

## **Enhancing of the OPTIMUS Packaging System for High-Activity Radioactive Source Transportation**

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### **ABSTRACT**

In this paper, we examine the enhancement of the OPTImal Modular Universal Shipping (OPTIMUS®) packaging system for the transportation of high-activity radioactive sources. Addressing both the challenges of expired original packaging and the need for increased source activity capacity, the OPTIMUS system is being adapted to meet industry needs. This adaptation involves a novel method for crediting existing device shielding transportation and/or disposal of high-activity sources.

The OPTIMUS®-L, initially focusing on lower-dose waste content for anticipated needs, is undergoing significant additions. The Phase II development of OPTIMUS®-L marks a substantial increase in its loading capabilities, now accommodating much higher quantities of currently approved materials, such as Cs-137 and Co-60. This shift in capacity underscores the evolution from a system designed for lower dose waste transportation to one capable of handling a much greater concentrated content.

This paper presents an analysis of the integrated development paths of the OPTIMUS packaging system, emphasizing the seamless transition in its operational scope. It outlines the modifications analyzed to meet the needs of the industry and discusses preliminary results, highlighting the system's safety and efficiency in radioactive material transportation. This development in the OPTIMUS line demonstrates NAC International's commitment to innovation in response to the evolving demands of radioactive material management.

### **INTRODUCTION**

NAC developed the OPTIMUS® line of packaging to serve as an optimal solution for transportation of high and low activity Type B quantities of radioactive materials, replacing a single conventional large package footprint, with multiple, smaller footprint packages. This allows for a modular solution to that can be scaled up or down to meet the needs of an ever-changing industry.

Specifically, the OPTIMUS®-L is ideal for situations where there are weight restrictions for floor loading over overhead lift height or capacity.

The industry need for a small and nimble package that can handle high activity sources has been growing. The OPTIMUS®-L, meeting the small and nimble requirements, lacks the shielding required to transport these high activity sources. Where the OPTIMUS®-H can accept these sources in combination with the array of inserts offered, the package has a much larger footprint that restricts the ease of use is confined areas like hospital parking lots.

This novel approach to credit the shielding contained within sealed source shields opens up the operability of the OPTIMUS®-L for shipments where an emphasis is put on its light weight and low requirements for

operability. This paper discusses the methodology for design, engineering, and licensing for the OPTIMUS®-L for High-Activity Radioactive Source Transportation.

### OPTIMUS®-L Packaging Description

The OPTIMUS® packaging product line currently includes two different designs: OPTIMUS®-H and -L, shown in Figure 1. Both packages are designated Type B(U)-F and designed to satisfy the most limiting requirements of 10 CFR 71 and IAEA SSR-6 [1]. The OPTIMUS®-H packaging is used to transport radioactive materials (RAM) that require more substantial shielding for gamma radiation, whereas the OPTIMUS®-L packaging is used to transport RAM that requires minimal gamma shielding.

Both OPTIMUS®-H and -L packagings use the same Cask Containment Vessel (CCV) design. However, the outer packagings of the OPTIMUS®-H and -L differ due to shielding requirements for the intended contents. The outer packaging of the OPTIMUS®-H consists of a thick-walled Outer Shield Vessel (OSV) and an Impact Limiter System (ILS), whereas the outer packaging of the OPTIMUS®-L consists of a stainless-steel drum-like assembly filled with rigid polyurethane foam for impact and thermal protection. The physical attributes of the OPTIMUS®-H and -L packages are summarized in Table 1.

The outer packaging of the OPTIMUS®-H and -L are significantly different due to shielding requirements for the intended contents. Because of the differences in the outer packaging, the OPTIMUS®-L has a much smaller outer envelope and gross weight than the OPTIMUS®-H. As shown in Table 1, OPTIMUS®-L has an Ø1.24-meter (Ø49-inch) outer diameter and maximum gross weight of only 4,173 kg (9,200 pounds) compared to Ø1.88-meter (Ø74.2-inches) and 14,515 kg (32,000 pounds) for the OPTIMUS®-H. The smaller size and weight of the OPTIMUS®-L package result in significant improvement in operational efficiencies for lower activity contents than larger packages. In addition, the per-drum content weight, decay heat, and fissile gram equivalent limits of OPTIMUS®-L are much higher than those of larger transportation packages that accommodate several drums.

Table 1 – OPTIMUS® Packaging Physical Attributes

Packaging Physical Attributes	Packaging Design	
	OPTIMUS®-H	OPTIMUS®-L
Outer Diameter <sup>(1)</sup> , m (in)	Ø1.88 (Ø74.2)	Ø1.24 (Ø49)
Outer Length <sup>(1)</sup> , m (in)	2.11 (83.2)	1.78 (70.0)
Cavity Diameter, m (in)	0.83 (Ø32.5)	0.83 (Ø32.5)
Cavity Length, m (in)	1.19 (47.0)	1.19 (47.0)
Packaging Tare Weight, kg (lb)	11,204 (24,700)	2,722 (6,000)
Max. Contents Weight, kg (lb)	3,311 (7,300)	1,429 (3,150)
Max. Gross Weight, kg (lb)	14,515 (32,000)	4,173 (9,200)
Gamma Shield Thickness <sup>(2)</sup> , cm (in)	≥ 20.3 (8.0)	≥ 3.3 (1.3)

The OPTIMUS®-H and -L packagings are designed to ship similar contents with different activities. For large shipping campaigns having a range of contents, OPTIMUS®-H and -L packagings can be used in combination to significantly reduce the number of shipments required and the total occupational exposure, improve operational safety, and provide significant cost savings. By using a common CCV design in both the OPTIMUS®-H and -L packagings, operating procedures for loading contents, CCV closure, and unloading contents are largely standardized, simplifying operations for users that operate both OPTIMUS®-H and -L packagings. In addition, the use of a common CCV design allows for

interchangeability of the CCV between packages, which has clear economic benefits for users that operate both OPTIMUS®-H and -L packagings.

Loading operations for the OPTIMUS® packages differ by content and facility type. Typical contents of the OPTIMUS®-L package with low surface dose rates may be loaded directly into the CCV. Contents with high surface dose rates may require loading via a shielded transfer cask and/or transfer adapter or via remote operations. The OPTIMUS®-H and -L packaging may be loaded while mounted on the trailer deck or removed from the trailer for loading operations performed inside a facility. The modularity of the OPTIMUS®-H and -L packaging provides maximum flexibility for operations.

Unlike most other Type B(U) packaging used to transport similar RAM contents, the OPTIMUS® Packagings' are relatively small and lightweight, simplifying lifting and handling operations. The primary mode of lifting and handling the OPTIMUS® packages is by forklift using custom pallets. The pallets allow the OPTIMUS® packages to be quickly and easily loaded onto or unloaded from a trailer outside the secure area of a facility without the need for a mobile crane and it eliminates the need to bring the tractor and trailer into the facility's secure area.

### CURRENT CONTENTS

Current contents of OPTIMUS®-H and -L packaging include intermediate level waste (ILW), transuranic (TRU) waste, low-enriched uranium (LEU) fuel waste, fissile material (FM) canisters, and CANDU fuel baskets. These contents shall not exceed the fissile gram equivalent (FGE) limits for ILW/TRU waste and FM canister contents or the fissile equivalent mass (FEM) limits for LEU contents from Table 2.

The maximum weight of the package contents, including the CCV support plate, any secondary containers (e.g., drums) and shoring, is limited to 3,311 kg (7,300 lb) and 1,588 kg (3,500 lb) in OPTIMUS®-H and -L, respectively.

Table 2 – Typical OPTIMUS® Packaging Content Limits

Content	Limit	Packaging	
		OPTIMUS®-H	OPTIMUS®-L
ILW / TRU Waste	FGE, g <sup>239</sup> Pu (g <sup>235</sup> U)	≤ 390 (606)	≤ 395 (614)
FM Canisters	FGE, g <sup>239</sup> Pu (g <sup>235</sup> U)	≤ 676 (1,050)	≤ 676 (1,050)
LEU	FEM, wt % <sup>235</sup> U	≤ 0.96	≤ 0.90
	Particle Size, cm	≤ 0.1 and/or ≥ 8.0	None
	Uranium Mass, kg (lb)	2,268 (5,000)	1,134 (2,500)
CANDU Fuel Baskets	Max. Burnup, GWd/MTU	5.0	N/A
	Min. Cooling Time, years	40	N/A
	Max. fuel mass, kg (lb) UO <sub>2</sub>	1,809 (3,988)	N/A

The OPTIMUS®-L was originally intended to transport contents with lower gamma shielding requirements than the OPTIMUS®-H; however, with increased interest in a small footprint package that can handle a variety of high activity special and normal formed sealed sources. This allows users streamlined operations, as well as reduces operating and transport costs.

### **Irradiator Device Contents**

Irradiators have been used for decades by hospitals, nuclear power plants, laboratories, universities and various commercial industries as a source of ionization radiation from irradiating blood to portable moisture/density gauges. Many of these sources were initially transported in various Type B packages to their destination. Many of the Type B packages the sources were transported in are not in use due to source suppliers not in business or the certification have expired. This poses an issue when the sealed source is no longer needed where it was originally operated and must be disposed of.

The issue many sites that host these sources encounter is their ability to safely package and transport the unwanted or disused sealed sources; which can pose a risk to health, safety, and security of the host site. A Type B package that is licensed for various sealed sources would enable the host sites that do not wish to continue maintaining a site license for radioactive material or want to replace a disused source with a fresh source. There is a large market for a general package with capabilities to transport these sources without relying on an expired certification.

NAC is currently licensing various shielded devices (e.g. irradiators) as allowable contents for the OPTIMUS-L. The specific content for the devices are special and normal form sources contained within lead filled steel weldments that house the sources. A Shielded Device Insert Assembly, primarily comprised of a cylindrical laminated fiberboard insert and aluminum spacer plates, provides support of the Shielded Device within the OPTIMUS-L CCV cavity. The lead filled steel weldments provide the necessary shielding required to comply with the external package surface dose rate limits for Normal Conditions of Transport (NCT) specified in 10 CFR 71.47, Hypothetical Accident Conditions (HAC) in 10 CFR 71.73, and additional requirements for Type B Packages, 10 CFR 71.51.

The current licensing basis for the OPTIMUS-L will remain valid and a novel approach to crediting the shielding of the content is implemented to increase the allowable activity for the shipment configuration. This process consists of additions to shielding, thermal, and structural analysis in the licensing basis of the OPTIMUS-L to expand the capabilities.

Structural analyses were performed for the Shielded Device Insert Assembly and bounding Shielded Device content under NCT and HAC free drop test conditions. For the side drop orientation, dynamic analyses using LS-DYNA were performed to demonstrate that the maximum contact force acting on the CCV shell, exerted by the fiberboard insert and device, was bounded by the equivalent static loading considered in the current licensing basis structural analysis of the CCV. For the end drop orientations, stresses in the aluminum spacer plates were shown to be within the applicable ASME code allowable stress limits.

Maximum activity for the Shielded Devices is credited up to 2800 curies of Cs-137, and 5 curies of Co-60. This results in a maximum thermal heat load of approximately 13.5 watts which is below the current 50 watt limit for air back filled OPTIMUS-L CCV cavity.

Thermal analyses were performed to demonstrate that component temperatures of the Shielded Device Insert Assembly and Shielded Device within OPTIMUS-L CCV cavity remain acceptable under NCT and HAC.

Shielding analyses were performed on the Irradiator Shielded Devices content to demonstrate compliance with the requirements of 10 CFR 71.47 and 10 CFR 71.51 utilizing MCNP6.2 mesh tallies. Six Shielded Device models were considered in the analysis to demonstrate the NCT and HAC dose rate limits are met.

### Regulatory Approvals

OPTIMUS®-L has been certified by the Canadian Nuclear Safety Commission (CNSC) for use in Canada (CDN/2099/B(U)F-96) and by the U.S. Nuclear Regulatory Commission (NRC) (CoC No. 9390) for a variety of contents, including unirradiated TRISO compacts. NAC has submitted its application for the Shielded Device Content to the NRC on July 10, 2024.

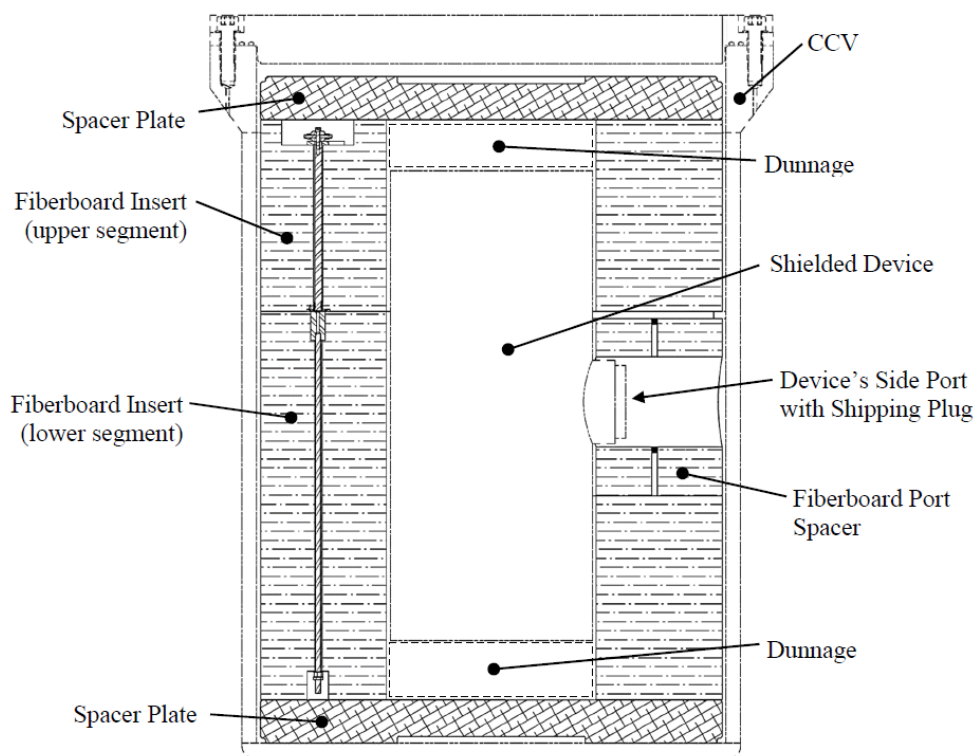


Figure 1: Insert Concept for OPTIMUS-L Packaging

### Conclusions

NAC's OPTIMUS® transport packaging systems are certified Type B(U)F packagings that are ideal for transporting a wide variety of radioactive materials, including Type B quantities of intermediate level waste (ILW), transuranic waste (TRU) and irradiated fuel waste (IFW), reactor components, experiment wastes, pool debris, and reactor products (e.g., sources, irradiated materials, etc.) Furthermore, the OPTIMUS®-L packaging is ideal for the transport of a variety of shielded devices containing high activity sealed sources. Analyses performed by NAC highlight the advantages of OPTIMUS®-L packaging for sealed source transportation. These include its small size and weight for simplified

handling operations within a facility, its relatively large cavity size and payload weight capacity, and the ability to transport several packages on a single LWT shipment make it an ideal packaging for transportation of various forms of sealed sources and devices. Additional work is planned to prepare and submit amendment request(s) for additional Sealed Source contents in the OPTIMUS®-L NRC CoC.