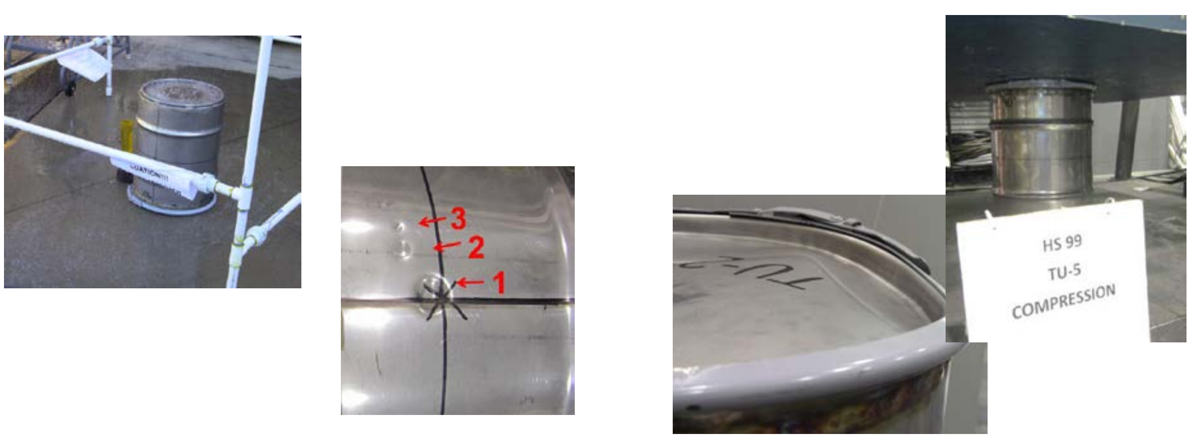
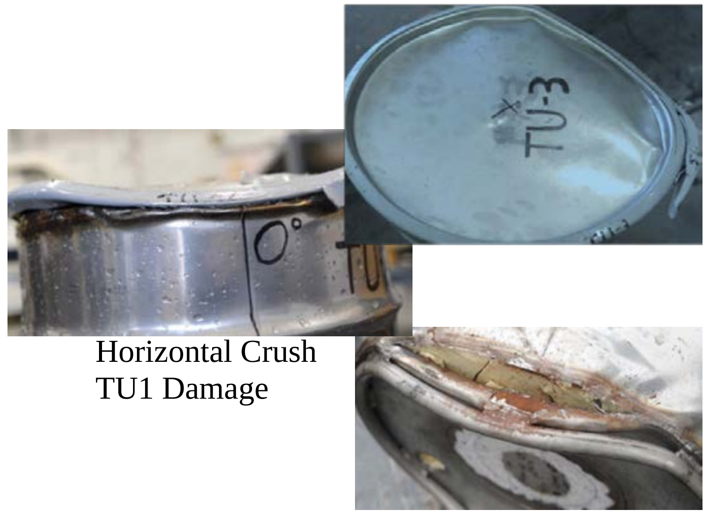



**Figure 4 NCT Testing (Water Spray, Compression) - Damage from 4-Ft drop and Puncture bar**

Figure 5 illustrates HAC 30-ft drop and Crush testing.  For the 30-ft drop, deformation of the package was greatest for the Center of Gravity over Corner drop orientation; Test Unit #2 (TU2) pictured.  For the crush test, deformation of the package was greatest in the horizontal orientation.  Overpack surface tearing at the  drum surface resulted in some exposure of the drum polyurethane foam; TU1 is pictured.

CG Crush
TU-2 Setup

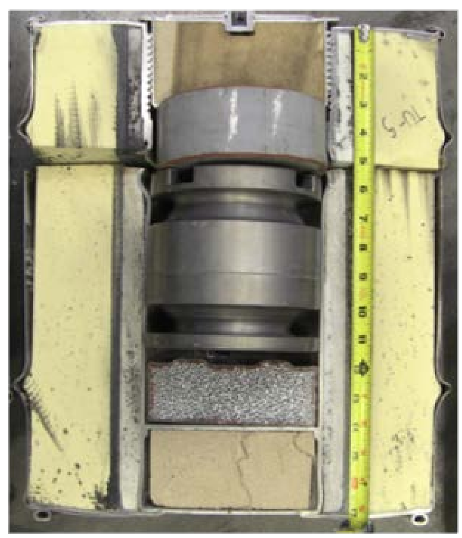
Horizontal
Crush Setup




Horizontal Crush
TU1 Damage

**Figure 5  Hypothetical Accident Condition 30-Foot Drop and 30-Foot (1,100 lb. Plate) Crush**

The picture to the right of Test Unit #5 (TU5) shows the overpack re-assembled following destructive examination. The sectioned configuration illustrates the results following its Center of Gravity 30-ft drop and vertical crush. Destructive examination of TU1 and TU3 showed similar damage.  Because of the unknowns relating to cutting through the Kevlar®-reinforced Composite Shell, along with the 17-4 heat-treated stainless steel, lubricating oil was used for destructive cutting and can be seen in the TU5 photograph by the black discoloration of the yellow polyurethane foam.



Following the HAC structural testing, the Overpack Closure Plug were removed. All of the content Carrier Assemblies could be opened by hand. The post tested configuration of the 9980 drums is shown in the following picture. As can be seen very little structural damage resulted from the NCT and HAC structural testing of the 10-gallon drum overpack.

## CONCLUSIONS

An air-transport Type A Fissile radioactive shipping package for transporting a special form uranium source has been developed by the Savannah River National Laboratory for Homeland Security. Results from testing were shown to demonstrate how the 9980 complies with the regulatory safety requirements of the Nuclear Regulatory Commission for an air-transport Type A Fissile radioactive shipping package. It is anticipated that the Certificate of Compliance for the 9980 will be issued in October 2013 with fabrication commencing in the 4$^{th}$ quarter of 2013.

## REFERENCES


1. Transportation, Code of Federal Regulations, Title 49, Part 173, Washington, DC.
2. Packaging and Transportation of Radioactive Material, Code of Federal Regulations, Title 10, Part 71, Washington, DC.
3. 49 CFR 178.500, Subpart L—Non-bulk Performance- Oriented Packaging Standards.
4. American Welding Society, AWS D1.6, Structural Welding Code - Stainless Steel.
5. ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Supports, American Society of Mechanical Engineers, New York, NY.