# Developments of the Versa-Pac to Expand Use for the Industry – 17475

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## ABSTRACT

The Versa-Pac is a certified Type AF packaging (USA NRC Certificate # USA/9342/AF-96), designed as a replacement for USA DOT 6M drum-type transportation packaging, which was retired approximately ten years ago. The Versa-Pac can be used directly or in conjunction with pails, drums, or inserts, and a variety of smaller containers and vessels.

The Versa-Pac comes in two sizes: the VP-55 (i.e. 200-liter drum version) and VP-110 (i.e. 400-liter drum version). It features a patented design that, in combination with the drum exterior, provides enhanced structural protection to payloads under Normal Conditions of Transport and Hypothetical Accident Conditions.

Since its introduction in 2010, the Versa-Pac has been utilized mainly as a one-time-use package for disposing of radioactive waste. However, the Versa-Pac package, which has the familiar simplicity of a drum, is a reusable transport package with the capability of shipping a variety of radioactive materials.

In the spirit of simplicity yet versatility, the capability of the package has been improved several times in collaboration with our customers. The latest design improvements include a new configuration designated the VP-55HC (high capacity), which utilizes an internal safe geometry pipe container that increases the U-235 capacity. The pipe container is similar in design to the historic USA DOT 2R vessel.

Other planned and proposed improvements include provisions to transport UF6 in 1S, 2S, and 5A/5B cylinders; design changes that further increase the amount of U-235 at enrichments less than 20 wt.%; increasing the capacity of the VP-110 with a VP-110-specific analysis; developing a new, lighter 113-liter version of the package; 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

The Versa-Pac is a package that can be used to store, transport, or dispose of any uranium compound at any U-235 enrichment. The Versa-Pac packaging design meets all USDOT [1], USNRC [2], and IAEA [3] regulatory requirements of a Type AF package. All design and licensing efforts for the Versa-Pac are aimed at providing a familiar, simple-to-use packaging that is also versatile enough to meet customers' current and future needs. The drum-style design of the Versa-Pac makes operations and handling of the package similar to the routine operations of any facility.

The lack of content restrictions on allowable uranium compounds and the wide range of allowable pre-packaging materials makes the Versa-Pac ideal for a wide variety of storage, transport, and disposal needs. While the Versa-Pac currently offers a convenient design with a high degree of flexibility in the allowable contents, improvements are continually being made to the package and its license to meet the needs of all current and potential customers. Figure 1 provides a 3D rendering of the Versa-Pac VP-55 package.


Fig. 1. The Versa-Pac VP-55 Package.

## VERSA-PAC DESIGN

Figure 2 provides a cross-section view of the Versa-Pac design. Pre-packaged or loose contents can be directly loaded into the Versa-Pac cavity. The components of the packaging provide sufficient thermal and impact protection to assure the safe transport of the enclosed radioactive contents.

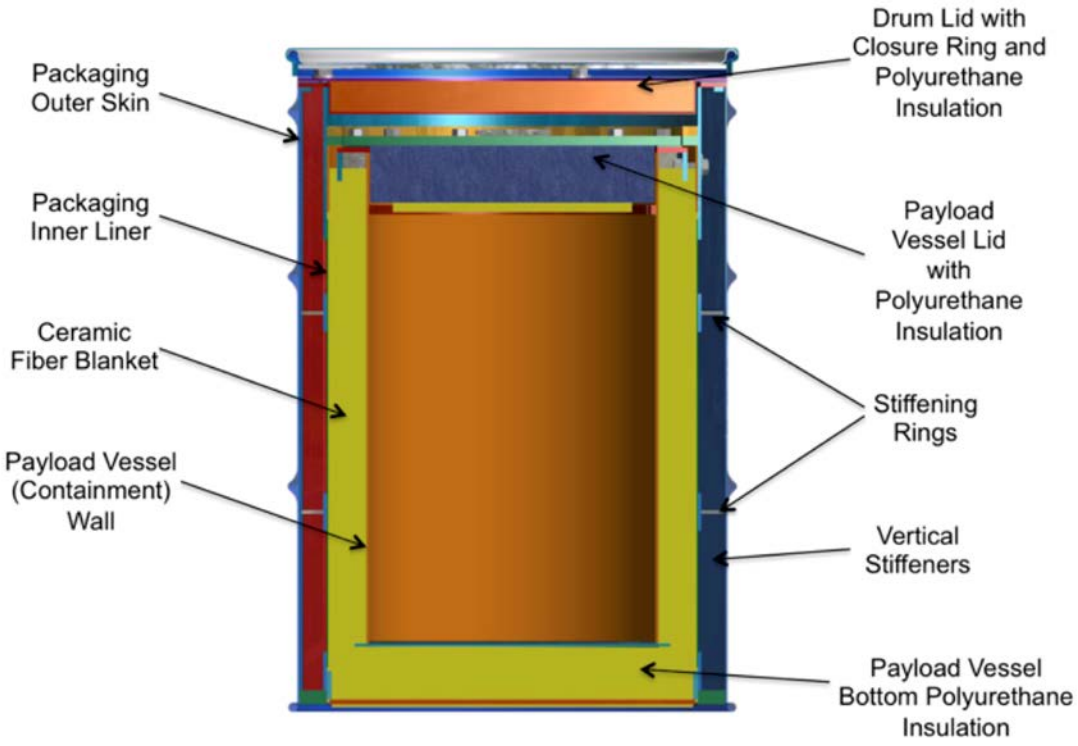


Fig. 2. Components of the Versa-Pac Design.

## STANDARD VERSA-PAC CONFIGURATION

The initial license for the Versa-Pac allowed for shipping up to 350 g of U-235 in uranium compounds enriched up to 100 wt.%. The licensing that allowed for this content was modeled in a uranium/high-density polyethylene (0.98 g/cm$^3$) homogeneous sphere. This allowed for high density polyethylene packaging materials, such as bottles or other plastics, to be loaded with the fissile contents. One of the recent improvements to the package license was the addition of a loading curve, allowing for greater quantities of U-235 to be shipped for lower-enriched uranium.

For each additional enrichment level, a new, most-reactive sphere radius was determined, which modeled the limiting mass of U-235, while remaining under the upper subcritical limit. Sphere radius vs. $k_{eff}$ curves are shown in Figure 3 and the current allowable U-235 mass payload limits for the standard Versa-Pac configuration, by enrichment, are listed in Table I. The standard configuration is rather restrictive, as the assumed spherical geometry of the homogenized contents is a worst-case scenario. This configuration is ideal for waste-type contents with a large mass overall but a low concentration of uranium. The standard Versa-Pac configuration can also transport natural thorium in any form, with no limits on thorium mass.

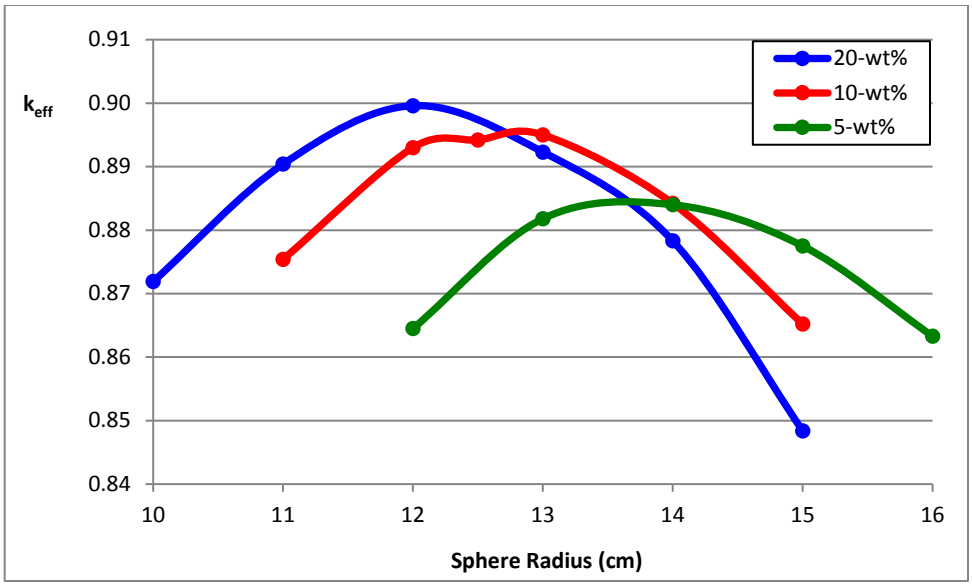


Fig. 3. Sphere Radius Variation Holding U-235 Mass Constant.

TABLE I. Allowable Payloads by Enrichment, Standard Versa-Pac Configuration

| Wt.% U-235 | Mass U-235 (g) | Mass U (g) | CSI |
|---|---|---|---|
| **5** | 580 | 11,600 | 0.7 |
| **10** | 470 | 4,700 | 0.7 |
| **20** | 410 | 2,050 | 0.7 |
| **100** | 350 | 350 | 0.7 |

## VERSA-PAC HIGH CAPACITY CONFIGURATION

To increase the payload capacity of the Versa-Pac, the “High Capacity” configuration was added to the package license. By restricting the radioactive contents in the package to a 5-inch inner diameter pipe container, the U-235 mass limits for the package increase significantly. For this configuration, the radioactive contents are loaded into the licensed, 5-inch pipe container design that is then closed with a simple screw-on cap. This 5-inch pipe can then be loaded into a standard Versa-Pac package, with or without any additional shoring. The 5-inch pipe used in the High Capacity configuration of the Versa-Pac package is shown in Figure 3.


Fig. 3. High Capacity Versa-Pac 5-inch Pipe Container Design.

While the Versa-Pac packaging provides all of the required thermal and impact protection for the radioactive contents in the payload, the 5-inch pipe restricts the fissile contents to a narrower, non-spherical geometry. Restricting the geometry of the fissile contents allows for a significantly larger quantity of U-235 to be loaded into a single package.

## DESIGN

The 5-inch pipe container is based on the DOT-specification 2R container. The benefit of this container is that it contains the fissile mass in a suboptimal configuration. The container maximizes the ratio of the surface area of the container to the volume of the fissile material in the form of a narrow cylinder, which allows for more neutron leakage than the standard Versa-Pac configuration's free-form sphere of optimally moderated fissile material. This results in much higher fissile mass limits for the VP-55 with the 5-inch pipe configuration. For uranium content forms with a lower density (e.g., powders), the volume of the pipe may be more limiting than the total uranium masses listed.

Although the Versa-Pac packaging provides the thermal and impact protection for the contents, the 5-inch pipe was subjected to a HAC drop testing. The 5-inch pipe was subjected to the full HAC drop test series, without the added protection of the Versa-Pac, to demonstrate that the fissile contents would remain confined within the cylindrical geometry in an accident scenario. The drop testing of the 5-inch pipe provides assurance that the fissile contents will remain in the pipe in an accident

scenario and cannot reconfigure into a spherical geometry.

To determine the limiting U-235 mass for a given enrichment level within the 5-inch pipe container for the VP-55, the ratio of hydrogen to fissile material and the fill percentage of the 5-inch pipe container were varied to determine the most reactive configuration. The 100-wt.% and 20-wt.% mass limits were set by the upper subcritical limit. However, the 10-wt.% and 5-wt.% mass limits were set by the volume of the container. This can be noted in Figure 4, as the 10-wt.% and 5-wt.% curves never reach the USL, even at the 100% fill level. For these lower enrichments, the addition of another 5-inch pipe into the Versa-Pac cavity could increase the uranium mass limit. However, this addition would require additional analysis and licensing. The current U-235 mass payload limits for the Versa-Pac High Capacity configuration are listed in Table II, by enrichment.

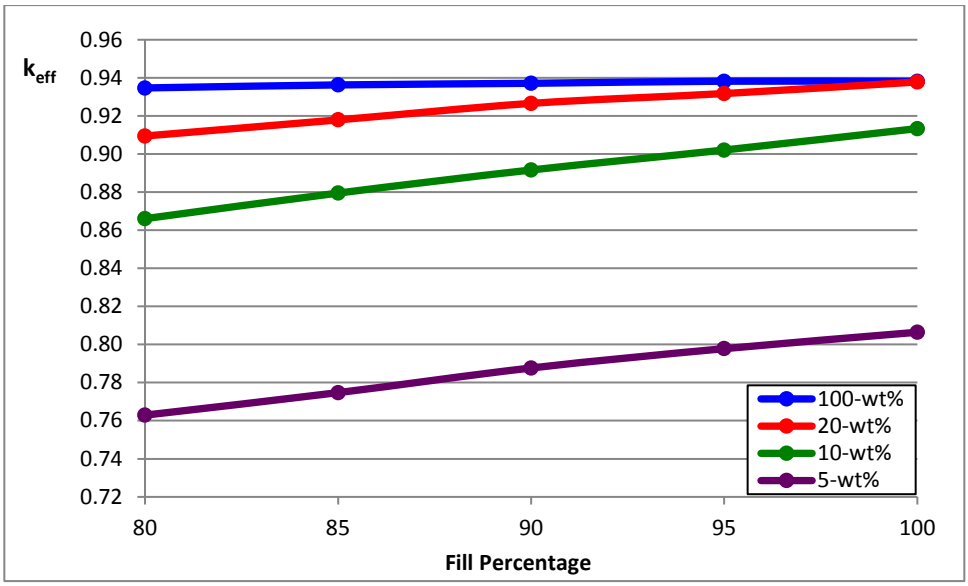


Fig. 4. Fill Percentage Sensitivity of Versa-Pac High Capacity, NCT Package Array.

TABLE II. High Capacity Versa-Pac Design Allowable Payloads by Enrichment

| Wt.% U-235 | Mass U-235 (g) | Mass U (g) | CSI |
|---|---|---|---|
| **5** | 1,065 | 21,300 | 1.0 |
| **10** | 1,605 | 16,050 | 1.0 |
| **20** | 1,215 | 6,075 | 0.7 |
| **100** | 695 | 695 | 0.7 |

## FUTURE LICENSING CHANGES AND ADDITIONS

In the spirit of simplicity yet versatility, continuous content assessments have expanded the capability of the package without changing the packaging design. Future developments will include evaluating content densities and crediting content configurations. The assessment of content specifications allows for an optimized

payload for the individual content type. Crediting content density, such as the reduced density of $UO_2$ powder in contrast to the current content evaluation of U-metal, will result in an increase in the quantity of material per package. Evaluating the content configuration, such as research reactor fuel element geometry, in conjunction with packaging design changes, can further optimize the package and usage versatility. Additionally, packaging enhancements to the thermal performance of the package can allow for the assessment of slightly irradiated or low specific activity material.

For fissile packages, the engineering analyses are based around the criticality safety assessment of the package, and demonstrating compliance with USNRC [2] and IAEA [3] regulatory requirements. If packaging changes are incorporated, then the impact to the structural and thermal bases is assessed. For minor changes, the approved safety analysis may be bounding and no changes to the license may be required. However, any revision to the package design or engineering basis would then require revision of the safety analysis report and amendment to the license. For the Versa-Pac, the base certificate is approved by the USNRC. Any license amendments would begin with the USNRC review. Continuous improvements to the Versa-Pac package, through the assessment of additional, well-defined content specifications and package enhancements, increases the versatility of the package.

## CONCLUSIONS

The Versa-Pac package design provides a highly versatile storage, transport, and disposal option for a wide variety of customers and applications. Recent improvements to the Versa-Pac license have provided additional flexibility to the allowable contents for the package. Additional improvements to the package are consistently being made to meet current customer needs and to meet the needs of the nuclear industry in the future.

## REFERENCES

1. United States Department of Transportation (USDOT), Title 49, Code of Federal Regulations Part 173, Subpart I - Class 7 (Radioactive) Materials, 2016.
2. United States Nuclear Regulatory Commission (USNRC), Title 10, Code of Federal Regulations Part 71 – Packaging and Transportation of Radioactive Material, 2016.
3. International Atomic Energy Agency, (IAEA), "Regulations for the Safe Transport of Radioactive Material," IAEA Safety Standard SSR-6, 2012.