PATRAM 2013
Hilton San Francisco Union Square
August 18-23, 2013

13-A-503-PATRAM

FABRICATION AND DEPLOYMENT OF THE 9979 TYPE AF RADIOACTIVE WASTE PACKAGING FOR THE DEPARTMENT OF ENERGY

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ABSTRACT

This paper summarizes the development, testing, and certification of the 9979 Type A Fissile Packaging that replaces the UN1A2 Specification Shipping Package eliminated from Department of Transportation (DOT) 49 CFR 173. The DOT Specification Package was used for many decades by the U.S. nuclear industry as a fissile waste container until its removal as an authorized container by DOT. This paper will discuss stream lining procurement of high volume radioactive material packaging manufacturing, such as the 9979, to minimize packaging production costs without sacrificing Quality Assurance. The authorized content envelope (combustible and non-combustible) as well as planned content envelope expansion will be discussed.

Introduction

In January of 2004, the Department of Transportation (DOT) and Nuclear Regulatory Commission (NRC) proposed the elimination of specification packaging from 49 CFR 173. In October of 2004, the proposal was adopted and it was mandated that specification packaging be removed from service no later than October 2008. In a coordinated effort, initiated in April 2008, the Offices of Transportation and Packaging of the Department of Energy, Environmental Management, and National Nuclear Safety Administration, directed the Packaging and Technology Organization of the Savannah River National Laboratory (SRNL) to develop a Type A Fissile Packaging as a replacement for the UN1A2 specification container previously authorized by DOT 49 CFR 173.417(a)(6). In June 2010, Revision 0 of the DOE CoC USA/9979/AF-96 was issued and in January 2011 the first 9979 was produced.

9979 Development

Development of the Type A Fissile packaging replacement for the DOT UN1A2 packaging was competitive within DOE contractors with three design concepts, development schedules and fabrication proposals presented for evaluation. Review of the estimates by DOE and NNSA resulted in award of the project to the SRNL Packaging Technology Organization. The key factors in the SRNL 9979 proposal included:

- Use of a30-gallon drum as the radioactive material content container,
- Development cost and schedule,

- Minimization of package production costs,
- Maximization of content envelope,
- Compatibility with burial ground waste acceptance criteria, and
- Safety and ease of use.

Seven prototypical packages were conceptualized at SRNL in pursuit of optimizing (thermal/structural) performance and fabrication costs for the Type A Fissile UN1A2 packaging replacement.[1] These seven packages were designed, fabricated and evaluated within six months of project initiation. Principal to each of the designs was the use of a 30-gallon drum positioned inside a 55-gallon drum as previously used for decades in the transport and disposal of Type A fissile materials. Figure 1 illustrates the design concepts. A feature also shared by each of the design concepts was the use of a split-ring drum closure in lieu of the standard industry c-ring drum closure. Extensive testing had proven this modification to be an economical and reliable closure for Type B package use, [Reference 2].. Concept 6 of Figure 1 shows a split-ring drum closure installed on a 30-gallon drum configured in a 55-gallon drum.

Some of the materials and manufacturing techniques used in these designs are proprietary and therefore are not included here in accordance with non-disclosure agreements. Specific information regarding materials and manufacturing can be obtained by contacting the author(s). Concept 1 used a non-combustible insulation insert to fill the volume between the 30 gallon and 55 gallon drums. Concept 2 replaced the insulation insert with Celotex, a fibrous material extensively used in the home building industry and previously used in radioactive material packaging designs. Alternatively, concept 3 filled the space using a pour-in-place automotive polyurethane foam confined within an engineered liner welded to the inside of the 55-gallon drum. Concepts 4 and 5 substituted polyurethane foam used commonly in the aerospace industry as well as in previous radioactive material package designs. Concept 4 used the polyurethane foam as an insert, similar to Concepts 1 and 2, while, Concept 5 used a poured-in-place technique involving a removable mold in the 55-gallon drum that eliminated the need for an inner welded liner. Concept 6 and 7 used an aerospace honeycomb composite material often found in the construction of commercial aircraft. A drop in configuration was used for Concept 6 while Concept 7 fixed the drop in place, similar to Concept 5.

Concept 1 Ceramic Insert | Concept 2 Celotex Insert | Concept 3 Polyurethane Foam | Concepts 4/5 Polyurethane Foam | Concept 6/7 Composite

Figure 1 Prototypical Type A Fissile Packaging Designs

Regulatory Testing

Regulatory certification of a package design can be demonstrated by test, analysis, or comparison to other similar packaging, or any combination of these techniques (49 CFR). The final Type A(F) package design discussed in this paper was demonstrated to meet the regulatory requirements by test with supporting analysis to validate package margin of safety. The required design function of the Type AF package is to maintain the material in a subcritical state and to prevent loss (confinement) of the material while withstanding NCT and HAC drop-crush-fire events, e.g., a 30-ft drop followed by a 1,100 lb plate dropped from 30-ft ending with a 30-minute duration 1,475 °F thermal test.

The initial drop from 30-ft in accord with 10CFR71.73 HAC requirements resulted in no more than minimal damage to any of the Type AF concept packages. Response to the crush test, however, varied widely among the tested packages and only those packages which responded well to impact by the plate were considered further.

Figure 2 illustrates the worst case effect of the HAC crush test on Concept 1 and Concept 4. Concept 5 with the pour-in-place foam, labeled as PT8, performed significantly better than the liner concept package labeled PT7 (Concept 4). Reference 3 is a comprehensive report documenting the conceptual package testing and field modifications that were made to improve crush performance.

Concept 1 (Ceramic Insert)   Concepts 4 and 5 (Foam insert and

Figure 2 Worst case Effects of the HAC Crush Test on Type A Fissile Package Concept Designs

Certification Testing of the 9979

Based on the pre-prototype test results, Concept Package 3 with an integrally welded liner and poured-in-place polyurethane foam was selected as the candidate design for certification. Five prototypical packages were procured by SRNL from Paragon, Design & Engineering located in Grand Rapids, Michigan in December 2009 in accordance with SRNL design requirements. Figure 3 depicts a design of the Model 9979 package along with a pictured prototype.

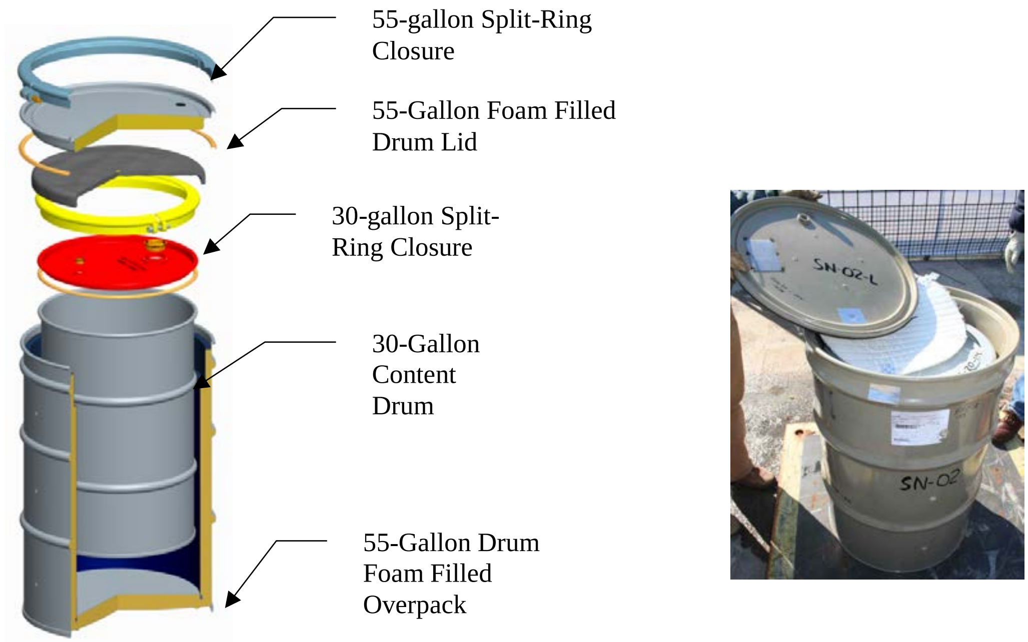

Figure 3 9979 Type A Fissile Packaging Design

The major components of the 9979 prototype package include an insulated 55-gallon drum overpack with insulated lid and a 30 gallon drum that secures the contents. A Dow Automotive polyurethane foam was used to fill the annular volume between the 55-gallon drum outer wall and its liner; and the 55-gallon lid and its liner. The liner and foam combination design of the 55-gallon drum provides the needed structural support for withstanding the HAC crush test and subsequent 30-minute 1,475 °F thermal event. An empty 9979 packaging weighs approximately 230 pounds. The outside dimensions of the 55-gallon overpack are 23 inches in diameter by 34½ inches high when closed. Figure 4 shows the general dimensions and weights of the final 9979 design.

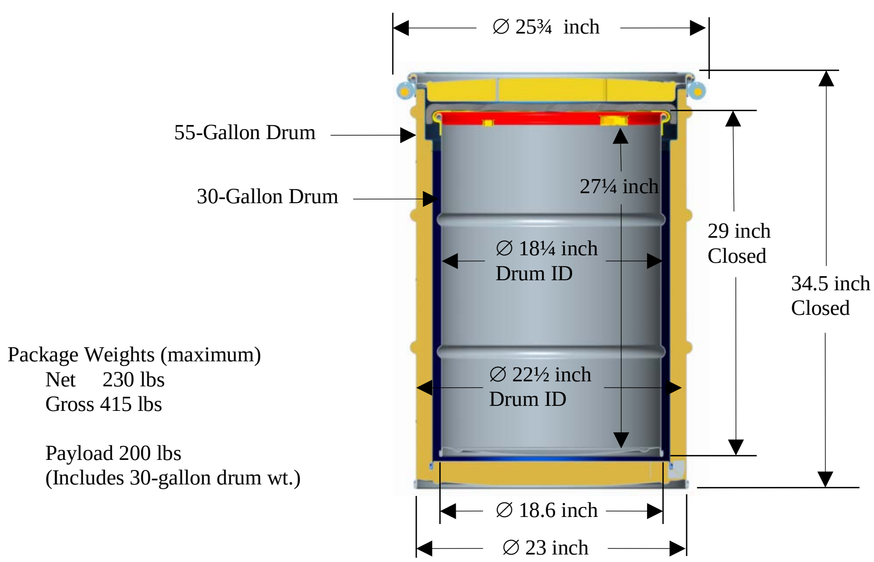

Figure 4 9979 Packaging General Dimensions

NCT and the HAC Regulatory tests were conducted at the Savannah River Site, Aiken, South Carolina. Representative pictures from the NCT and HAC structural tests are shown in Figure 5. Figure 6 shows the conditions of the five prototypes following the required regulatory structural drop-crush-puncture testing. Compliance with HAC thermal requirements was demonstrated through analysis. References 4 and 5 provide details of the NCT and HAC testing of the 9979. Testing and supporting analysis reported in the 9979 Safety Analysis Report for Packaging[6] demonstrated that the design met the performance requirements of 10CFR71 for a Type A Fissile Package and a CoC for the 9979 design was issued in June 2010.

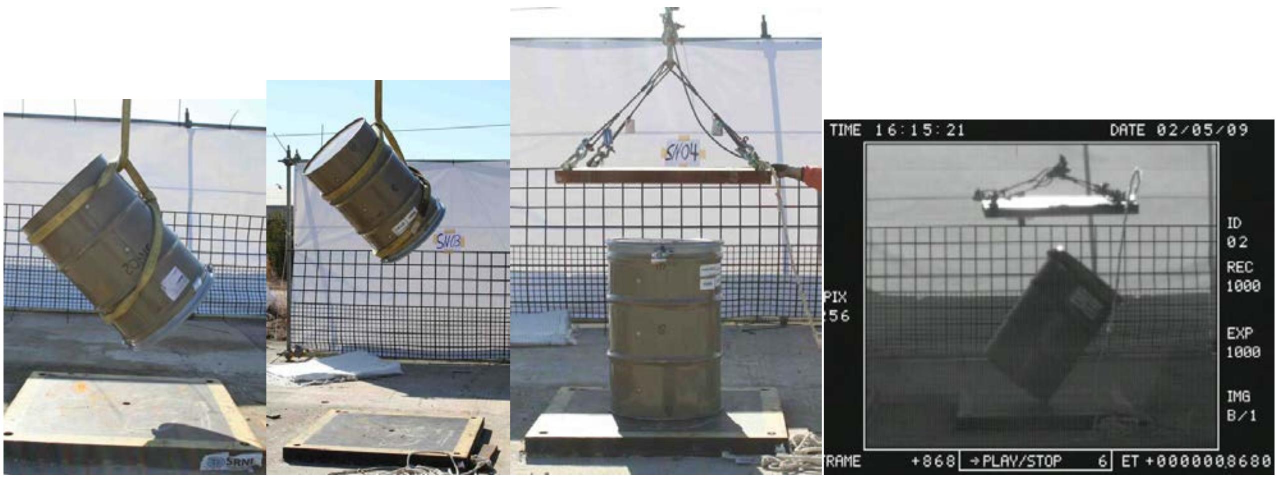

Figure 5 Representative examples of NCT and HAC Regulatory Testing.

Figure 6 Prototype Packages following HAC Structural Tests

Procurement of the 9979 Packaging

The UN1A2 specification package served primarily as a single-use waste container and, when used, was constructed to a set of prescriptive requirements specified in 49 CFR. Many thousands of these style packages were procured by the DOE for the transport and disposal of radioactive material. The prescriptive requirements allowed for very economical ($200-$300) mass production of the package. In contrast, the cost of a typical radioactive material package can be in the tens of thousands of dollars to produce. Therefore, final production costs were an important consideration in the final design, though packaging safety could not be compromised in the pursuit of an inexpensive package. The design of the 9979 packaging specifically integrated hardware that lends itself to forming and automated manufacturing to achieve significant reduction in assembly costs. Figure 7 depicts the components of the 9979 design that are formed. Formed components are produced with exacting dimensions and therefore can be used in repetitive automation thereby reducing production and assembly costs.

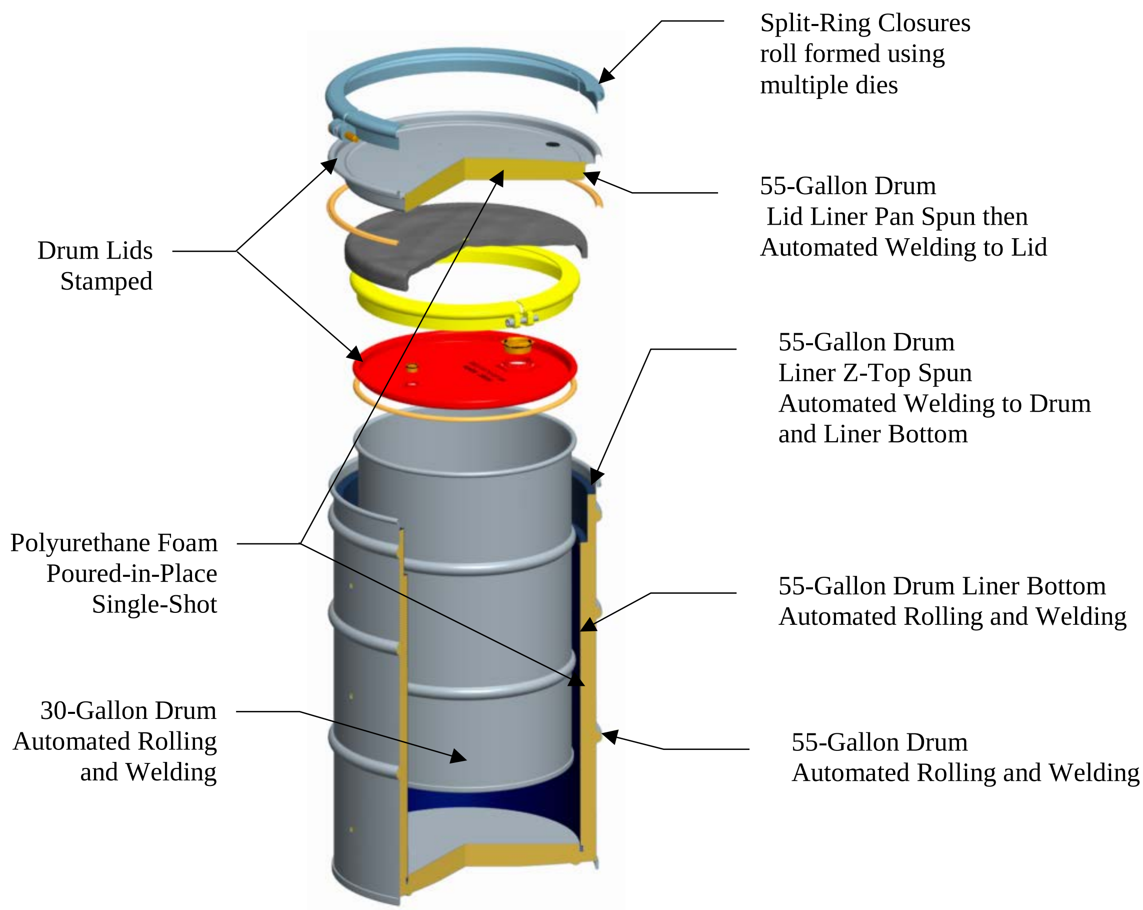

Figure 7 Components of the 9979 Designed for Automated Production

The current production cost of a 9979 package is approximately ± $3,000 per package (dependent on quantity ordered). This is an order of magnitude greater than the predecessor UN1A2 Specification Packaging but significantly less than the typical cost of other radioactive material packaging. This cost includes the as delivered hardware plus required quality assurance (QA) documentation required by 10 CFR 71, Subpart H and NRC Regulatory Guide 7.10. [7, 8]

This QA documentation, for each serialized packaging, constitutes many hundreds of pages of supporting quality verification documents. The documentation chronicles; training required for producing packaging, the materials of construction, certifications (NDE, welding, etc.) for individuals performing work and component testing documentation as well as others.

Savannah River National Laboratory has worked with select vendors to reduce the level of QA documentation required by vendors without sacrificing product quality or regulatory compliance. In lieu of repetitive documents itemizing the fabrication of each package; commercial grade dedication of off-the-shelf components and data sheets that identify specific traceability and inspection requirements, can replace in-depth nonessential documentation. Figure 8 illustrates a simplified data sheet in comparison to a typical data package delivered with a radioactive packaging procurement.

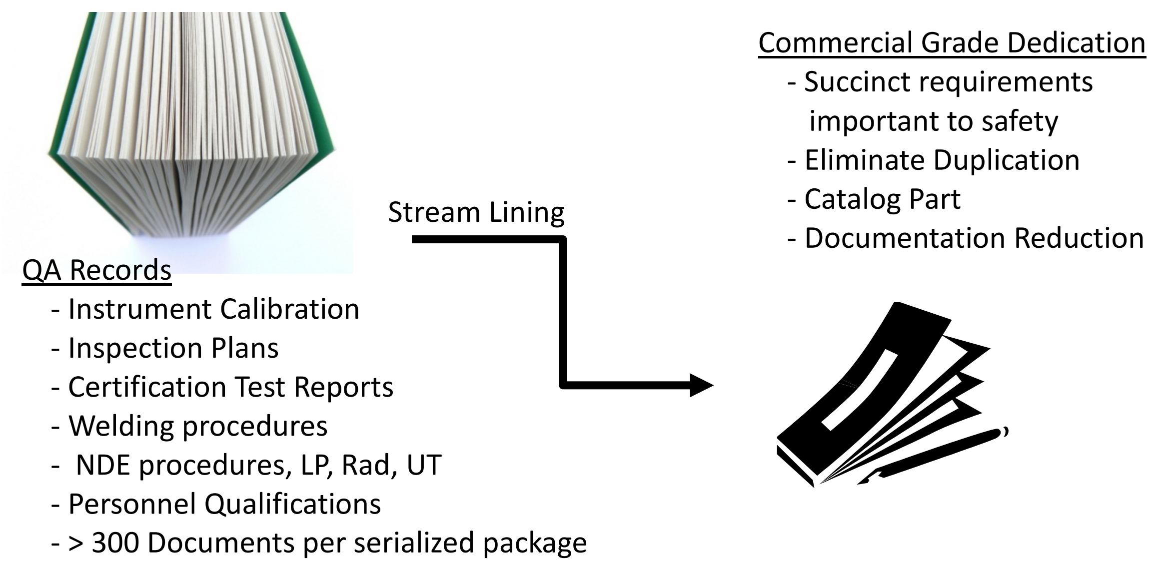

Figure 8 Reducing Production Costs by Smart Documentation Management

Contents

A UN1A2 Specification Package was limited to a defined set of radioactive materials; it 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 removable head drum with a body constructed from 18 gauge steel with a 16 gauge drum lid; and gross restricted weight of 350 lbs. Drum closure was specified as a 12-gauge single nut C-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. The preferred inner product container across the DOE complex was a 30-gallon drum as it maximized the volume of material that could be shipped in any single specification packaging.

The 9979 is also authorized to ship up to 350 grams of U-235 in any enrichment and non-pyrophoric form. All radioactive (fissile and non-fissile) and non-radioactive materials must be confined within the 30 gallon drum.

The radioactive contents for the 9979 are broadly grouped into two payload categories:

- non-combustible materials, and
- combustible materials

Table 1 provides the payload categories with general description and material form of each.

Table 1 9979 Content Categories

Payload Categories	Material Form	General Description
COMBUSTIBLE	Filters	Roughing, sock, demister, HEPA and other uranium filters
	Rubber, Plastics, Cellulose Products	Clothing, gaskets, bottles, filter frames, paper, wood, mop heads etc.
	Floor Sweepings	Miscellaneous materials collected from cleaning activities
	Process Solids	Furnace residues. (pan filter cloth and scrapings, wipes/sponges, etc.)
NON-COMBUSTIBLE	Graphite/Carbon	Carbon and graphite scrap molds
	Slag and Liner	Residue that contains magnesium oxide, calcium fluoride and/or lithium fluoride
	Ceramics/Glass	Crucibles, glassware and borosilicate rings
	Borax Pellets	From analytical x-ray operations.
	Reduction Sand	granular magnesium oxide (MgO)
	Asbestos/Firebrick	Insulation, floor tiles, etc.
	Solid Compounds	Uranyl Fluoride, UO_4, ammonium diuranate and residues and solid mixtures
	Standards and Sources	Encapsulated calibration standards, LEU Plates/Cube

CONCLUSIONS

The design of an inexpensive Type AF performance based package is an engineering challenge. Seven design concepts were evaluated to optimize payload capacity and reduce production costs without compromising safety. To date procurements nearing 1,000 packages have been authorized with many thousands expected in the future. Processes to further reduce fabrication costs and eliminate unessential quality assurance documentation are being explored to reduce overall packaging costs. Approval of new contents is also under consideration to increase the usability of the package.

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