



# OPTIMUS<sup>®</sup> Packagings for Test, Research and Training Reactor Wastes and Products

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October 14, 2022  
TRTR 2022 – State College, PA



The Skills and Experience to Deliver Nuclear Excellence



# NAC International Inc.

## Company Overview

- **Founded in 1968**
- **Global Provider of Fuel Cycle Consulting Services and Technology Solutions**
  - **Engineering, Licensing & Supply of Casks & Canister solutions for Spent Fuel and HLW**
  - **Packaging and Transportation of Nuclear Materials**
  - **Fuel Cycle Consulting Solutions**
- **Safely completed more than 3,700 spent nuclear fuel shipments from more than 70 nuclear facilities worldwide**
- **Over 50 International Packaging Validations for shipment of Spent Fuel and ILW**
- **Dominant package provider in support of U.S. Government Global Threat Reduction Initiative to repatriate used HEU fuel from Research & Test Reactors**
- **Recently received U.S. DOE Secretary's Honor Awards on a Joint U.S/Canadian project NRU/NRX spent fuel packaging and transportation project.**



# Recent Transportation Experience

## SELECT RESEARCH AND TEST REACTOR MISSIONS

2021 ORNL	2012-Avogadro	2010-CCHEN, RECH-I & RECH-II
2021-USGS	2012-Atominstitut Wien	2010-SOREQ
2020-Finland	2012-INL	2010-CNAEM TR-2
2020-NIST	2012-Salazar	2009-NIST
2019-Greece	2011-NIST	2009-INER
2019-Portugal	2011-Reed College	2009-WSU
2019-McMaster Univ.	2011-Safari 1	2009-OSU
2018-ORNL-PNNL	2011-WPI to UMass	2009-UWNR
2018-NIST	2010-Univ. Arizona	2009-ANSTO
2017-Peru	2010-ANL	2008-McMaster Univ.
2017-ISOTEK	2010-AECL	2008-INR
2016-ISOTEK	2010-General Atomics	2008-Sandia
2015-ISOTEK	2010-UWNR	2007-Sandia
2015-Jamaica		



Versatile Type B Packagings

- Customers include both U.S. and other government entities, national labs, universities and commercial nuclear companies

## OPTIMUS<sup>®</sup> (OPTImal Modular Universal Shipping cask)

- **NAC product line of Radioactive Material (RAM) transportation packages**
  - OPTIMUS<sup>®</sup>-L: Ships Low (-L) activity contents
    - CH-TRU, ILW, fuel, fuel debris, sources, and other radioactive contents typically shipped as Type A(F) or Type B
  - OPTIMUS<sup>®</sup>-H: Ships High (-H) activity contents
    - RH-TRU, spent fuel debris, sources, CANDU fuel, and other ILW-HLW wastes
- **Ships a wide variety of challenging contents by road, rail, or sea**
- **Modularity for optimal handling and shielding performance**
- **Today's presentation:**
  - Overview of the OPTIMUS<sup>®</sup> packagings
  - OPTIMUS<sup>®</sup> current contents
  - Comparison vs. traditional large casks
  - Update on recent developments

## OPTIMUS® Packaging Family

- Cost Effective, modular, configurable for content, easily handled, and adaptable for wide-ranging applications
- Contents can exceed 3000A<sub>2</sub> value
- OPTIMUS®-L U.S. NRC CoC (USA/9390/B(U)F-96) issued December 2021
- OPTIMUS®-H application submitted to U.S. NRC December 2021 and NAC responded to NRC Information requests in August 2022
- OPTIMUS®-L CoC (CDN/2099/B(U)F-96) for Intermediate Level Waste (ILW) issued July 2020 and CoC Rev. 1 for Fissile Material (FM) issued August 2021. OPTIMUS®-H CoC (CDN/2098/B(U)F-96) for ILW issued August 2021 and CoC, Rev. 1 for FM and non-exclusive use issued August 2022
- OPTIMUS®-H Australian validation received in December 2021
- 26 OPTIMUS® packagings have been delivered and more are being currently fabricated.
- Significant opportunities to expand OPTIMUS applications globally.



# OPTIMUS® Product Comparison



Packaging Attribute	OPTIMUS®-H	OPTIMUS®-L
Package Designation	B(U)F	
Controls	Exclusive-Use or Nonexclusive-Use	
Cavity Size (in.)	Ø32.5 x 47.0 (fits 110 gallon drum)	
MNOP (psig)	100	
Outer Dimensions (in.)	Ø74 x 83	Ø49 x 70
Empty Weight (lb.)	24,700	6,050
Max. Content Weight (lb.)	7,300	3,150
Gross Weight (lb.)	~25,000 to 32,000	~6,500 to 9,200
Packages LWT Shipment	2	6



■ OPTIMUS®-H



■ OPTIMUS®-L

- **Cask Containment Vessel (CCV)**

- Stainless steel
- Bolted closure w/ elastomeric O-ring face seals
- Captured lid bolts
- Port in lid for inerting cavity, if required
- Lifting attachments in closure lid
- The same CCV is used in both the OPTIMUS®-L & OPTIMUS®-H

- **Outer Packaging (OP)**

- Fully encases CCV for impact and fire protection
- Constructed from stainless steel shells and foam
- Thick outer shell resists road damage
- Integral lifting and tiedown features
- OP lid secured to OP body by 12, ¾-inch Socket Head Cap Screws



- **Lifting features simplify handling operations**
  - **Pallet provided for forklift handling**
    - *Ideal for sites with restricted access and crane limitations*
    - *Speeds up loading/unloading operations*
  - **Lifting lugs on OP lid can be used to lift loaded package (including pallet and tiedowns)**
    - *Designed per ANSI N14.6 ( $S_v/6$  and  $S_v/10$ )*

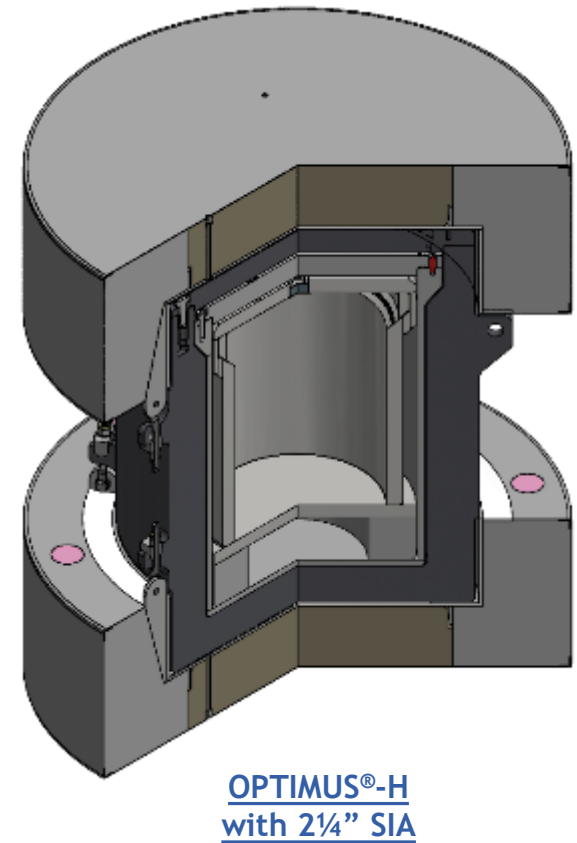
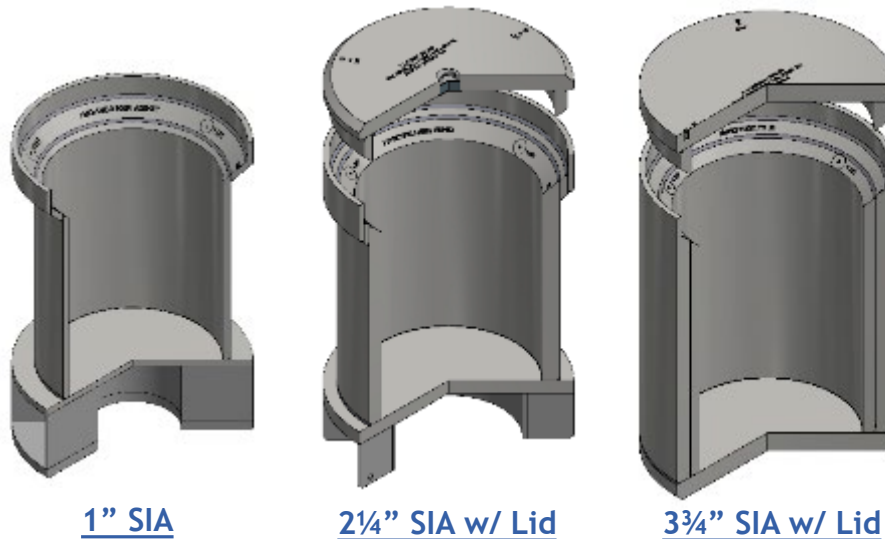


- **No need to remove tiedowns**
  - **OP base remains attached to pallet**
    - Remove securements to trailer deck
    - Forklift pallet/package off trailer
  - **Tiedown directly to trailer deck**
    - Load/unload package directly on trailer deck



- Large cavity and high payload weight limit allows OPTIMUS® packaging to be reconfigured with Shield Insert Assemblies (SIAs)
  - *Balance weight and shielding constraints*

SIA	OPTIMUS®-H	OPTIMUS®-L
1"	✓	✓
2¼"	✓	✓
3¾"	✓	---



## OPTIMUS®-L

Package Configuration	Activity Limits, Ci (Factor Increase)	
	Co-60	Cs-137
Bare, 1x6 array (Open Transport)	4.25E-02 (1.5×)	1.43E+02 (1.5×)
2¼" SIA, 1x6 array (Open Transport)	2.36E-01 (8.3×)	4.59E+03 (47.2×)

## OPTIMUS®-H

Package Configuration	Activity Limits, Ci (Factor Increase)	
	Co-60	Cs-137
Bare (Open Transport)	1.16E+01	2.15E+06
3¾" SIA (Open Transport)	2.90E+02 (25.0×)	1.26E+08 (58.5×)

- **OPTIMUS<sup>®</sup> ships a wide range of challenging RAM contents:**
  - **Intermediate Level Waste (ILW) and compliant transuranic (TRU) waste**
  - **Non-compliant TRU waste**
    - *Aerosol cans w/ compressed gas propellant or liquified propellant*
    - *Lecture bottles with known non-flammable gases or unknown contents*
  - **Fissile Material Canisters**
  - **Low-Enriched Uranium (LEU) fuel waste**
  - **CANDU fuel**
  - **Sources**

Contents	Configurations	FGE Limits	
		OPTIMUS-H	OPTIMUS-L
Form	Configurations		
ILW and TRU waste	$\leq 1$ wt% Beryllium, No $^{240}\text{Pu}$ Credit	335g $^{249}\text{Pu}$	340g $^{249}\text{Pu}$
	$\leq 1$ wt% Beryllium, $\geq 25\text{g}$ $^{240}\text{Pu}$ Credit	390g $^{249}\text{Pu}$	395g $^{249}\text{Pu}$
	Machine Compacted	250g $^{249}\text{Pu}$	250g $^{249}\text{Pu}$
LEU	No Particle Size Restrictions	$\leq 0.80$ wt% $^{235}\text{U}$	$\leq 0.90$ wt% $^{235}\text{U}$
	Particle Size $\leq 0.1\text{cm}$ and/or $\geq 8.0$ cm	$\leq 0.99$ wt% $^{235}\text{U}$	N/A

- Advantages of OPTIMUS®-L over traditional large casks**

- Lower shipping costs and fewer restrictions**
  - OPTIMUS-L allows LWT shipments on trucks as small as 2.5-ton capacity and standard trailers
  - Traditional large cask may require custom-designed trailer and permits
- Fewer shipments for content with high heat load and/or high FGE**
- Comparable drum payload per shipment**

<b>Parameter</b>	<b>OPTIMUS®-L</b>	<b>Large Cask</b>
# Packages/Shipment	6	1
# Drums/Package	1	10
# Drums/Shipment	6	10
Heat Load/Package	≤100 watts	≤200 watts
FGE/Package	≤ <b>395g <sup>239</sup>Pu</b>	≤325g <sup>239</sup> Pu
<b>Heat Load/Shipment</b>	<b>≤600watts</b>	≤200 watts
<b>FGE limit/Shipment</b>	<b>≤2,370g <sup>239</sup>Pu</b>	≤325g <sup>239</sup> Pu

**OPTIMUS®-L allows LWT shipments of contents with significantly higher heat loads and FGE content than a traditional large Type B cask**

- U.S. Patent No. 11,373,773 issued 6/28/2022
- NAC currently fabricating a fleet of OPTIMUS®-L, OPTIMUS®-H, and Shield Insert Assemblies
  - Two (2) OPTIMUS®-Ls completed (2 more in fabrication for delivery 12/2022)
  - One (1) OPTIMUS®-H completed (2 more in fabrication for delivery 12/2022)
  - Two (2) 2.25” Shield Insert Assemblies under fabrication for delivery 11/2022
- **First OPTIMUS®-L commercial shipment completed successfully in September 2022**



**The OPTIMUS® systems are a small, lightweight Type B(U)F-96 package that provide many operational advantages over traditional large casks**

- *Significantly higher heat load and FGE limit per shipment of packages than a traditional large cask with a 10-drum capacity*
- *Forklift handling eliminates need for cranes for lifting*
- *LWT shipments using standard trailers vs. custom trailers with permits*
- *Shielding inserts can be added as needed for higher activity drums allowing flexibility for payload optimization*

**OPTIMUS® leverages existing analyses and proven methodologies, providing design enhancements that will result in:**

- *Significant increase in the quantity of non-compliant TRU waste contents*
- *Significant increase in the FGE limits for TRU waste*
- *Expands packaging options for problematic waste*

***Available for lease or sale to support TRTR fuel, product, and waste cleanout transportation campaigns***

# Questions



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# Reference Materials

## OPTIMUS-L® Contents

Isotope	No SIA			1-inch SIA			2¼-inch SIA			HAC Dose Rate (mrem/hr/Ci)
	Method 1 Activity Limit <sup>(1)</sup> (Ci)	NCT Dose Rate (mrem/hr/Ci)		Method 1 Activity Limit <sup>(1)</sup> (Ci)	NCT Dose Rate (mrem/hr/Ci)		Method 1 Activity Limit <sup>(1)</sup> (Ci)	NCT Dose Rate (mrem/hr/Ci)		
		Method 2			Method 2			Method 2		
		Pkg Surface	2-meter		Pkg Surface	2-meter		Pkg Surface	2-meter	
Ag110m	3.93E-02	2.41E+03	6.10E+01	9.21E-02	1.08E+03	2.61E+01	2.79E-01	3.62E+02	8.33E+00	6.55E+02
Am241	4.61E+03	2.16E-02	5.16E-04	1.59E+04	6.48E-03	1.49E-04	3.32E+04	3.05E-03	7.04E-05	5.92E-03
C14	5.10E+04	2.01E-03	4.68E-05	5.55E+05	2.02E-04	4.30E-06	1.64E+06	9.29E-06	1.80E-07	5.48E-04
Co58	1.06E-01	8.95E+02	2.25E+01	2.65E-01	3.81E+02	9.03E+00	8.78E-01	1.16E+02	2.59E+00	2.45E+02
Co60	4.25E-02	2.20E+03	5.67E+01	8.77E-02	1.10E+03	2.74E+01	2.36E-01	4.20E+02	9.88E+00	5.93E+02
Cr51	4.27E+00	2.34E+01	5.59E-01	1.75E+01	6.27E+00	1.40E-01	1.19E+02	1.01E+00	2.20E-02	6.50E+00
Cs134	7.35E-02	1.31E+03	3.26E+01	1.96E-01	5.26E+02	1.23E+01	7.14E-01	1.47E+02	3.25E+00	3.59E+02
Cs137	1.43E+02	7.12E-01	1.68E-02	7.91E+02	1.39E-01	3.04E-03	4.59E+03	1.95E-02	4.21E-04	1.96E-01
Fe55	UNLIMITED	4.67E-08	1.09E-09	UNLIMITED	4.75E-09	1.01E-10	UNLIMITED	2.18E-10	4.24E-12	1.28E-08
I129	1.01E+05	1.01E-03	2.36E-05	1.10E+06	1.02E-04	2.16E-06	3.26E+06	4.67E-06	9.07E-08	2.76E-04
Mn54	1.26E-01	7.50E+02	1.90E+01	3.07E-01	3.28E+02	7.81E+00	9.93E-01	1.02E+02	2.30E+00	2.05E+02
Nb95	1.48E-01	6.50E+02	1.63E+01	3.84E-01	2.69E+02	6.31E+00	1.35E+00	7.77E+01	1.72E+00	1.78E+02
Ni59	2.95E+05	3.33E-04	8.15E-06	8.82E+05	1.18E-04	2.69E-06	3.75E+06	2.76E-05	5.91E-07	9.13E-05
Ni63	UNLIMITED	9.35E-11	2.21E-12	UNLIMITED	7.62E-17	1.59E-18	UNLIMITED	0.00E+00	0.00E+00	2.68E-11
Pu238	2.34E+04	3.99E-03	9.90E-05	2.88E+04	3.37E-03	8.04E-05	3.44E+04	2.88E-03	6.77E-05	1.10E-03
Tc99	1.99E+03	5.14E-02	1.20E-03	1.92E+04	5.83E-03	1.24E-04	6.41E+04	3.52E-04	7.21E-06	1.41E-02
U235	2.74E+00	3.74E+01	8.72E-01	2.40E+01	4.69E+00	9.95E-02	8.78E+01	3.33E-01	6.99E-03	1.03E+01
U238	6.70E+02	1.39E-01	3.46E-03	7.62E+02	1.27E-01	3.04E-03	8.91E+02	1.11E-01	2.62E-03	3.99E-02
Zn65	1.76E-01	5.31E+02	1.36E+01	3.79E-01	2.59E+02	6.37E+00	1.05E+00	9.51E+01	2.22E+00	1.44E+02
Zr95	1.50E-01	6.42E+02	1.61E+01	3.89E-01	2.66E+02	6.24E+00	1.36E+00	7.68E+01	1.70E+00	1.76E+02

Note: <sup>1</sup>Isotopes with an activity limit exceeding 10<sup>8</sup> Ci are labeled as 'UNLIMITED'.

## OPTIMUS-H® Contents with 3 ¾" SIA

Isotope	NCT Dose Rate/Curie (mrem/hr/Ci)						HAC Dose Rate/Curie (mrem/hr/Ci)			Activity Limit (Ci)	
	Package Surface			Trailer Surface	2-Meter	Driver Cab	1-Meter			Open Transport	Closed Transport
	Top	Bottom	Side				Top	Side	Bottom		
Ag110m	3.65E-01	4.85E-01	4.15E-01	1.12E-01	2.08E-02	3.10E-03	1.74E-01	2.03E-01	2.30E-01	3.71E+02	4.32E+02
Am241	6.05E-04	6.57E-04	1.26E-03	3.76E-04	7.19E-05	1.05E-05	2.76E-04	3.07E-04	3.07E-04	1.25E+05	1.25E+05
C14	2.05E-13	4.34E-13	3.37E-14	7.55E-15	1.27E-15	1.99E-16	7.12E-14	1.05E-13	1.51E-13	4.14E+14	2.07E+15
Co58	4.20E-02	5.88E-02	3.87E-02	9.86E-03	1.78E-03	2.65E-04	1.83E-02	2.22E-02	2.58E-02	3.06E+03	5.07E+03
Co60	4.60E-01	6.21E-01	4.91E-01	1.29E-01	2.38E-02	3.51E-03	2.16E-01	2.53E-01	2.87E-01	2.90E+02	3.78E+02
Cr51	1.04E-05	1.70E-05	5.00E-06	1.15E-06	1.97E-07	2.84E-08	3.88E-06	5.26E-06	6.45E-06	1.06E+07	4.57E+07
Cs134	4.42E-02	6.19E-02	4.15E-02	1.07E-02	1.96E-03	2.87E-04	1.94E-02	2.35E-02	2.72E-02	2.91E+03	4.59E+03
Cs137	9.70E-07	1.43E-06	7.41E-07	1.82E-07	3.24E-08	4.74E-09	4.00E-07	5.02E-07	5.91E-07	1.26E+08	2.78E+08
Fe55	4.81E-18	1.02E-17	7.93E-19	1.78E-19	2.98E-20	4.68E-21	1.67E-18	2.47E-18	3.56E-18	1.76E+19	8.82E+19
I129	1.03E-13	2.19E-13	1.70E-14	3.80E-15	6.37E-16	1.00E-16	3.58E-14	5.28E-14	7.62E-14	8.24E+14	4.12E+15
Mn54	3.58E-02	5.05E-02	3.14E-02	7.87E-03	1.41E-03	2.09E-04	1.53E-02	1.87E-02	2.18E-02	3.57E+03	6.39E+03
Nb95	1.78E-02	2.57E-02	1.45E-02	3.57E-03	6.39E-04	9.28E-05	7.44E-03	9.18E-03	1.08E-02	7.01E+03	1.41E+04
Ni59	2.03E-09	3.08E-09	1.37E-09	3.28E-10	5.77E-11	8.51E-12	8.02E-10	1.04E-09	1.24E-09	5.85E+10	1.56E+11
Pu238	7.20E-04	7.83E-04	1.51E-03	4.49E-04	8.58E-05	1.26E-05	3.30E-04	3.67E-04	3.67E-04	1.05E+05	1.05E+05
Tc99	4.10E-10	7.02E-10	1.72E-10	3.93E-11	6.71E-12	9.66E-13	1.51E-10	2.08E-10	2.62E-10	2.57E+11	1.28E+12
U235	2.45E-04	2.67E-04	5.12E-04	1.53E-04	2.93E-05	4.25E-06	1.12E-04	1.24E-04	1.25E-04	3.07E+05	3.07E+05
U238	2.93E-02	3.20E-02	6.25E-02	1.86E-02	3.55E-03	5.19E-04	1.38E-02	1.52E-02	1.53E-02	2.53E+03	2.53E+03
Zn65	8.46E-02	1.16E-01	8.74E-02	2.28E-02	4.15E-03	6.13E-04	3.89E-02	4.62E-02	5.18E-02	1.56E+03	2.17E+03
Zr95	1.76E-02	2.54E-02	1.43E-02	3.53E-03	6.31E-04	9.17E-05	7.36E-03	9.08E-03	1.07E-02	7.09E+03	1.43E+04