# Developments that are making the Versa-Pac Indeed More Versatile (and More Useful to Industry) - 16267

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## ABSTRACT

Daher-TLI acquired the assets and employees of Century Industries, a radioactive material packaging manufacturing facility, in 2013. Included in that acquisition was the Versa-Pac Shipping Package. The Versa-Pac is an NRC licensed Type AF packaging (Certificate of Compliance #USA/9342/AF-96) [1] and was originally designed as a replacement for standard 7A drum-type transportation packaging. It can be used directly or in conjunction with pails, drums or inserts that can be manufactured to accommodate a variety of smaller containers and vessels.

The Versa-Pac comes in two sizes, the VP-55 (i.e., 55-gallon drum version) and VP-110 (i.e., 110-gallon drum version). It features a patented [2] design concept in combination with the drum exterior to provide enhanced structural protection to payloads under Normal Conditions of Transport (NCT) and Hypothetical Accident Conditions (HAC), per 10CFR71.71 and 10CFR71.73 respectively. [3]

Since its introduction in 2010, the Versa-Pac has been utilized mainly as a one-time use package for disposing of radioactive waste. The package is also designed as a reusable package for transporting front-end materials. Discussions with current and prospective clients have resulted in numerous improvements, accomplished and planned, to the package's payload capability through additional engineering analyses and actual design modifications. Revision 10 to the NRC Certificate of Compliance, dated August 6, 2015, introduces an enrichment-loading table that allows shipping larger quantities of U-235 for enrichments less than 100 wt.%. It also authorizes shipment of natural thorium.

Other planned and proposed improvements include provisions to transport UF6 in 1S, 2S, and 5B cylinders, design changes that further increases the amount of U-235 at enrichments less than 100 wt.%, increasing the capacity of the VP-110, developing a lighter 30-gallon version, the VP-30, and introducing content limits specific to uranium-oxides in multiple forms. This paper traces the engineering and design efforts involved in expanding the Versa-Pac's versatility.

## INTRODUCTION

In October 2004 the United States Department of Transportation (DOT) issued a final rule [4] that amended requirements in the Hazardous Materials Regulations

(HMR) pertaining to the transportation of radioactive materials based on changes contained in the International Atomic Energy Agency (IAEA) regulations, TS–R–1 [5]. The purpose of this rulemaking initiative was to harmonize the HMR requirements with TS–R–1, which necessitated phasing out certain DOT specification packages that satisfied the 1967 IAEA Safety Series 6 requirements [6] but would not be authorized under TS-R-1 [4]. A main driver for the change was that the Safety Analysis Reports (SARP) for these DOT specification packages had not satisfied packaging requirements of the 1973, 1985, or 1996 IAEA radioactive material transport regulations, and therefore did not comply with NRC regulations (10CFR71).

During the period immediately following the discontinuation of these packages, the DOT issued numerous Special Permits to grantees, allowing them to continue to use discontinued packagings while giving time to transition to performance oriented packages. The Versa-Pac was introduced in 2010 to be one of the “performance oriented packages” that would replace the DOT specification packagings.

The initial Versa-Pac design mirrored the familiar drum exterior packaging and payload capacities of the retired packagings (i.e., 350 grams U-235 at 100-wt.% enrichment) but added enhanced structural features that satisfied the Hypothetical Accident Conditions (HAC) specified in the U.S. and international regulations. The Versa-Pac was designed so that it could be used directly or in conjunction with existing pails, drums, and other smaller containers and vessels, to provide safe transport for all types of fuel and waste products within the industry.

Subsequently, Daher-TLI recognized the benefit to industry if the Versa-Pac capabilities were expanded. Hence, design modifications have been made or are in progress/planning for the following:

- Greater quantities for lower enrichments
- Enriched UF6 in 1S/2S cylinders
- Pellets
- Enriched UF6 in 5B cylinders.
- Reduced tare weight of the Versa-Pac

## DESCRIPTION

### Packaging Description

The Versa-Pac design [7] utilizes standard shop dimensions, tolerances, and structural materials. It consists essentially of a payload vessel centered within either an insulated 55-gallon (VP-55) or 110-gallon (VP-110) drum. Figure 1 shows the VP-55 packaging and a view of the inside. Major packaging components are shown in Figure 2.


**Figure 1 Versa-Pac (VP-55) Rendering and Looking Inside**

The outer skin, seen in Figure 1, consists of at minimum a UN1A2 rated drum. The drum body is strengthened with vertical stiffeners and two stiffening rings, which are shown in Figure 3. A carbon steel plate reinforces the drum bottom.

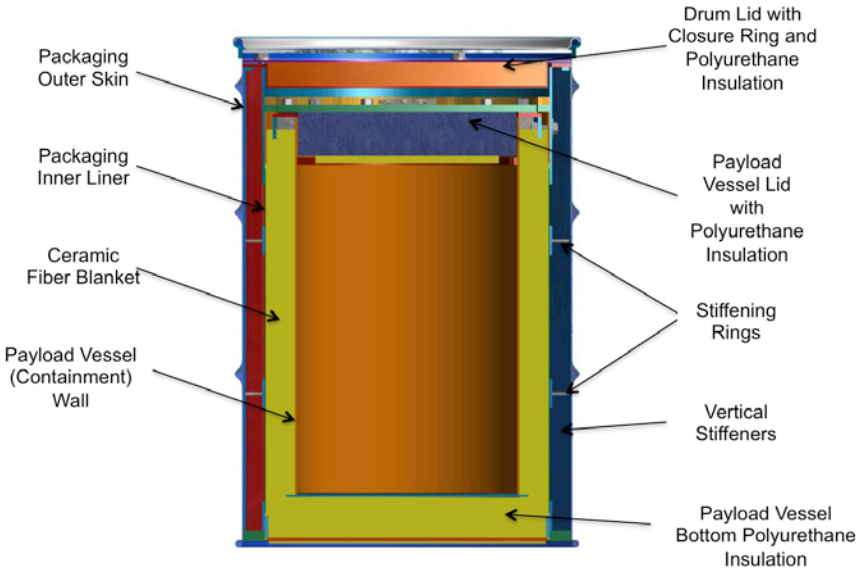


**Figure 2 Versa-Pac Major Components**

The drum lid is reinforced with a steel ring plate welded on top to provide added circumferential strength. It has a steel encapsulated high-density polyurethane (HDPE) disk affixed to the bottom to provide thermal insulation and impact support.

The lid is fastened to the drum using a 12-gauge closure ring and is bolted with either four (VP-55) or eight (VP-110) ½-inch bolts.

The payload vessel forms the containment boundary of the package. The upper end of the vessel is fitted with a carbon steel flange ring, to which is bolted the containment lid, a carbon steel blind flange. A high temperature heat resistant gasket fits between the steel flange ring and blind flange.

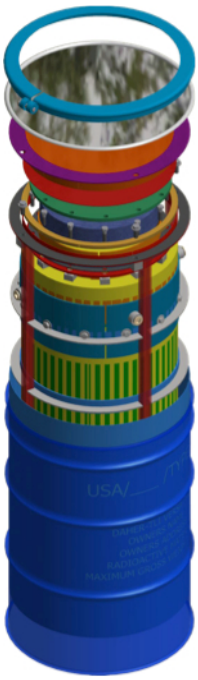

**Figure 3 Versa-Pac (VP-55) Exploded View**

Thermal insulation includes the previously mentioned steel-encapsulated High Density Polyurethane (HDPE) insulation affixed to the outer drum lid and the payload vessel lid (i.e., blind flange). In addition, there is HDPE beneath the payload vessel and ceramic thermal blankets between the outer drum skin and inner liner, and between inner liner and the payload vessel.

Nominal dimensions and other data are shown in Table I.

**Table I VP-55 VP-110 Nominal Dimensions and Parameters**

| | VP-110 | VP-55 | VP-55HC |
|---|---|---|---|
| **NRC Certificate of Compliance (CoC) (Expiration)** | USA/9342/AF-96 Rev 10 8/31/2020 | | (Amendment Request Submitted) |
| **DOT Competent Authority Certification (CAC) (Expiration)** | USA/9342/AF-96 Rev 1 8/31/2020 | | |
| **Description** | 110 gallon drum | 55 gallon drum | 55 gallon drum |
| **Packaging Outer Diameter in. (mm)** | 30 (773) | 23 (586) | 23 (586) |
| **Packaging Height in. (mm)** | 42 (1086) | 35 (883) | 35 (883) |
| **Payload Cavity Diameter in. (mm)** | 21 (533) | 15 (381) | 5 (127) |
| **Payload Cavity Height in. (mm)** | 29 (756) | 26 (657) | 19 (482) |
| **Payload Volume cf / (cc)** | 6 (170) | 2.7 (75) | 0.2 (6) |
| **Packaging Tare Weight lb. (kg)** | 705 (320) | 390 (177) | |
| **Package Gross Weight lb. (kg)** | 965 (438) | 640 (290) | |
| **Contents Max Weight lb. (kg)** | 260 (118) | 250 (113) | |
| **CSI** | Enrichment dependent | | |
| **Decay Heat limit** | 11.4 W | | |
| **Content Types** | Solid, homogeneous (powder or crystalline), or non-homogeneous uranium metals with no freestanding liquids. | | |
| **Specific Contents** | Uranium oxides<br>Uranyl nitrate crystals<br>Uranyl fluorides<br>Uranium metals<br>TRISO fuel as C/SIS/C<br>ThUC2 particles<br>Uranium alloys<br>Uranyl carbonates<br>Natural Thorium | | |

### Standard Configuration

As mentioned above, the initial Versa-Pac design allowed the transport of up to 350 grams U-235 for any enrichment up to 100-wt%. Recognizing that this penalized material transport for lower enrichments, Daher-TLI performed the necessary criticality analyses and relicensed the Versa-Pac with increased U-235 mass limits for lower enrichments. The Versa-Pac standard configuration, for both the VP-55 and VP-110, is now capable of transporting Type A fissile material according to the U-235 mass limits in Table II:

**Table II U-235 loading table for VP-55 and VP-110 Standard Configuration**

| Weight Percent U-235 | U-235 Mass Limit (g) | Uranium Mass Limit (g) |
|---|---|---|
| 100 | 350 | 350 |
| 20 | 410 | 2,050 |
| 10 | 470 | 4,700 |
| 5 | 580 | 11,600 |

Several other enhancements to improve the Versa-Pac's capability and versatility are in development or planning. These are discussed below.

## DISCUSSION

### VP-55HC

A new Versa-Pac package design, called the VP-55HC (High Capacity), features a 5-inch steel inner container, called the VP-55-2R shown in Figure 4, to facilitate the transport of greater quantities of U-235. Table III shows the U-235 mass limits for the VP-55HC.

**Table III U-235 Loading Table for the VP-55HC**

| Weight Percent U-235 | U-235 Mass Limit (g) | Uranium Mass Limit (g) |
|---|---|---|
| 100 | 695 | 695 |
| 20 | 1215 | 6,075 |
| 10 | 1605 | 16,050 |
| 5 | 1065 | 21,300 |

The VP-55HC 5-inch pipe container fits inside the VP-55 payload vessel. It is fabricated from Schedule-40 carbon steel. The top is closed with a threaded cap made from malleable iron. The VP-55-2R is held in place during routine transport by a "birdcage" device that provides no structural support.

The containment features for the VP-55HC are identical to those of the Versa-Pac, with the addition of the closure system for the inner containment vessel. The containment boundary of the VP-55HC is defined as the VP-55-2R and the payload vessel.

The VP-55-2R is the only accepted content container for the VP-55HC configuration, providing geometry control of the contents to enable a significant increase in mass limits. The content types for the VP-55HC are identical to the Versa-Pac standard configuration.

The Criticality Safety Index (CSI) for the VP-55 and VP-110 standard configuration is 1.0. The CSI for the VP-55HC is 0.7 for material up to 10wt%, and 1.0 for material greater than 10wt% up to 100wt%.

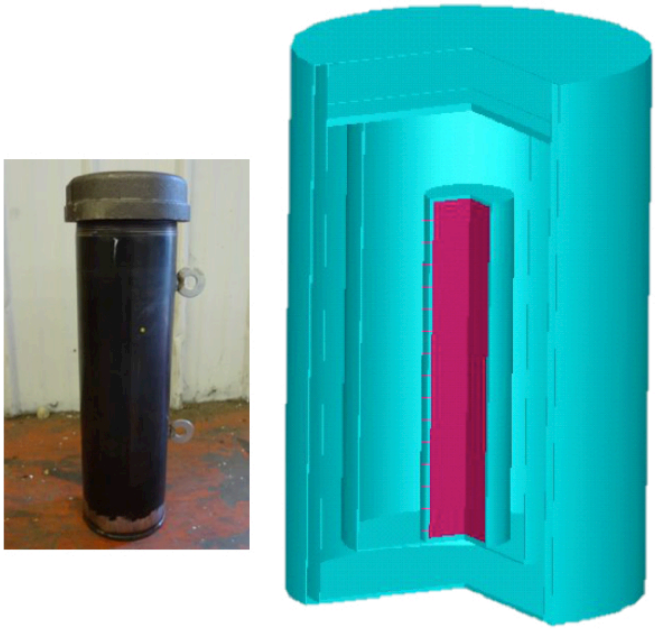

**Figure 4 VP-55-2R Photo and SCALE rendering in Versa-Pac**

### VP-55-1S/2S

Daher-TLI recently responded to a client's urgent need to transport NRC general license quantities of UF6 contained in ANSI N14.1 compliant 2S cylinders by modifying a licensed Type AF-96 foreign package to carry the cylinders. Subsequent to this, Daher-TLI recognized the need to have a permanent solution for 1S/2S cylinder transport, and has begun modifications to the Versa-Pac design to transport both general license and fissile quantities of UF6 in ANSI N14.1 compliant 1S and 2S cylinders. . Figure 5 shows a 2S cylinder and an exploded concept view of the Versa-Pac with the foam insert for the cylinder. Daher-TLI has demonstrated

that a packaging insert made of insulating foam can provide sufficient thermal protection and protect the 1S or 2S cylinder and valve from impact during transport.

**Figure 5 ANSI N14.1 2S Cylinder in the Versa-Pac**

U.S. regulations (49CFR173.417, 49CFR173.420 [8], and 10CFR71.22) [3] allow the transport of general license quantities of UF6 in a DOT Specification 7A packaging as long as the material is contained in ANSI N14.1 compliant cylinders and the packaging satisfies the thermal requirements of 10CFR71.73. The Versa-Pac, as a licensed NRC package, meets these requirements, and therefore can be used as a self-certified DOT Specification 7A package for this type of transport. Under general license provisions, the Versa-Pac can carry quantities of UF6 in 1S and 2S cylinders as shown in Table IV.

**Table IV Maximum Allowed UF6 in 1S and 2S Cylinders Under General License**

| Wt. % U-235 | Max Allowed U-235 Note 1 (g) | 1S Cylinder | | 2S Cylinder | |
|---|---|---|---|---|---|
| | | Maximum Allowed UF6 Note 2 (g) | Maximum Allowed U-235 (g) | Maximum Allowed UF6 Note 2 (g) | Maximum Allowed U-235 (g) |
| 100% | 60 | 88 | 60.0 | 88 | 60.0 |
| 50% | 60 | 177 | 60.0 | 177 | 60.0 |
| 25% | 60 | 355 | 60.0 | 355 | 60.0 |
| 24% | 60 | 369 | 60.0 | 369 | 60.0 |

| Wt. % U-235 | Max Allowed U-235 Note 1 (g) | 1S Cylinder | | 2S Cylinder | |
|---|---|---|---|---|---|
| | | Maximum Allowed UF6 Note 2 (g) | Maximum Allowed U-235 (g) | Maximum Allowed UF6 Note 2 (g) | Maximum Allowed U-235 (g) |
| 20% | 63 | 454 | 61.3 | 465 | 63.0 |
| 15% | 67 | 454 | 46.0 | 660 | 67.0 |
| 10% | 76 | 454 | 30.7 | 1124 | 76.0 |
| 5% | 108 | 454 | 15.3 | 2222 | 75.1 |
| 4% | 120 | 454 | 12.3 | 2222 | 60.1 |
| 3% | 150 | 454 | 9.2 | 2222 | 45.1 |
| 2% | 246 | 454 | 6.1 | 2222 | 30.1 |
| 1% | 1020 | 454 | 3.1 | 2222 | 15.0 |

Note 1

- 10CFR71.22 prescribes U-235 limits per enrichment for general license quantities.

Note 2

- ANSI N14.1 limits for 1S (1.0 lb.) and 2S (4.9 lb.)
- 49CFR173.420 requires that the volume of UF6 not exceed 61% of the certified volumetric capacity of the packaging.

Further, because the Versa-Pac is a licensed AF-96 package, it can be licensed to transport fissile quantities of UF6 in 1S and 2S cylinders.

### VP-XL

A request was received to consider developing an extended version of the Versa-Pac, called the VP-XL, for the purpose of transporting the 5B UF6 cylinder. [9] The 5B cylinder measures approximately 204 mm across (including handles) by 905 mm tall. The VP-55 payload dimensions are 381 mm diameter by 657 mm high. Hence the VP-XL design will have a payload area about 50% taller than the VP-55.

### VP-30

Certain clients and potential clients have indicated that they would like to see a lighter version of the Versa-Pac. The VP-55 tare weight is 177 kg and maximum gross weight is 290 kg. Data indicates that the average gross weight is about 179 kg. Daher-TLI has been examining the feasibility of introducing a 30-gallon version, called the VP-30, which will have its own favorable geometry inner container. This package would have capacity comparable to the VP-55 but would be half the weight.

### VP-55PEL

A final design concept for the VP-55 is the VP-55PEL, which would transport PWR or BWR pellets. Daher-TLI has been approached on occasion for help transporting small and large quantities of sintered production line pellets in a way that minimizes scrap. The needs have ranged from wanting to send a small sample lot to an overseas laboratory for analysis, to investigating the feasibility of transporting reload quantities of pellets from one location to another for rod loading. In these

cases, manufacturers are considering alternatives to maintaining production targets should their facilities experience temporary shutdowns due to natural disasters, industrial accidents, or regulatory imposed stoppages.

Daher-TLI has prepared initial conceptual designs for transporting a single cassette holding up to 13kg UO2 pellets enriched up to 5wt.% in the Versa-Pac, which is the maximum for the current VP-55 standard configuration. Other studies, which require additional criticality analyses, look at transporting more pellet trays. A key factor in designing a pellet package is to tailor the cassettes so they would hold trays that were compatible with the manufacturer's pelleting lines. The initial idea is to transport the VP-55PEL in the horizontal position, to facilitate easier loading and offloading. **Error! Reference source not found.** shows some conceptual renderings.

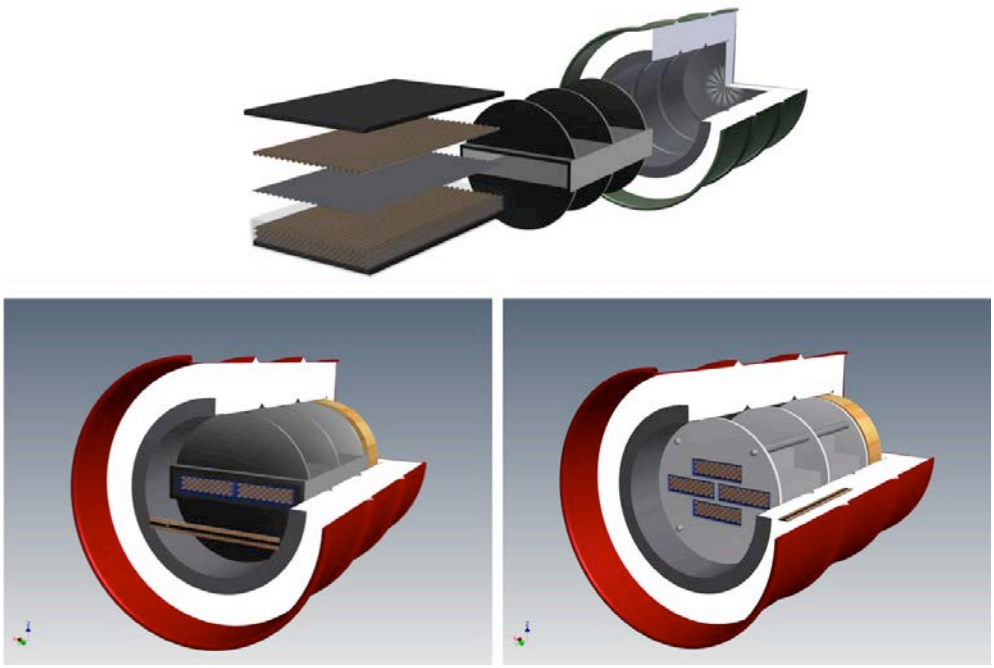

**Figure 6 Conceptual Designs for VP-55PEL**

## CONCLUSIONS

The Versa-Pac is utilized as reusable package for transporting front-end materials and as a one-way package for disposing of radioactive waste. Discussions with current and prospective clients have resulted in incorporating or planning numerous improvements to increase payload capacity and add new material types. These include transporting UF6 in 1S, 2S, and 5B cylinders, developing a lighter 30-gallon Versa-Pac, and introducing a configuration for transporting pellets with minimal scrap.

## REFERENCES

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