Record of Revisions – Revision 13 (December 2021 with June & July 2022 change pages)

Official approval of Versa-Pac SAR Revision 13 June and July 2022 change pages: DCN-22-003

General

- All headers changed to new Orano TLI logo.
- Starting with Revision 13, the revision listed in the header of all pages is the latest revision and revision bars from prior revisions are no longer retained. As a result, the "List of Effective Pages" has been removed.
- Pages dated June or July 2022 in the header are change pages that have been modified since the original December 2021 issue of Revision 13 of the SAR due to RAIs issued by the NRC or resulting from the NRC Inspection documented in Report No. 71-0947/2022-201

Licensing Drawing Revisions Descriptions in Proprietary SAR Version

Chapter 1

- §1.1 Added High-Capacity Basket, dual 5-inch pipe limit for 20-wt% contents to Table 1-4. Added sentence clarifying that 1S and 2S cylinders must be compliant with the version of the ANSI N14.1 standard effective at the time of fabrication.
- §1.2.2 Added mention of High-Capacity Basket contents and the inclusion of natural thorium.
- §1.3 Changed ANSI N14.1 reference to "Latest Revision".
- §1.4.1 VP-55-LD updated to Revision 5
- §1.4.2 Removed "enamel" from topcoat requirement.
- §1.4.3 Added FAR 25.853 as a permissible flame retardancy specification requirement.
- §1.4.8 and §1.4.9 Added for the new High-Capacity Basket description and Licensing Drawing.

Chapter 2

- §2.1.2 removed wording indicating that the Versa-Pac has a 10 year design lifetime
- Changed §2.12 to 'Appendices' to match Reg Guide 7.9 format. 'References' shifted to Section §2.12.1
- §2.6 and §2.7 added reference to Appendix 2.12.3 for HCB analysis
- §2.12.1 added new references for HCB analysis
- §2.12.2 added to include VP-55 LS-DYNA analysis
- §2.12.3 added to include the HCB stress analysis

Chapter 3

- §3.1.3.2 year '2012' removed from ANSI N14.1 reference. Changed containment gasket maximum allowable temperature in Table 3-3 to 500°F.
- §3.2.2 Changed containment gasket maximum allowable temperature to 500°F.
- Table 3-10 Reference [2] year '2012' removed from ANSI N14.1 reference and changed containment gasket maximum allowable HAC temperature to 500°F.
- Section 3.5 listed new appendix 3.5.4, classical equations appendix changed to 3.5.5

Record of Revisions – Revision 13 (December 2021 with June & July 2022 change pages)

- Section 3.5.1 changed Reference [2] to "Latest Revision" and added References [17] through [19]
- §3.5.2 year '2012' removed from ANSI N14.1 reference.
- Table 3-18 Changed containment gasket maximum allowable temperature to 500°F.
- Table 3-21 Changed containment gasket maximum allowable temperature to 500°F.
- §3.5.4 added appendix for HCB thermal analysis.
- §3.5.5.2.1 updated table numbering due to added HCB appendix.

Chapters 4 & 5

- No Changes

Chapter 6

- Frontmatter Tables of Contents, Tables, and Figures updated
- §6.1.1.4 Added to discuss the addition of the High-Capacity Basket (HCB)
- §6.1.2.6 Added to provide HCB criticality analysis summary
- §6.1.2.7 Updated to correct existing USLs, based on changes to Section 6.8 (see below) and added HCB USL. Note: the USL changes have no effect on the Versa-Pac criticality safety basis.
- Table 6.1.3-1 revised to list HCB CSIs
- §6.2.5 updated to specify ANSI N14.1 effective at the time of manufacturing
- §6.2.6 added to provide HCB fissile content description
- §6.3.1.3 added to provide HCB model configuration description
- §6.3.2.10 and 6.3.2.11, as well as Table 6.3.2-3 and 6.3.2-4 added to provide material description for the HCB and contents
- Table 6.3.3-1 revised to list HCB neutron history specification
- §6.3.4.4 editorial change for clarity
- §6.3.4.6 added to describe HCB analyses and methods
- §6.4.6 – HCB Single Package Analysis
- Table 6.5-1 updated to list NCT Array Size for HCB Analysis
- §6.5.6 – HCB NCT Array Analysis
- Table 6.6-1 updated to list HAC Array Sizes for HCB Analysis
- §6.6.6 – HCB HAC Array Analysis
- §6.8 updated to include new HCB USL equation and added supplemental benchmarks (HCT-011 and LCT-058) and corrected a transpositional error in Table 6.8.1-2 where c_k values listed for experiment series LST-002 and LST-003 were incorrectly ordered. The transpositional error affected the cases included in the USL generation and the corrections made resulted in very small changes in USLs for the given contents. A summary of all updated USLs due to these corrections is provided in the following table (note that not all USLs were affected):

Record of Revisions – Revision 13 (December 2021 with June & July 2022 change pages)

Content	Enrichment	OLD USL	NEW USL
Standard	100	0.9399	0.9400
	5	0.9423	0.9420
Hydrogen Limited	100	0.9399	0.9400
	5	0.9417	0.9420
5-inch Pipe	100	0.9399	0.9394
1S	100	0.9394	0.9395
Air Transport	100	0.9399	0.9400
	5	0.9417	0.9420

- §6.9.1 reference [1] date updated to "Latest Revision" and new references added in [5] and [7]. Other references renumbered by order first listed in the document accordingly.

Chapter 7

- §7.1.1 added gasket part numbers to Step f. Clarified that Part FE is optional when using BB-2 in Step h. Clarified Step j to inspect threads "on each pipe"
- §7.1.1 added Step k for the use of the HCB
- §7.1.2 added Steps e for the use of the HCB
- §7.1.2 clarified in Note k that Part IG is always required when using the HCB

Chapter 8

- §8.1.5 added CPVC material requirement
- §8.2.3.1 added Step g for HCB inspection requirement prior to each use

3.1.3.2 HAC Temperature Summary

The Versa-Pac must survive the HAC thermal analysis such that containment is maintained, and the structural integrity is sufficient for the criticality control credited in Section 6. The temperatures of key components are summarized in Table 3-3 for the standard configuration, 1S/2S, and No IG, with the full HAC results in Section 3.4., Appendix 3.5.2.5 and Appendix 3.5.3.5, respectively.

As shown in Table 3-3, the HAC fire does not adversely affect the Versa-Pac's structural or containment configurations. The Inner Cavity Air Volume remains below 600°F (316°C) for the Versa-Pac standard configuration. For the 1S/2S UF_6 cylinder configuration results, the foam liner surface temperature remains below the maximum UF_6 cylinder temperature of 250°F (121°C), as stated in Table 1 of ANSI N14.1. For the case where the containment insulation plug Part (IG) is removed, the maximum inner cavity temperature is 425°F (218°C) which is also below 600°F (316°C) for the Versa-Pac standard configuration.

Table 3-3 HAC Transient Thermal Evaluation Results – Standard Versa-Pac Configuration

Component	Part Number	Temperature °F (°C)						Maximum Allowable Temp °F (°C)	
		VP-55		1S/2S		No IG			
Air volume maximum	—	399	(204)	—	—	—	—	600	(316)
Air volume average	—	351	(177)	—	—	—	—	600	(316)
Foam liner average	—	—	—	221	(105)	—	—	250	(121)
Foam liner inner surface	—	—	—	245	(118)	—	—	250	(121)
Containment cavity surface	—	380	(193)	—	—	425	(218)	600	(316)
Containment plug surface	IG	380	(193)	340	(171)	—	—	600	(316)
Containment lid (Blind flange)	PD	423	(217)	413	(212)	433	(223)	2600	(1427)
Containment body	PA	412	(211)	400	(204)	423	(217)	2600	(1427)
Containment Gasket	GB	425	(219)	416	(213)	436	(224)	500	(260)
Inner flange	PH	434	(223)	425	(219)	445	(229)	2600	(1427)
Drum lid	DL	1457	(792)	1456	(791)	1456	(791)	2600	(1427)
Drum	DA	1461	(794)	1460	(793)	1460	(793)	2600	(1427)

3.1.4 Summary Tables of Maximum Pressures

Due to permeation in the silicone coating of the cavity seal, the maximum normal and HAC operating pressure are expected to be near atmospheric pressure. However, based on the maximum cavity temperatures, the maximum hypothetical pressures for NCT and HAC are approximately 3.3 psig (124 kPa) and 9.8 psig (169 kPa), respectively. Both are well below the 15 psig (205 kPa) containment pressure rating. Thus, the Versa-Pac meets the requirements of 10 CFR 71 [1].

3.2.1.6 Gasket Materials

Gasket materials are not credited for thermal insulation and their properties are not explicitly modeled in this calculation. Because the gaskets will attain the temperature of the material around them, properties of the surrounding steel are used in this analysis.

3.2.1.7 Thermal Emissivity

A painted surface is considered for NCT and pre-fire conditions. Fire and post-fire emissivity values are as provided in regulatory handbooks. All emissivity values and references are documented in Table 3-9.

Table 3-9 Thermal Emissivity Values

Surface Condition	Emissivity	NCT	HAC (Fire)	HAC (Post Fire)
Painted surface	0.9	Painted surface (0.9)	Fire (0.9)	Oxidized Steel (0.8)
Fire	0.9			
Oxidized Steel	0.8			

Reference:
[1] Emissivity HAC fire and post-fire, 10 CFR 71.73(c)(4)
[7] Emissivity of painted surface "Black glass paint"

3.2.2 Component Specifications

The Versa-Pac is insulated to protect the containment boundary during Hypothetical Accident Conditions (HAC). The drum and the liner are separated by air gaps except at the locations of the vertical and horizontal stiffeners. The volume between the liner and the payload canister is filled with ceramic blanket insulation. A fiberglass thermal break is used to limit the flow of heat to the payload cavity through the steel flange components. The package containment is rated to an internal pressure of 15 psig. The relevant thermal material properties are provided in Section 3.2.1 above.

These insulators have been shown by the manufacturers to perform adequately over extended periods of time, with no shrinkage, settling, or loss of insulating properties. Additionally, these insulators do not burn. The melting point of the ceramic blanket insulation and the fiberglass thermal break are well above the temperature of the 1475°F (800°C) fire specified by 10 CFR 71.73. These insulation products are provided as fire-protection and are sacrificial components during a fire event. Steel components are serviceable to 800°F (427°C) per the ASME Code and have a melting point of about 2500°F (1371°C).

The payload cavity gaskets are rated for operating temperatures between -40°F (-40°C) and 500°F (260°C); however, due to permeation in the silicone coating of the cavity seal, the maximum normal and HAC operating pressure are expected to be near atmospheric pressure during all conditions of transport.

The Versa-Pac design allows for the use of two neoprene pads: a 1/8-inch bottom pad, and a 3/8-inch top pad. The pads serve the purpose of protecting the inner containment shell during repeated use. As the use of these pads is optional, the neoprene material is not included in the thermal model. The flash point available in open literature for neoprene is approximately 500°F

(260°C). Since the internal temperature of the containment vessel has been shown not to exceed 400°F (204°C), the inclusion of neoprene does not increase the thermal load of the package.

Thermal design criteria are specified for separate regions throughout the Versa-Pac shipping package. Each region is limited to the temperature specified in Table 3-10. This table presents the maximum design temperatures of the components or materials that affect structural integrity, containment, and criticality control. Where available, temperature limits for the Versa-Pac components are obtained from manufacturers' literature. Otherwise, the component temperature limits are defined as the melting temperature of the material of construction. NCT limits generally reflect the upper temperature limit listed for retention of structural integrity, continuous load ratings, or the maximum allowable temperature of the contents. HAC limits generally reflect melting temperatures, short-term (transient) material temperature limits, or the maximum allowable temperature of the contents.

Table 3-10 Temperature Limits

Component or Material	NCT Temperature Limit °F (°C)		HAC Temperature Limit °F (°C)	
ASTM A-36 Carbon Steel	---[a]	---	2600	(1427)
525 Fiberglass [b]	150	(66)	1800	(982)
Cerablanket (6 pcf)	2150	(1177)	2400	(1316)
Polyurethane Foam (Containment insulation plug)	270	(132)	2000+[c]	(1093)
High Temp., Heat Resistant, Silicone-Coated Fiberglass Gasket	500	(260)	500	(260)
Inner Cavity – Standard and High-Capacity Configurations	600 [d]	(316)	600 [d]	(316)
Inner Cavity – 1S/2S UF_6 Cylinder Configuration	250	(121)	250	(121)
Accessible Surfaces of Package	122 [e]	(50)	---	---

References:

[8] 525 Fiberglass, Carbon steel melting temperature.

[4] Cerablanket: Continuous use and Classification temperature rating, Page 16.

[6] Polyurethane Foam NCT Temp. Limit: Glass Transition.

[2] 1S/2S Inner Cavity Limit: Table 1 of ANSI N14.1.

[1] Accessible Surfaces of Package: Non-exclusive use requirements per 10 CFR 71.43(g).

Notes:

[a] Carbon steel is not expected to have a significant loss of thermal properties during NCT.

[b] For NCT, 150°F is the temperature at which most FRPs begin to decompose. Some more specialized FRPs will begin decomposing at higher temperatures. For HAC, the reference states that, "…it is not uncommon for a fire retardant FRP product to be able to withstand a hydrocarbon fire at temperatures up to 1800°F for 30 minutes."

[c] In Reference [9], 2000+°F is the temperature at which the foam's intumescent char will begin to decompose. This char, consisting of burned foam, serves as a secondary, insulating barrier for the remainder of the foam in a fire event.

[d] 600°F is the temperature limit specified for these configurations of the Versa-Pac.

[e] Based on 10 CFR 71.43(g) non-exclusive use limit, only applies for case in the shade (no solar insolation).

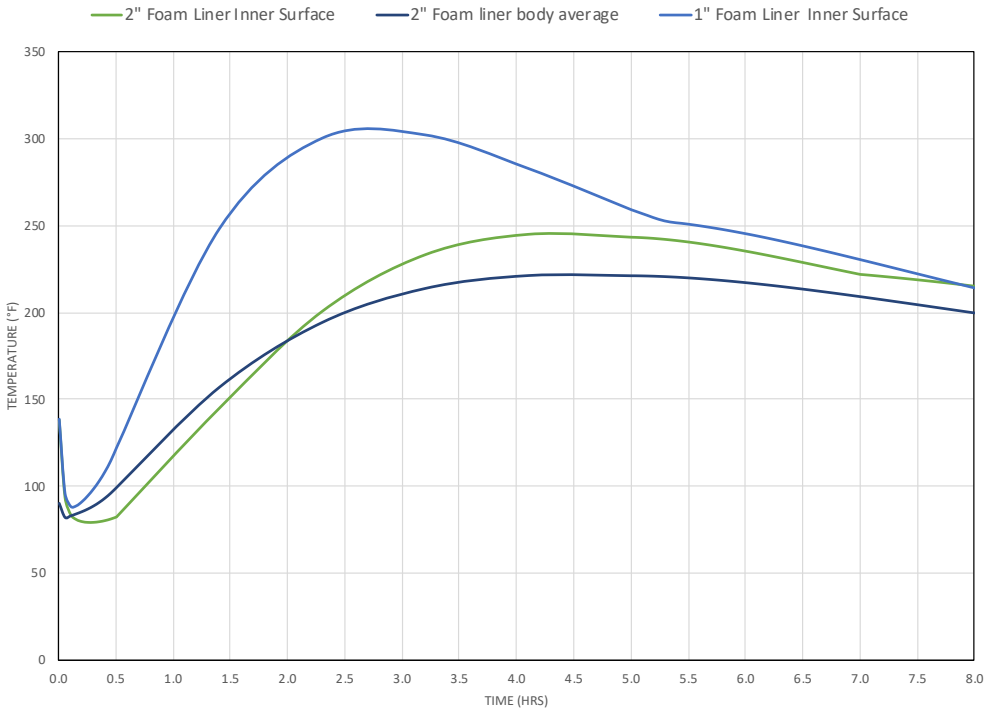

Figure 3-27 VP-55 1S/2S UF6 Cylinders – Containment Inner Surface Temp. with Foam Liners

Maximum temperature values for selected components are documented in Table 3-18 below. In addition, the temperature-time histories of the package components are displayed in Figure 3-28 and Figure 3-29. The body temperature contour of the package is displayed in Figure 3-30 and Figure 3-31.

Table 3-18 HAC Fire Transient Results – 1S/2S UF_6 Cylinder VP-55 Configuration

Component	Part Number	Results		Maximum Allowable Temperature °F (°C)	
		Temperature °F (°C)		Time Hr. (Sec.)	
Foam liner average	N/A	221	(105)	4.10 (14761)	250 (121)
Foam liner inner surface maximum	N/A	245	(118)	4.10 (14761)	250 (121)
Containment plug bottom surface	IG	340	(171)	1.40 (5042)	2000 (1093)
Containment lid (Blind flange)	PD	413	(212)	1.40 (5042)	2600 (1427)
Containment body	PA	400	(204)	1.40 (5042)	2600 (1427)
Gasket	GB	416	(213)	1.40 (5042)	500 (260)
Inner flange	PH	425	(219)	1.40 (5042)	2600 (1427)
Drum lid	DL	1456	(791)	0.5 (1802)	2600 (1427)
Drum	DA	1460	(793)	0.5 (1802)	2600 (1427)

3.5.3.5.3 HAC Results

The HAC results for the VP-55 without containment insulating plug is provide in Table 3-21. Temperature-time history plots for select components of entire package and containment region are displayed in Figure 3-39 and Figure 3-40, respectively. Temperature contour plots are shown in Figure 3-41 and 3-42.

As shown in Figure 3-40, the maximum temperature in the containment region of 445°F (229°C) was recorded at 1.4 hours. However, package component temperatures remain below the maximum allowable temperatures.

Table 3-21 HAC Transient Thermal Evaluation Results – VP-55 Configuration Without Containment Insulation Plug

Component	Part Number	Results		Maximum Allowable Temperature °F (°C)	
		Temperature °F (°C)		Time Hr. (Sec.)	
Containment cavity surface	N/A	425	(218)	1.40 (5042)	600 (316)
Containment lid (Blind flange)	PD	433	(223)	1.40 (5042)	2600 (1427)
Containment body	PA	423	(217)	1.40 (5042)	2600 (1427)
Gasket	GB	436	(224)	1.40 (5042)	500 (260)
Inner flange	PH	445	(229)	1.40 (5042)	2600 (1427)
Drum lid	DL	1456	(791)	0.5 (1802)	2600 (1427)
Drum	DA	1460	(793)	0.5 (1802)	2600 (1427)

Note: See Table 3-10 for HAC temperature limits.

7 PACKAGE OPERATIONS

The Versa-Pac Shipping Package is used to transport a variety of materials, typically by non-exclusive use. It is to be loaded, inspected and handled in accordance with standard, plant operating procedures. At a minimum, the operating procedure should include the steps described in the subsequent sections.

Due to the low specific activity and low abundance of gamma emitting radionuclides, dose rates from the contents of the package are minimal. As a result of the low dose rates, there are no special handling requirements for radiation protection. As a Type AF package, the contents of the Versa-Pac are always limited to be less than or equal to an A_2 quantity, calculated per the guidance of 10CFR71 Appendix A. All radioisotopes in the contents shall be included in the A_2 calculation (typically uranium isotopes: U-233, U-234, and U-236).

7.1 Package Loading

7.1.1 Preparation for Loading

Prior to loading the Versa-Pac, the packaging is inspected to ensure that it is in unimpaired physical condition. The inspection looks for damage, dents, corrosion, and missing hardware. Acceptance criteria and detailed loading procedures derived from this application are specified in user written procedures. These user procedures are specific to the authorized content of the package inspected to ensure packaging complies with Appendix 1.4.1, Packaging General Arrangement Drawings.

Components requiring repair will be fixed prior to shipping in accordance with approved procedures consistent with the quality program [1].

The User shall inspect the accessible surfaces of the closure and sealing devices in accordance with approved procedures prior to loading of the container to assure the following at a minimum:

a. Ensure that the most recent certification performed is in accordance with Section 8.2.
b. The contents are within the limits of the Certificate of Compliance.
c. The package inner and outer surfaces are visually free from damage that may impair the safe use of the package.
d. The Package is free of debris or other foreign matter that could interfere with the proper and safe use of the container.
e. Verify that the outer drum and visible inner plugs are in place.
f. Gaskets (Parts GA & GB) are in place and intact and are not deteriorated or damaged. Replace as needed.
g. The containment flange and outer drum cover and all mating surfaces are sound and fit properly.
h. Closure bolts are the proper type and size and that threaded inserts (Part FE) are in working order, when required. NOTE: when using Part BB-2, Part FE is optional, used only for thread repairs.
i. Ensure that security seal holes are functional and capable of maintaining their integrity when seals are required.
j. When utilizing the 5-inch pipe, visually inspect the threads on each pipe for damage that would interfere with the appropriate operation of the cap and body connection obtaining the minimum 5 full turns of closure. If required, repair threads by an appropriate method or replace the component.