**Contract No:**

This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-08SR22470 with the U.S. Department of Energy.

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Proceedings of INMM 49th Annual Meeting
Nashville Convention Center and Renaissance Hotel, Nashville, TN
July 13-17, 2008

**SRNS-STI-2008-00104**

# DEVELOPMENT OF A NEW TYPE A(F) RADIOACTIVE MATERIAL PACKAGING FOR THE DEPARTMENT OF ENERGY

**Paul S. Blanton**
**Savannah River National Laboratory**
**Aiken, South Carolina, USA**
**paul.blanton@srnl.doe.gov**

**Kurt R. Eberl**
**Savannah River National Laboratory**
**Aiken, South Carolina, USA**
**kurt.eberl@srnl.doe.gov**

**Paul T. Mann**
**National Nuclear Security Administration**
**Albuquerque, New Mexico, USA**

**Ashok K. Kapoor**
**U. S. Department of Energy**
**Germantown, MD, USA**

## ABSTRACT
In a coordinated effort, the Department of Transportation (DOT) and Nuclear Regulatory Commission (NRC) proposed the elimination of the Specification Packaging from 49 CFR 173.[1] In accordance with the Federal Register, issued on October 1, 2004, new fabrication of Specification Packages would no longer be authorized. In accordance with the NRC final rulemaking published January 26, 2004, Specification Packagings are mandated by law to be removed from service no later than October 1, 2008.

This coordinated effort and resulting rulemaking initiated a planned phase out of Specification Type B and Type A fissile (F) material transportation packages within the Department of Energy (DOE) and its subcontractors. One of the Specification Packages affected by this regulatory change is the UN1A2 Specification Package, per DOT 49 CFR 173.417(a)(6). To maintain continuing shipments of DOE materials currently transported in UN1A2 Specification Package after the existing authorization expires, a replacement Type A(F) material packaging design is under development by the Savannah River National Laboratory. This paper presents a summary of the prototype design effort and testing of the new Type A(F) Package development for the DOE.

## INTRODUCTION
This paper discusses the progress made in the development of a Type A Fissile Packaging to replace the expiring 49 CFR UN1A2 Specification Fissile Package. The Specification Package was mostly a single-use waste disposal container. The design requirements and authorized radioactive material contents of the UN1A2 Specification Package were defined in 49 CFR. A UN1A2 Specification Package was authorized to ship up to 350 grams of U-235 in any enrichment and in any non-pyrophoric form. The design was specified as a 55-gallon 1A2 drum overpack with a body constructed from 18 gauge steel with a 16 gauge drum lid. Drum closure was specified as a standard 12-gauge ring closure. The inner product container size was not specified but was listed as any container that met Specification 7A requirements

per 49 CFR 178.350. Specification 7A containers were required to withstand Type A packaging tests required by 49CFR173.465 with compliance demonstrated through testing, analysis or similarity to other containers. The maximum weight of the 7A product container, the radioactive content, and any internal packaging was limited to 200 lbs. The total gross weight for the UN1A2 Specification Package was limited to 350 lbs. No additional restrictions were applied. Authorization for use did not require the UN1A2 Specification Package to be tested to the Normal Conditions of Transport (NCT) and Hypothetical Accident Conditions (HAC) required for performance based, Type A(F) packages certified by the NRC or DOE.

The Type A(F) Packaging design discussed in this paper is required to be in compliance with the regulatory safety requirements defined in Code of Federal Regulations (CFR) 10 CFR 71.41 through 71.47 and 10 CFR71.71. Sub-criticality of content must be maintained under the Hypothetical Accident Conditions specified under 10 CFR71.73. These federal regulations, and other applicable DOE Orders and Guides, govern design requirements for a Type A(F) package. Type A(F) packages with less than an A2 quantity of radioactive material are not required to have a leak testable boundary. With this exception a Type A(F) package design is subject to the same test requirements set forth for the design of a performance based Type B packaging.

## AF DEVELOPMENT

Responses to a formal request by DOE for the development of a Type A(F) package was received from two DOE laboratories and a commercial vendor. Each of the three competitors presented a package design concept and estimate of fabrication costs as well as an associated development schedule. Evaluation of the bids resulted in package development award to the Savannah River National Laboratory (SRNL).

The development of the DOE Type A(F) package is a joint venture between the Office of Environmental Management and the National Nuclear Safety Administration (NNSA). Development costs are being equally shared between the two Department of Energy Agencies. Because of the potential use by commercial agencies, the package design will be reviewed and Certification will be performed by EM-63s Packaging Certification Office.

## DESIGN REQUIREMENTS

The Type A(F) package design is subject, at a minimum, to the Regulations of 10CFR, 49CFR and applicable Regulatory Guidance Documents. (These documents can be found at website http://rampac.energy.gov/DOE-Requirements/TypeAFRequirements.htm.) The specifics of these requirements will not be readdressed in the paper. Rather, this paper addresses the broad requirement that the Type A(F) design remains sub-critical and prevent loss of radioactive material under 10CFR71 NCT and HAC testing scenerios, including the HAC crush. Additional operational objectives imposed on the design effort are as follows:

- Minimization of package weight,
- Safe and simple package operation and maintenance,
- Utilization of a 30-gallon drum as the radioactive content container,
- Minimization of package production costs,
- Maximization of the content envelope, and
- Compliance with disposal facility waste acceptance criteria

Cost Optimization

The large quantity of A(F) packages required to support DOE programmatic missions and the cost of shipping to disposal sites resulted in design objectives of package fabrication cost and weight minimization. The DOE programmatic need for a Type A(F) package arises from the need for annual shipment of thousands of packages for disposal. In addition to the annual disposal shipments, thousands of other packages are loaded and in storage awaiting repackaging and disposition.

Typically, radioactive material package designs are not optimized for fabrication costs due to the limited number of packages that are produced. The cost of optimization during the design phase cannot be recovered in the fabrication phase. Due to its significant annual production estimate, the Type A(F) package development warrants initial expenditures to optimize the design for manufacturing costs. For example, a procurement of 5,000 AF packages costing $3,000 each, which could be easily achieved without design optimization, is $15M. Compared to a design optimized package for <$1,000 the cost savings is $10 million the first year. For packages with missions requiring large annual procurements, the cost of design optimization is clearly warranted by the reduced manufacturing costs.

Content Evaluation

The lack of content envelope specificity imposed by expiring regulations facilitated shipment of a wide range of material types and configurations in the UN1A2 Specification Package. A Safety Analysis Report for Packaging (SARP) is required for a Type A(F) package to individually evaluate the safe shipment of all proposed contents. The AF package design will maximize the content envelope to support the existing DOE missions. The diversity of intended content is illustrated in the partial proposed content list of Table 1.

| Radioactive Material | Material Type |
|---|---|
| $UO_2$, $UO_3$, $U_3O_8$, $UF_4$, $UF_6$<br><br>< 700 grams,<br>any enrichment,<br>non-pyrophoric | Standards/Calibration Sources<br>Firebrick<br>$UF_6$ Trapping Material<br>Filters<br>Laboratory Salvage<br>Crucible (Skull) Oxide<br>Nitrate Crystals<br>Reduction Sand<br>Miscellaneous Combustibles<br>Rubber and Plastics<br>Construction Debris |

Table 1 Proposed Type A(F) Package Contents

## DESIGN FEATURES

The Type A(F) package is designed to be similar in size and weight to the majority of predecessor UN1A2 Specification Packages used by the DOE. The outer drum remains a 55-gallon container which functions as an overpack to an inner 30-gallon container. The inner 30-gallon content container functions as the confinement barrier for the radioactive material. The Type A(F) package design will accommodate

the future use of an inner 16-gallon container. An illustration of the conceptual Type A(F) package design is shown in Figure 1.

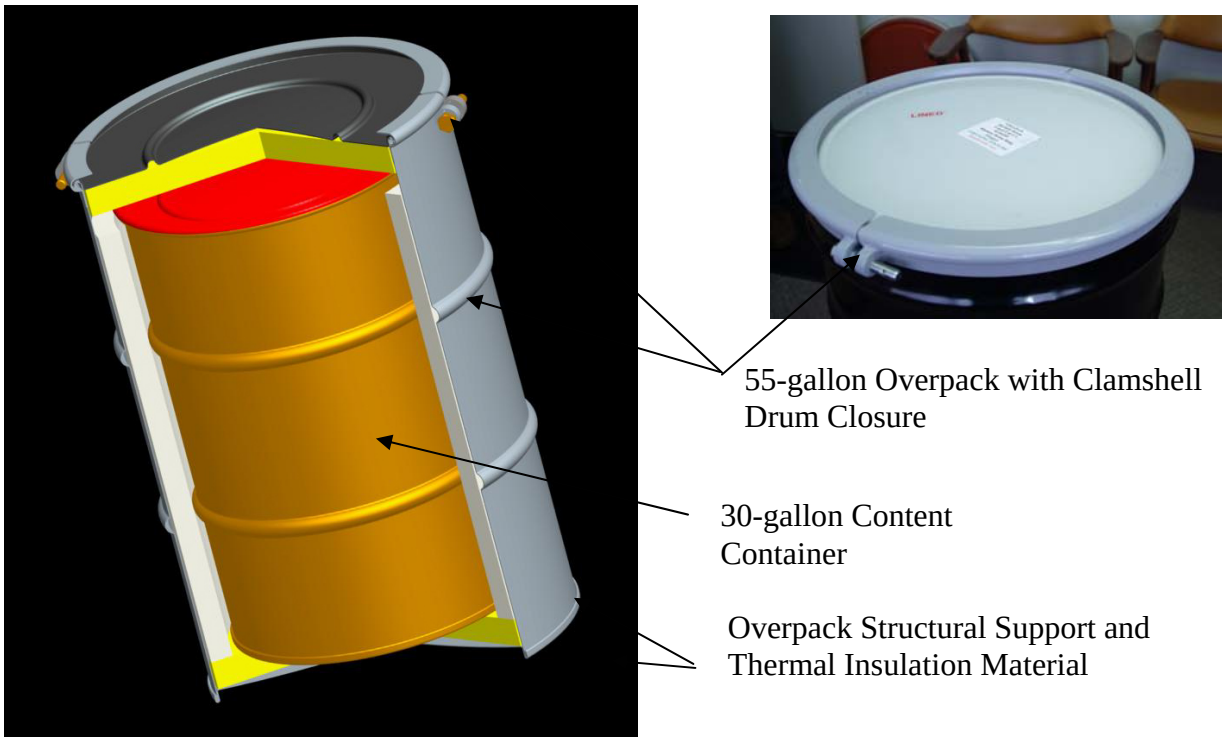



Figure 1 Type A(F) Conceptual Design

As illustrated, the 30-gallon drum is concentrically oriented inside the outer 55-gallon drum overpack. The 55-gallon drum closure uses a reinforced split-ring clamshell closure that has been demonstrated to meet performance requirements and is in use by the NNSA in the transport of 6M packages. The 30-gallon drum may also incorporate the same reinforced closure design. Alternatively, Figure 2 pictures a 30 and 55-gallon continuous clamshell closure that may be used in lieu of the split-ring clamshell to simply drum closure operations. Various structural support and insulation materials used to separate the 30-gallon drum from the 55-gallon drum, shown as yellow and white in Figure 1, are under investigation.

The Type A(F) package will have a content payload weight of approximately 200 lbs, including the radioactive material, package components, and the 30-gallon drum. The final gross weight of the package will depend on the material chosen to separates the 30- and 55-gallon drums. The 55-gallon drum is 22½ inches in diameter and 35-inches in height. The 30-gallon drum is approximately 19 inches in diameter and 29-inches in height. The AF drums and closures will be fabricated from carbon steel with an option for stainless steel if packaging program missions require extended package reuse.

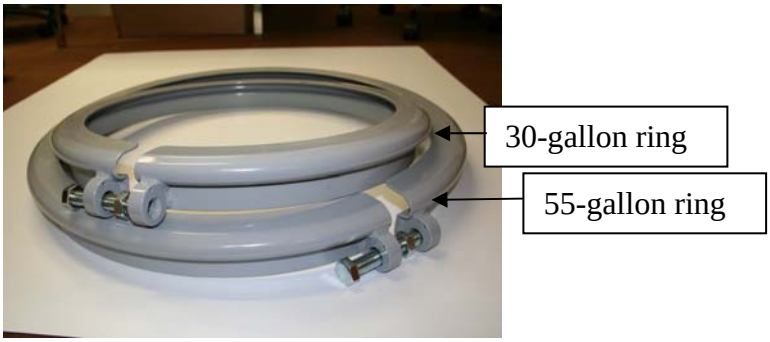



Figure 2 Type A(F) Reinforced Drum Clamshell Closure

An evaluation of available insulation and structural support materials for the Type A(F) has resulted in several design options. The design will attempt to take advantage of the lightest weight material options to minimize shipping cost.

Materials under investigation include materials already proven within certified packaging designs (aerospace polyurethane foams and Celotex fiberboard) as well as materials not typically used for radioactive material packaging applications (ceramic insulations, automotive polyurethane foams, and aerospace honeycomb laminates). Four of the prototype configurations which have been fabricated are illustrated in Figure 3. The aerospace honeycomb laminate still in the design stage is shown in Figure 4.

Ceramic material can be vacuum formed into cylinders and disks and inserted inserted into 55-gallon drums as shown in the left image of Figure 3. The 30-gallon drum is placed inside the ceramic insulation material. The ceramic material is thermally stable up to 2300°F and is not affected by water. To provide structural support, the ceramic will be reinforced with fiberglass sheathing not pictured.

The automotive foam material shown in Figure 3 is a DOW Corning product designed for use in automobile applications. The liquid foam is poured between the 55-gallon drum wall and fabricated metal liner and solidifies in place. This design approach is similar to that used for the Certified USA/9977/B(M)-96 Packaging. The foam is expected to perform in a manner comparable to that of other similar materials used in existing Type B packages.

The Celotex material has been used in radioactive material packages for decades. The insert pictured would be installed in the same fashion as the ceramic filler material. The fiberboard insert is reinforced with plywood to provide the added protection needed to survive the HAC crush test. Celotex thermal and structural performance is already well established.

The aerospace foam insert shown in Figure 3 is identical to that used in the existing 9977 package. Testing will be performed for the pictured insert as well as a poured-in-place configuration pictured at the lower right hand corner of the insert photograph. Thermal and structural performance of the aerospace foam is also well established.

Because of the proprietary nature of some the materials, specifics of design and manufacturing techniques are not presented in this publication. Once a final design has been established, pertinent information will be disclosed in future publications or may be obtained by contacting the author.

Ceramic Vacuum Formed Insert

Automotive Foam Poured in Place

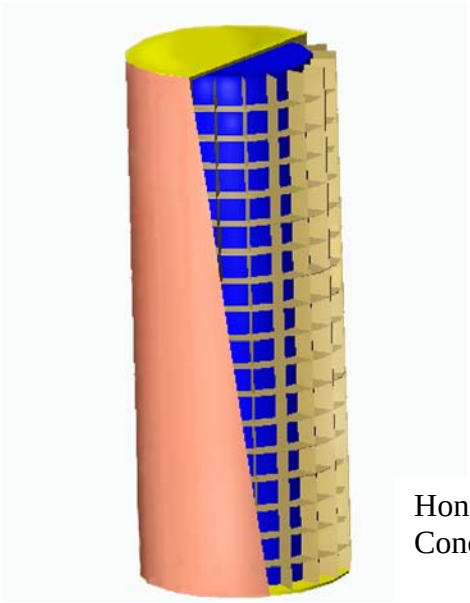
Reinforced Celotex Fiberboard Insert

Aerospace Foam Insert

Figure 3 Type AF Prototype Overpack Materials

Section of Composite Core Structure making up the honeycomb concept

- Low weight / high strength
- Flame retardant



Honeycomb Concept

Figure 4 Honeycomb Composite Structures

**PACKAGE PERFORMANCE**

The performance of a package design may be proven by test, analysis or comparison to other similar packaging; or any combination of the above, 49 CFR. Performance of the Type A(F) packages presented in this paper will be demonstrated through testing with analytical validation of the margin of safety. With the exception of scoping analysis used to determine design concept feasibility, no validation analysis has

yet been performed. Five Type A(F) design concepts are under investigation including the four pictured in Figure 3 and the fifth, conceptually illustrated in Figure 4. General details of the various package concepts and preliminary results of the designs already tested follow.

At the time of this publication, preliminary testing has been performed for the first two pictured configurations, i.e., vacuum formed ceramic insert and automotive foam. The results of the initial testing are shown in Figure 5. These baseline tests were used to characterize the amount of damage that may be expected from the HAC crush test on drums that were not initially reinforced. Results from HAC crush testing on a redesign including reinforced automotive foam were successful as indicated in Figure 6. Remaining designs and associated testing are expected to be complete by the end of September, 2008.

The design function of the Type A(F) package is to maintain material subcriticality and prevent loss (confinement) of material following NCT and HAC events, including the HAC crush. The primary challenge for the Type A(F) package effort is to design an inexpensive performance based package, with less than 1¾ inch of structural/insulation material between the 55-gallon drum overpack and 30-gallon drum inner container, that can withstand the crush accident test (a 1,100 lb plate dropped from 30-ft) and subsequent thermal test (30-minute 1,475°F fire) and maintain package integrity. If not for the packaging fabrication costs, a reinforced welded and bolted flanged closure for the overpack and inner container would easily accomplish the design goals.

The effects of the 1,100 lb plate crush test on two 1A2 style containers with partially reinforced closures is illustrated in Figure 5. The drum used for the tests shown in Figure 5 included the clamshell closure. It is expected that use of standard drum closures would have resulted incomplete lid detachment following 6M tests with the standard closure. Both of the Type A(F) prototype packages where dropped from 30-ft in accordance with 10CFR71.73 HAC requirements[2]. Damage was minimal, consisting primarily of minor surface dents. If not for the 10CFR71.73 HAC 30-ft crush requirement, performance of the two tested packages would have been sufficient to support package certification. The 30-ft drops and crushes were performed with the package horizontally oriented.

Ceramic Filled Package (no reinforcement)

Automotive Foam (no reinforcement)

Figure 5 Effects of HAC Crush on UN1A2 Style Drums

Frontal view of crush tested drum. Crush damage is minimal with no indication of outer drum lid removal. Post test examination of inner drum showed no indication of drum lid separation.

End view of crush tested drum. Deformation is similar to that seen in the frontal view. Drum chime crimped, seams showed no significant damage.

Figure 6 Crush Results of Type AF Package with Reinforced Automotive Foam

Figure 6 shows the crush results of a first round modification to the automotive foam filled Type AF design after the drum lid was reinforced. Damage to the drum was minimal, without notable failure such that the test was considered successful.

Following testing of the remaining prototypes, the package design demonstrating the greatest margin of safety with the least expensive manufacturing cost will be selected by SRNL for submittal to DOE for certification. A Safety Analysis Report for Packaging (SARP) will be written to support the design and submitted for Certification to EM-63. The planned submittal of this SARP is late 2008.

## CONCLUSIONS

The design of an inexpensive, Type A(F) package capable of satisfying the identified objectives presents significant challenge. Five design concepts and partial testing results have been presented for a Type A(F) package design that will replace the expiring 49 CFR UN1A2 Specification Package. The five concepts are designed to optimize the inner content container volume and support enhanced ease of use while providing protection during the regulatory accident scenarios.

## REFERENCES


1. *Transportation*, Code of Federal Regulations, Title 49, Part 173, *Shippers-General Requirements for Shipments and Packagings*, Washington, DC (October 1999).

2. *Packaging and Transportation of Radioactive Material*. Code of Federal Regulations, Title 10, Part 71, Washington, DC (January 2002).