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**We Put Science To Work**

# Type B Radioactive Material (RAM) Packagings for Plutonium Content

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**December 15, 2008**



**The Coming Nuclear Renaissance – Maximizing Benefits While Minimizing Proliferation Risks**

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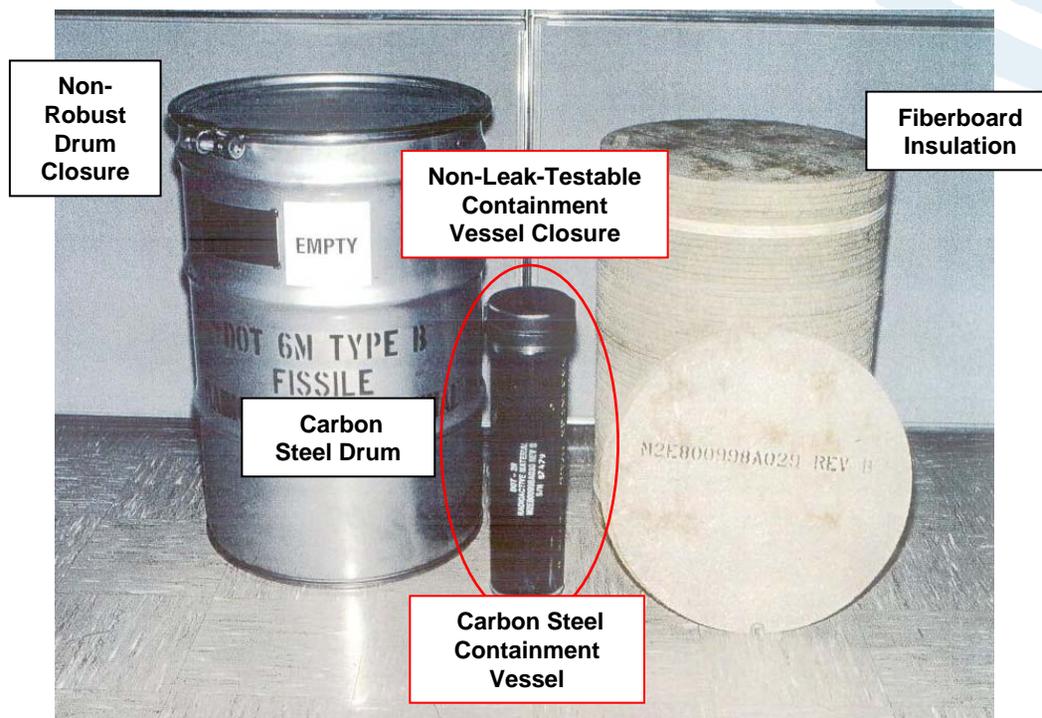
Joint Institute of Computational Sciences (JICS) Building 5100

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## Type B RAM Packagings for Plutonium Content

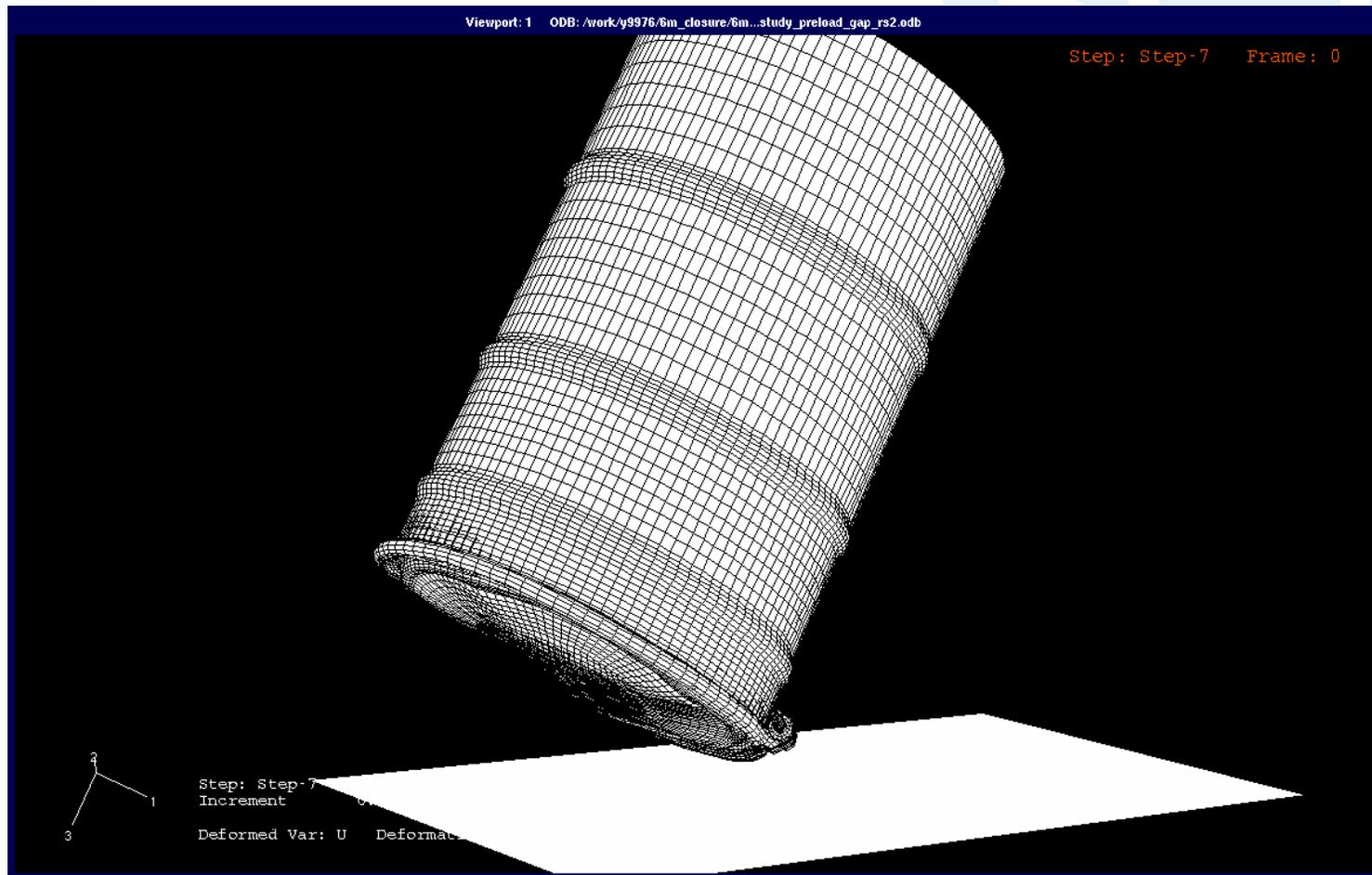
The DOT 6M Specification Packaging has been used by the DOE to ship Plutonium and Uranium approaching 40 years in service.



All DOT Specification Packagings, including the 6M, were removed from the CFR on October 1, 2008, and are no longer legal for shipment of Plutonium

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# Type B RAM Packagings for Plutonium Content



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## Type B RAM Packagings for Plutonium Content



DOT 6M following 9 m Regulatory Drop

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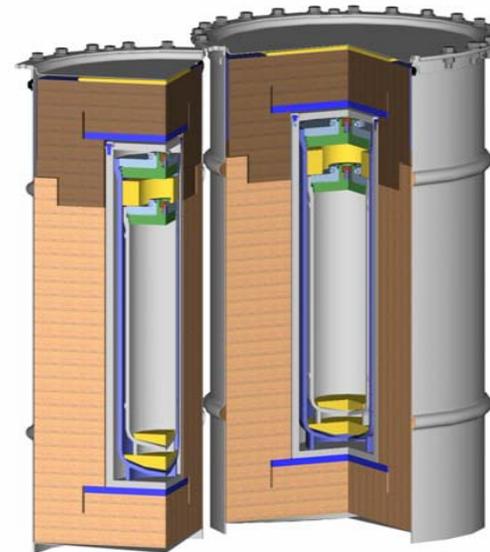
## Type B RAM Packagings for Plutonium Content

Plutonium packaging options are limited.

### Current / Future Plutonium Packagings

- **9975** (Double Containment)
- **9977** (RTG Content Only)
- **9978** (In Regulatory Review)
- **ES-3100** (Amendment Planned)

RTG - Radioisotopic Thermoelectric Generator  
CFR - Code of Federal Regulations



Model 9975

Double Containment requirement for Plutonium eliminated from the CFR October 1, 2004.

## Type B RAM Packagings for Plutonium Content

Model 9975 is the only RAM packaging currently certified for broad Plutonium content utility.

### Model 9975 Authorized Contents:

- Stabilized Pu/U Metals<sup>1</sup>
- Stabilized Pu/U Oxides<sup>1</sup>
- <sup>238</sup>Pu Heat Sources
- Uranium Metal
- Neptunium Oxide

1 – Stabilized in accordance with DOE-STD-3013



Model 9975

## Type B RAM Packagings for Plutonium Content

Model 9975 is the only RAM packaging currently certified for broad Plutonium content utility.

### Model 9975 Negatives:

- Double Containment
- Heavy (400 pounds with 45 pound payload)
- Fiberboard Insulation
- Exposed Lead Shielding
- Large Number of Drum Bolts



## Type B RAM Packagings for Plutonium Content

### Robust Containment Vessels (CV)



"Chalfant" CV Design

- 5" CV failed through wall at 7,560 psig - closure maintained seal. (Pictured)

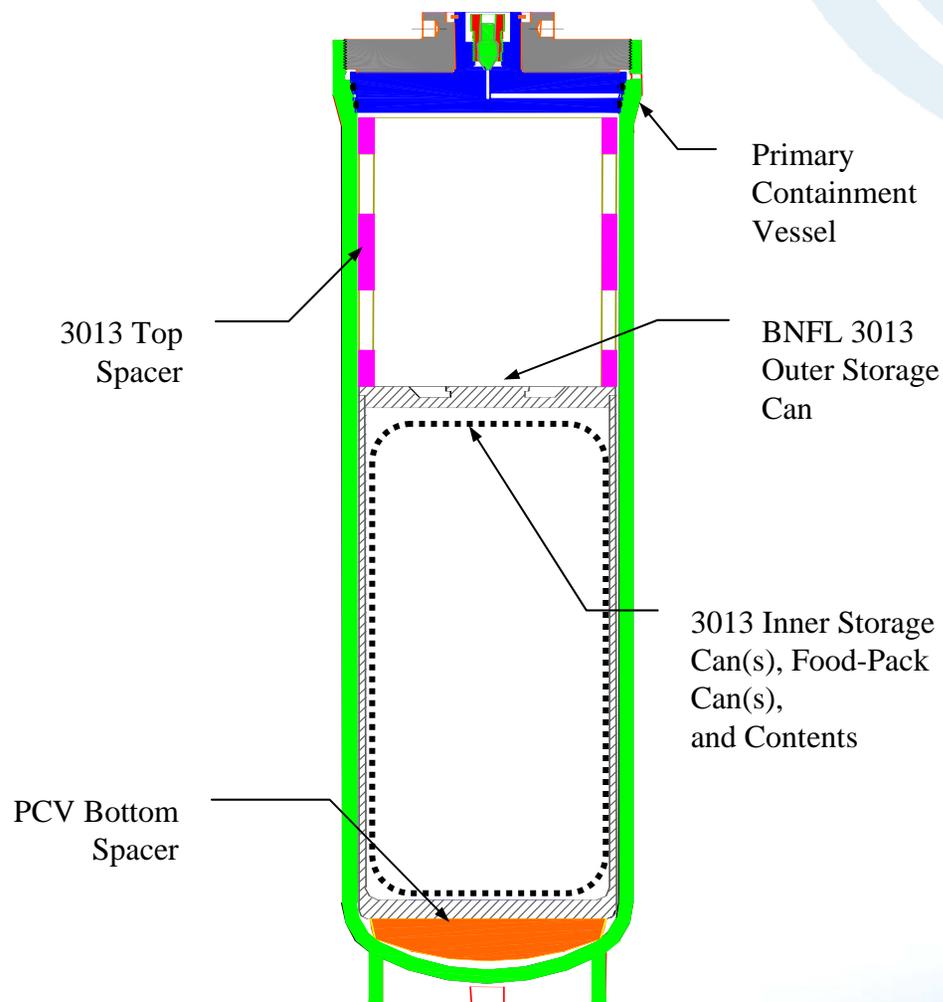
- 6" CV failed through wall at ~4,000 psig.

- 6" CV O-Ring seal survived with 1,000 psig up to 783°F.

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# Type B RAM Packagings for Plutonium Content

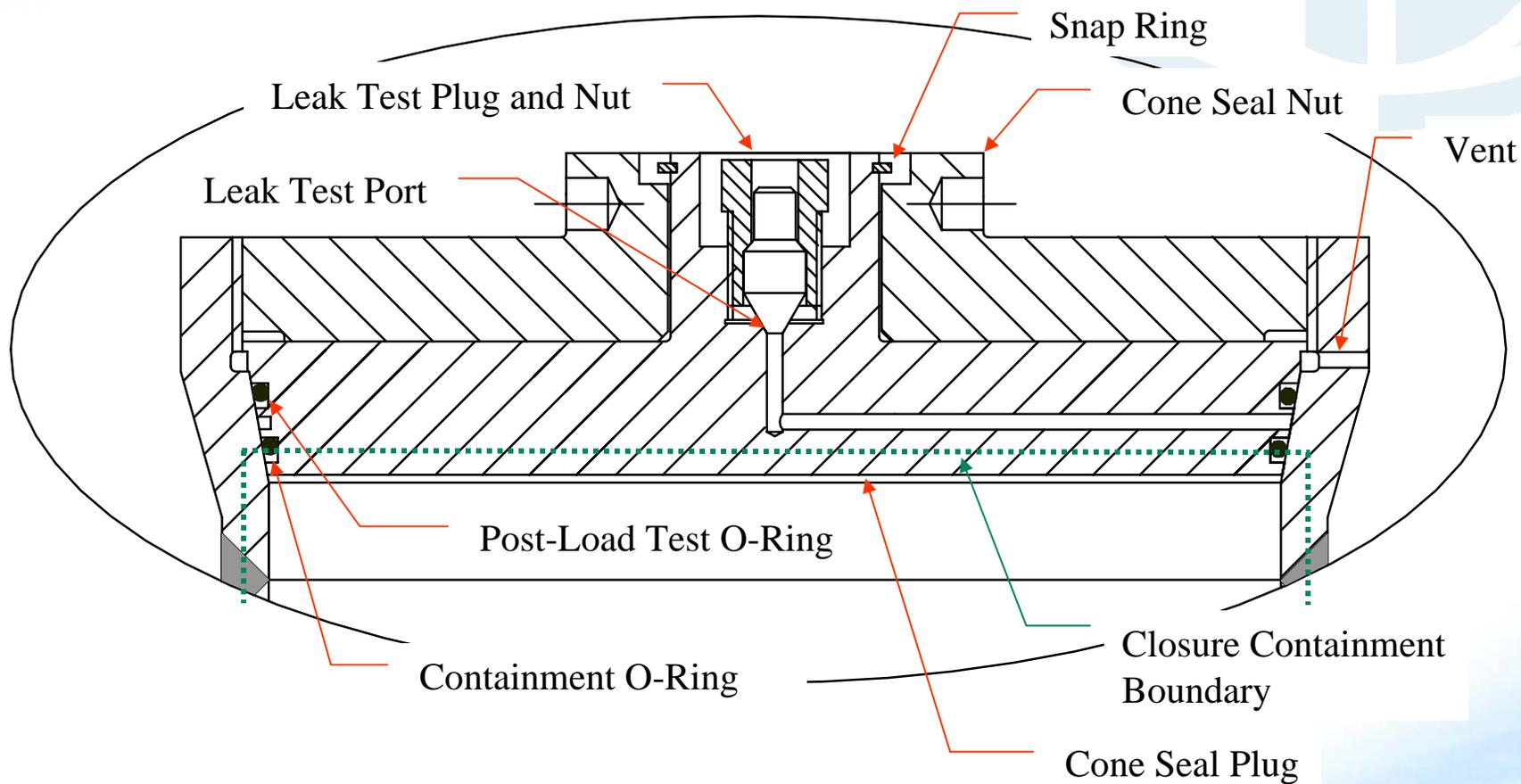
## Chalfant CV Design



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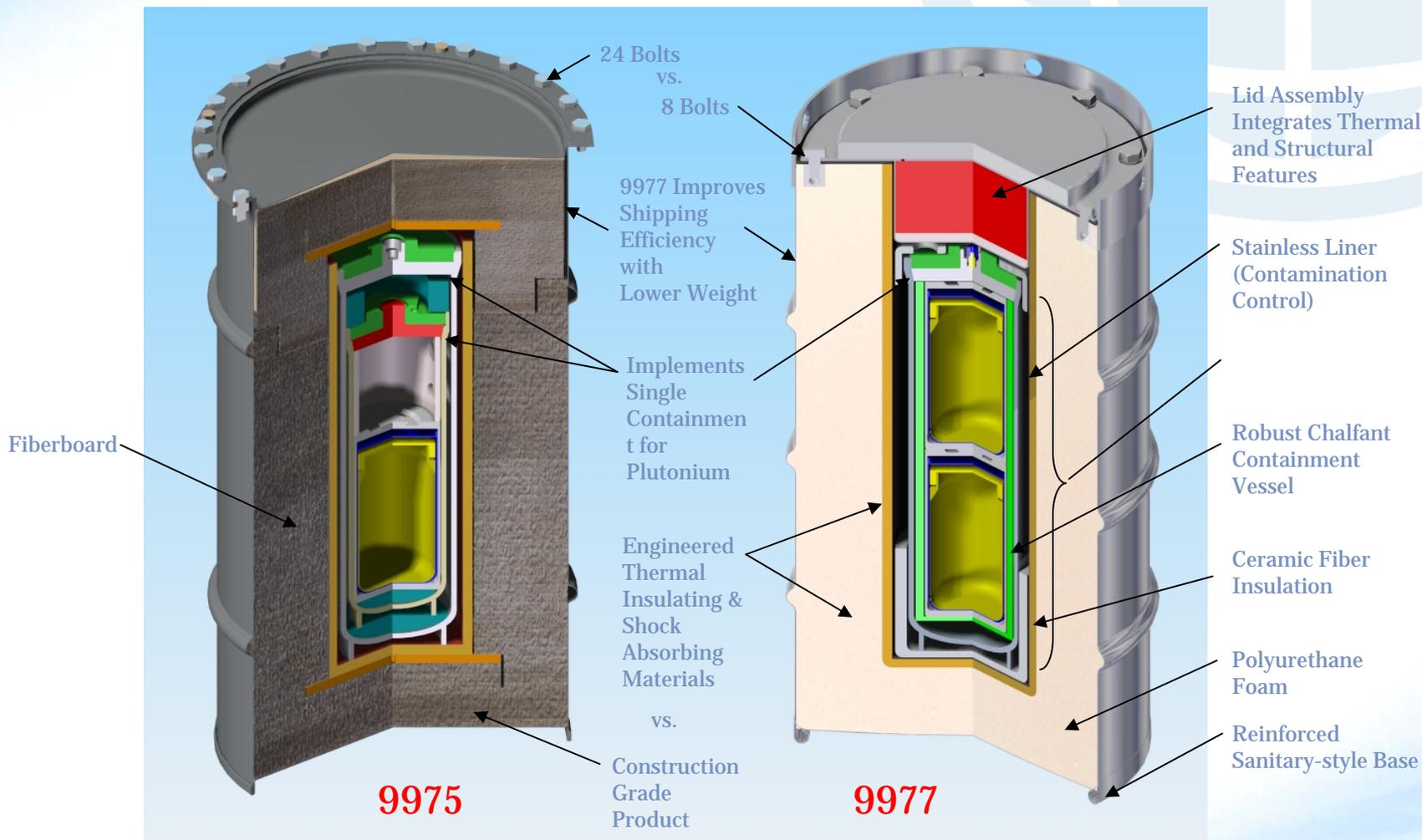
# Type B RAM Packagings for Plutonium Content

## CV Closure Design



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# Type B RAM Packaging for Plutonium Content

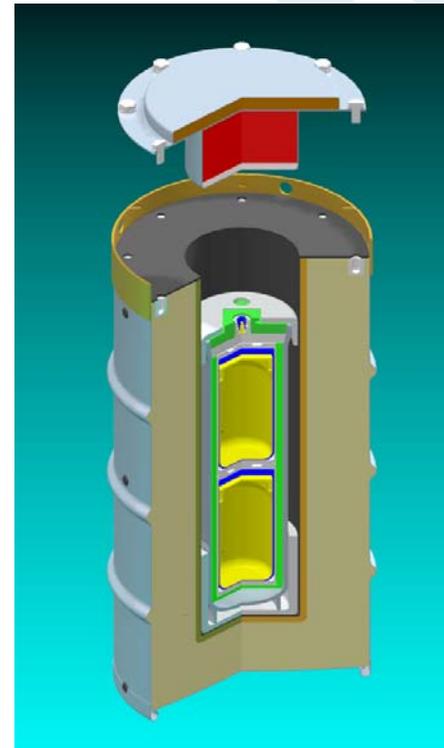


## Type B RAM Packagings for Plutonium Content

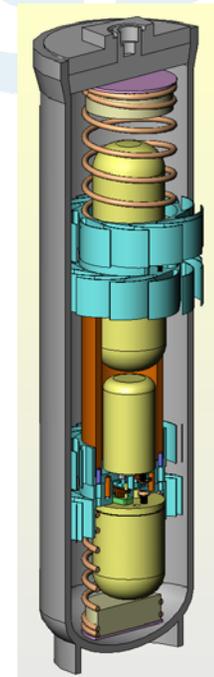
Model 9977 is currently certified by the DOE for Radioisotopic Thermoelectric Generators.

### Model 9977 Attributes:

- Single Containment
- Lighter than 9975 (350 pounds with twice the payload)
- Large, Robust 6" ID Containment Vessel (800 psig Design Pressure)
- Can Accommodate Internal Shielding Features
- 8 Bolt Drum Closure
- Easy to Operate and Decontaminate
- Engineered Thermal Insulating and Shock Absorbing Materials (Ceramics and Fire Retardant Polyurethane foam)



Model 9977



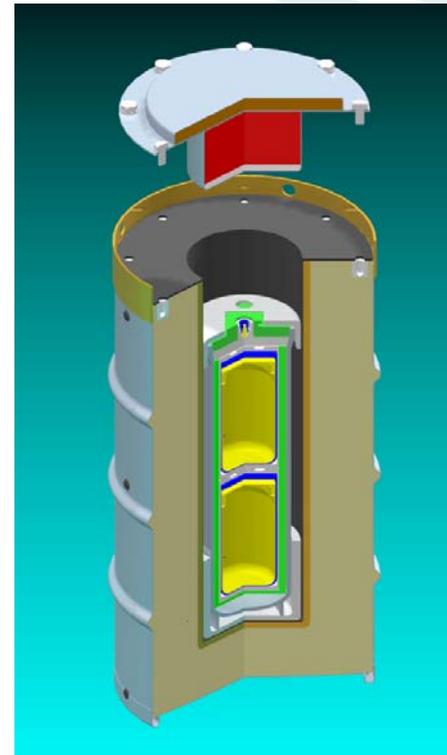
CV with RTG

## Type B RAM Packagings for Plutonium Content

Model 9977 shown with Two 10" Product Cans.

### Future Model 9977 Contents:

- Orphaned Sources and Specialty Items
- Small Gram Quantities
- Stabilized Pu/U Metals
- $^{238}\text{Pu}$  Heat Sources
- Uranium Metal and Oxides
- Neptunium Oxide



Model 9977

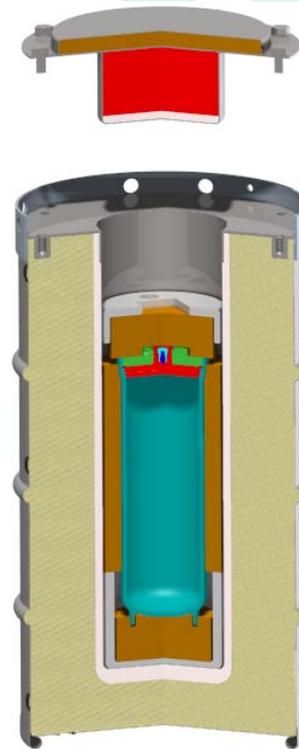
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# Type B RAM Packagings for Plutonium Content

Model 9978 is currently under DOE Regulatory Review

## Model 9978 Attributes:

- **Single Containment**
- **Lighter than 9975 and 9977 (285 pounds with 50 pound payload)**
- **Robust 5" ID Containment Vessel (900 psig Design Pressure)**
- **8 Bolt Drum Closure**
- **Easy to Operate and Decontaminate**
- **Engineered Thermal Insulating and Shock Absorbing Materials (Ceramics and Fire Retardant Polyurethane foam)**



Model 9978

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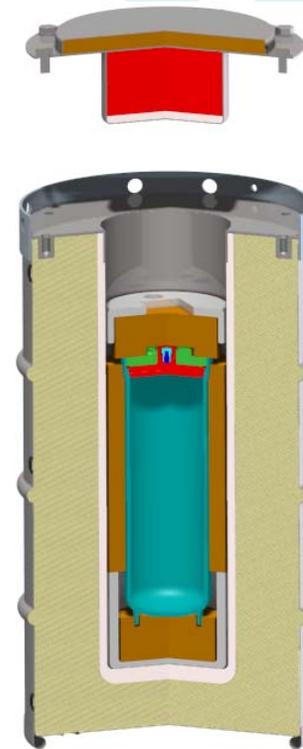
# Type B RAM Packagings for Plutonium Content

Model 9978 is currently under DOE Regulatory Review

## Future Model 9978 Contents:

- Stabilized Pu/U Metals
- Samples and Sources
- $^{238}\text{Pu}$  Heat Sources
- Uranium Metal, Alloys and Oxides
- Small Gram Quantities

Blue Indicates Contents in Review



Model 9978

# Type B RAM Packagings for Plutonium Content

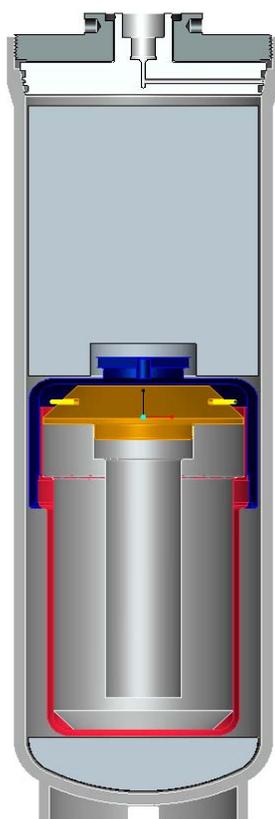
## Typical Content Table

	Material	Pu/U Metals (wt% Except as noted)
Radioisotope	<sup>238</sup> Pu	2
	<sup>239</sup> Pu	100
	<sup>240</sup> Pu	40
	<sup>241</sup> Pu	15
	<sup>242</sup> Pu	5
	<sup>241</sup> Am	15
	<sup>232</sup> U	$1 \times 10^{-7}$
	<sup>233</sup> U	0.5
	<sup>234</sup> U	100
	<sup>235</sup> U	100
	<sup>236</sup> U	40
	<sup>238</sup> U	100
Total Mass	Radioactive Materials	4.4 kg
	Impurities	70 %
	All Contents	4.4 kg

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# Type B RAM Packagings for Plutonium Content

Proposed Small Gram Quantity Addendum  
(for 9975, 9977 and 9978)



Lead Bottom  
&  
Top



Container  
Bottom  
&  
Top

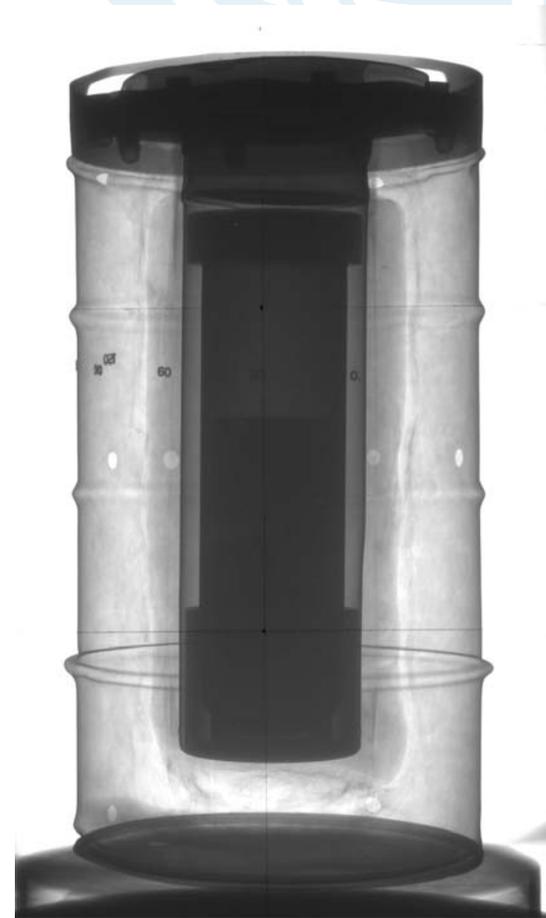
## Type B RAM Packagings for Plutonium Content

### Type B Regulatory Testing - Hypothetical Accident Conditions (HAC)

#### HAC Regulatory Testing Sequence

- Drop from 9 m (30 ft) onto a flat, unyielding surface
- Crush – 500 kg steel plate from 9 m
- Puncture – 1 m onto a 15 cm cylindrical steel bar
- Thermal – 30 minutes in a fully engulfing 800°C fire

**Shielding - Subcriticality - Containment**



Digital Radiograph 9977 after HAC

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# Type B RAM Packagings for Plutonium Content

Type B Regulatory Testing - Hypothetical Accident Conditions (HAC)



9 m Drop

**GPFP SN-3  
HAC DROP TEST  
(Chilled/Horizontal)**

2005

**GPFP SN-3  
HAC DROP TEST  
(Chilled/Horizontal)**

2005

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# Type B RAM Packagings for Plutonium Content

Type B Regulatory Testing - Hypothetical Accident Conditions (HAC)



Crush

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# Type B RAM Packagings for Plutonium Content

Type B Regulatory Testing - Hypothetical Accident Conditions (HAC)



**GPFP SN-4  
HAC PUNCTURE TEST  
(Horizontal)  
2005**

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# Type B RAM Packagings for Plutonium Content

Type B Regulatory Testing - Hypothetical Accident Conditions (HAC)



Fully Engulfing Fire



Post Fire Off-Gassing

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# Type B RAM Packagings for Plutonium Content

Type B Regulatory Testing - Hypothetical Accident Conditions (HAC)



Fire Test in Progress

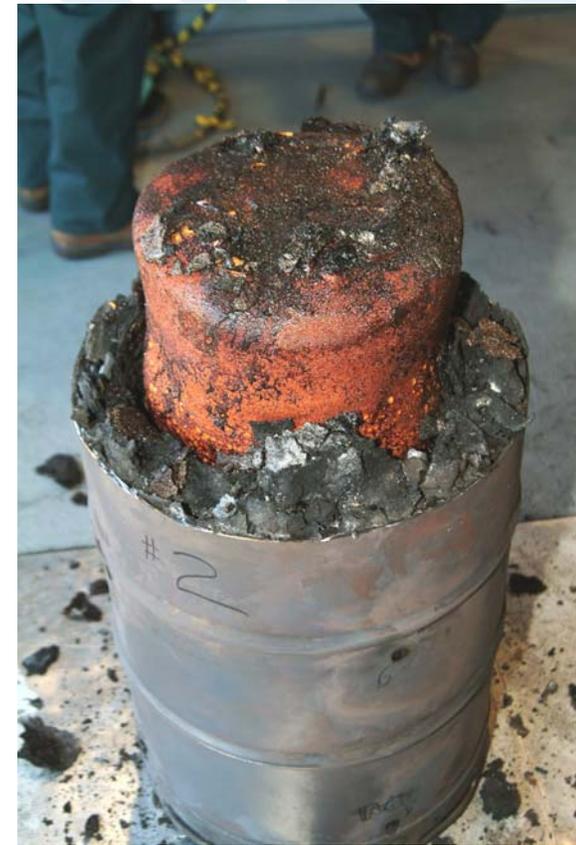


Post Fire Off-Gassing

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# Type B RAM Packagings for Plutonium Content

Type B Regulatory Testing - Hypothetical Accident Conditions (HAC)



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# Type B RAM Packagings for Plutonium Content

Type B Regulatory Testing - Hypothetical Accident Conditions (HAC)



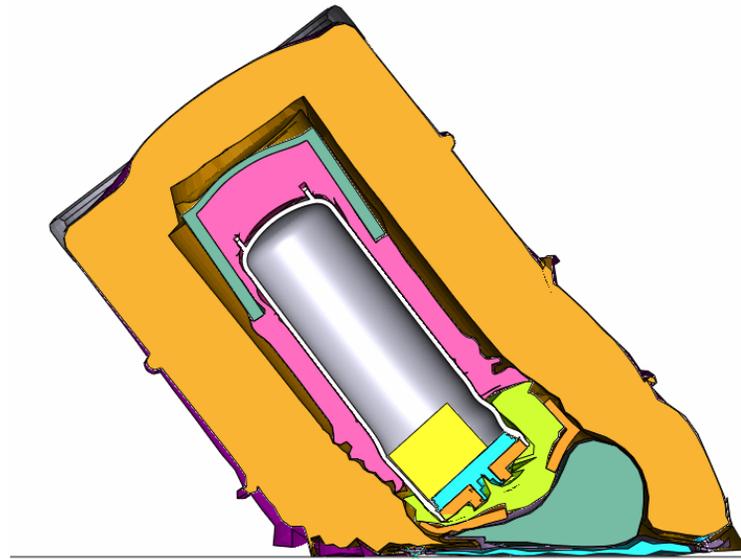
Typical 9977 CV following HAC Sequence

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## Type B RAM Packagings for Plutonium Content

Type B Regulatory Testing - HAC for Air Transportation of Pu



### Model 9978

- Impact with an unyielding surface at 290 miles/hour
- Top down Center-of-Gravity over Corner (CGOC)