

# RT-100 Cask Certificate of Compliance Pre-Application Meeting

June 26-27, 2012

Open Session

Shielding and Containment

*Robatel Technologies, LLC*

*Roanoke, VA*



- ***Introductions***
- ***RT-100 Design Summary***
  - ❖ Overview
  - ❖ Design Features
  - ❖ Summary of Recent Changes
- ***Source Term Evaluation***
  - ❖ Gamma, Beta, Neutron Emitters
  - ❖ Payload Configuration and Limits

## ***Agenda (continued)***

### ➤ ***Shielding Evaluation***

- ❖ Normal Conditions of Transport Analysis
- ❖ Hypothetical Accident Conditions Analysis

### ➤ ***Containment Evaluation***

- ❖ Containment Boundary
- ❖ Normal Conditions of Transport Analysis
- ❖ Hypothetical Accident Conditions Analysis

### ➤ ***Proprietary Session***

- ***Robatel RT-100 Team***
  - ❖ Robatel Technologies
  - ❖ Robatel Industries
  - ❖ ENERCON Federal Services
- ***NRC***

- ***Package contents***
- ***Source Terms***
- ***Predominant Nuclides***
- ***Preliminary NCT Shielding Evaluations***
- ***NCT Loading Table Results***
- ***Preliminary HAC Shielding Evaluations***
- ***Conclusions***

- ***Resins, filters and reformed resin from nuclear power plant operation***
- ***Maximum content mass 15,000 lbs (6806 kg) including liners***
- ***Preliminary evaluations performed for these materials, but application will include all solid byproduct radioactive material***

- ***Preliminary evaluation performed on typical contents for resins and filters determined in a survey of activity from a DOE database and utility data***
- ***Predominant Nuclides Characterized and Evaluated***
- ***Predominant nuclides are the highest activity and highest energy emission in typical resin and filters***

## ***Sources of Source Terms Data***

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- ***Gamma Spectra – SCALE 6.0 ORIGEN-S Photon Yield Library, `origen.rev02.mpdkgam.dat`***
- ***Beta Spectra – ICRU Report 56, Appendix D***
- ***Bremsstrahlung Photons – MCNP5 mode *e p****
- ***Spontaneous Fission and Alpha-N Spectra from SCALE 6.0 ORIGEN-S and actinide decay library, `origen.rev00.alphdec.data`***



### ➤ **Gamma:**

❖ Mn-54

❖ Fe-59

❖ Co-58

❖ **Co-60**

❖ Zn-65

❖ Cs-134

❖ Cs-137

❖ Ag-110m

### ➤ ***Beta/Bremsstrahlung***

✦ Sr-90/Y-90 18.2

✦ Cs-137 349.3

### ➤ ***Alpha-N+ Spontaneous Fission Neutrons***

❖ Cm-242

❖ Cm-243

❖ Cm-244

❖ Am-241

❖ Pu-238

❖ Pu-239

❖ Pu-240

❖ Pu-242

- ***Nuclides other than predominant will be evaluated and included in the SAR***
- ***Minor nuclide contributors will be grouped and assigned a minimum dose rate response***

- ***MCNP5 Monte Carlo, release 1.41***
- ***Compute exterior dose rate (mrem/hr) for 1 Ci of each nuclide distributed in the cavity***
- ***Tally on segmented cask surface and 2 meter from the vehicle surface***
- ***Determine maximum valued on the cask surface and on 2 meter surface. This defines the dose rate response functions in mrem/hr/curie***

- ***Perform computations for the side, top and bottom***
- ***Utilize ANSI/ANS 6.1.1-1977, Neutron and Gamma Flux-To-Dose Conversion Factors***

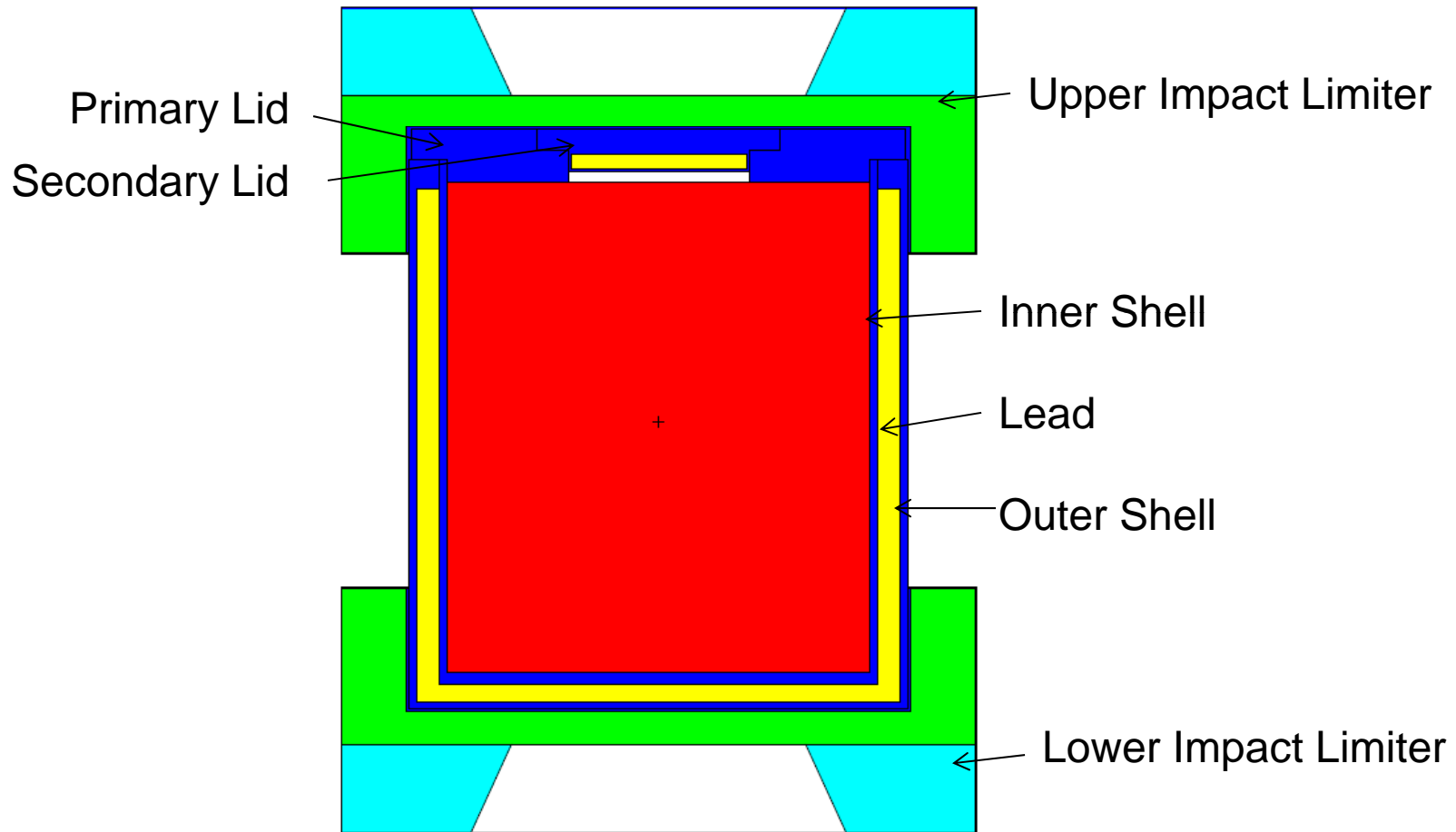
### ➤ ***Normal Conditions of Transport (NCT)***

- ❖ Impact limiters in place
- ❖ Impact limiter foam at 75 % of nominal density
- ❖ Shells and lead at nominal dimensions, minimal lead thickness will be evaluated for SAR
- ❖ Uniform source in resin  $(CH_2)_n$  at  $0.65 \text{ g/cm}^3$ , density variation will be addressed in SAR
- ❖ Cavity full with resin and uniform cylindrical source, variation in the source distribution will be evaluated in the SAR

# *NCT Shielding Evaluations*

## *MCNP5 Model*

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# *Shielding Evaluations*

## *NCT Results (mrem/hr/Curie)*

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		Surface	2 Meter
<b>Gamma</b>	AG-110M	3.21E-03	4.55E-04
	CO-58	1.39E-03	1.98E-04
	CO-60	6.66E-02	9.04E-03
	CS-134	4.97E-03	6.90E-04
	CS-137	3.22E-05	9.56E-06
	FE-59	1.19E-02	1.61E-03
	MN-54	7.84E-04	1.15E-04
	ZN-65	6.64E-03	8.98E-04
<b>Beta/Brem</b>	SR-90/Yr-90	2.79E-06	3.92E-07
<b>Neutron (Alpha-n + Spon. Fiss.)</b>	CM-242	4.23E-03	2.27E-04
	Cm-243	3.08E-03	1.66E-04
	Cm-244	1.35E-02	7.44E-04
	Am-241	2.48E-03	1.31E-04
	PU-238	2.45E-03	1.31E-04

# Shielding Evaluations

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## NCT Results for Typical Loading (mrem/hr)

Side		Response (mrem/hr/curie)		Postulated Worst Case Loading	Dose Rate (mrem/hr)	
		Surface	2 Meter		Surface	2 Meter
Gamma	AG-110M	3.21E-03	4.55E-04	46.2	1.48E-01	2.10E-02
	CO-58	1.39E-03	1.98E-04	467.21	6.49E-01	9.25E-02
	CO-60	6.66E-02	9.04E-03	606.5	4.04E+01	5.48E+00
	CS-134	4.97E-03	6.90E-04	229.1	1.14E+00	1.58E-01
	CS-137	3.22E-05	9.56E-06	349.3	1.12E-02	3.34E-03
	FE-59	1.19E-02	1.61E-03	51.8	6.16E-01	8.34E-02
	MN-54	7.84E-04	1.15E-04	422	3.31E-01	4.85E-02
	ZN-65	6.64E-03	8.98E-04	251.32	1.67E+00	2.26E-01
Total					<b>44.96</b>	<b>6.12</b>
Beta/Brem	SR-90/Yr-90	2.79E-06	3.92E-07	18.2	<b>5.08E-05</b>	<b>7.13E-06</b>
Neutron (Alpha-n + Spon. Fiss.)	CM-242	4.23E-03	2.27E-04	0.0601	2.54E-04	1.36E-05
	Cm-243	3.08E-03	1.66E-04	0.0457	1.41E-04	7.59E-06
	Cm-244	1.35E-02	7.44E-04	0.0073	9.86E-05	5.43E-06
	Am-241	2.48E-03	1.31E-04	0.0751	1.86E-04	9.84E-06
	PU-238	2.45E-03	1.31E-04	0.0360	8.82E-05	4.72E-06
Total					<b>0.0008</b>	<b>0.0000</b>
Total					<b>44.96</b>	<b>6.12</b>
Limit					<b>200</b>	<b>10</b>

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# Shielding Evaluations

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## Preliminary Loading Table Based on NCT Responses

Based on 10 mrem/hr at 2 meters			Postulated Worst Case		User fills In this column with the contents of their package
	Nuclide	Max. Ci/g	Ci/g	% of Max.	
	AG-110M	0.007354	1.546E-05	0.2	
	CO-58	0.016899	1.563E-04	0.9	
	CO-60	0.00037	2.029E-04	54.8	
	CS-134	0.004849	7.666E-05	1.6	
	CS-137	0.350008	1.169E-04	0.0	
	FE-59	0.002078	1.733E-05	0.8	
	MN-54	0.029096	1.412E-04	0.5	
	ZN-65	0.003726	8.409E-05	2.3	
	SR-90/Yr-90	8.535906	6.090E-06	0.0	
	CM-242	0.01474	2.011E-08	0.0	
	Cm-243	0.020157	1.529E-08	0.0	
	Cm-244	0.004497	2.443E-09	0.0	
	Am-241	0.025543	2.513E-08	0.0	
	PU-238	0.025543	1.205E-08	0.0	
			Sum	61.2	
			Limit	100	

### ➤ ***Hypothetical Accident Conditions***

- ❖ Impact Limiters off
- ❖ Lead slumps to bottom creating an annular void at the top

### ➤ ***Hypothetical Accident Conditions***

- ❖ Source and material redistributes
- ❖ Bounding Source Conditions
  - ✓ Source compresses into smaller cylinder or hemi-cylinder

### ➤ ***Hypothetical Accident Conditions***

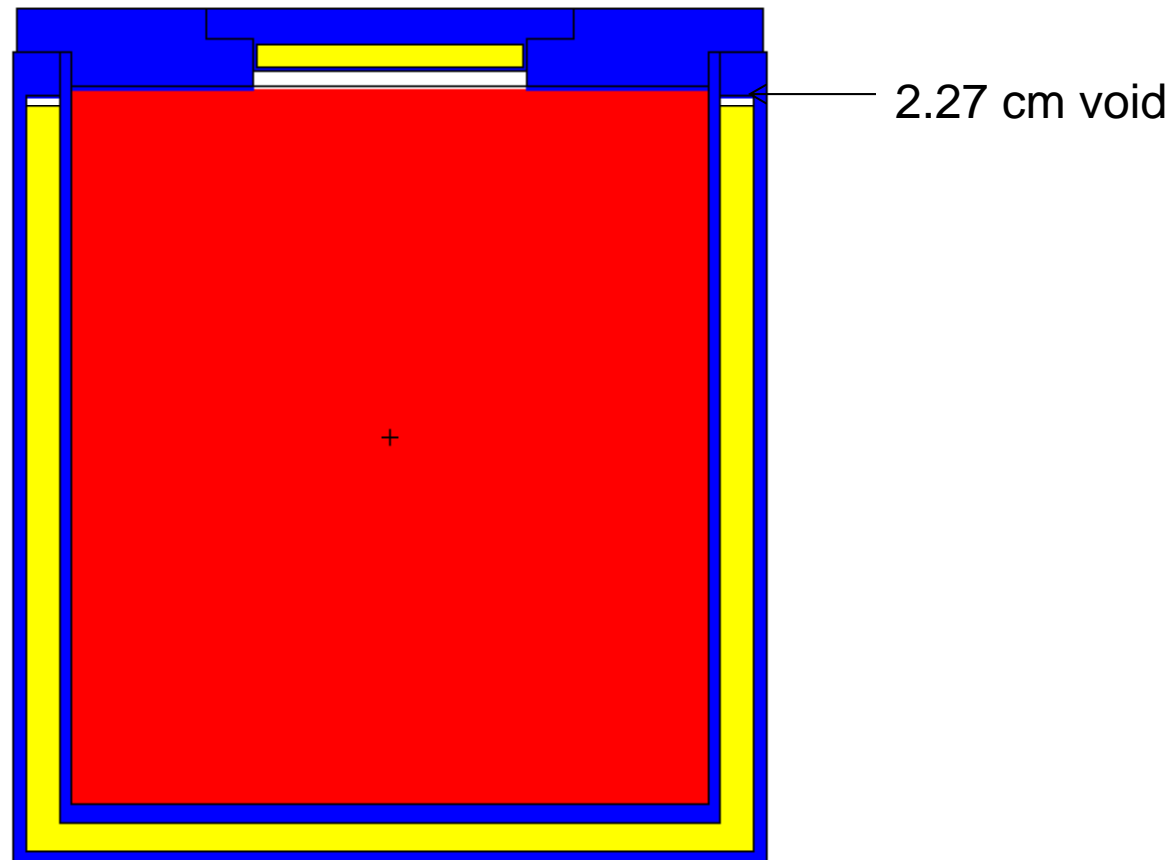
#### ✦ Initial Evaluations with Co-60

- ✓ Case A – Annular Void in Lead, No redistribution
- ✓ Case B – Annular Void in lead, 50 % Reduction in Volume of Resin to the Bottom
- ✓ Case C – Annular Void in lead, 50% Reduction in Volume of Resin to the Top

# *HAC Shielding Evaluations*

## *MCNP5 Model – Annular Void*

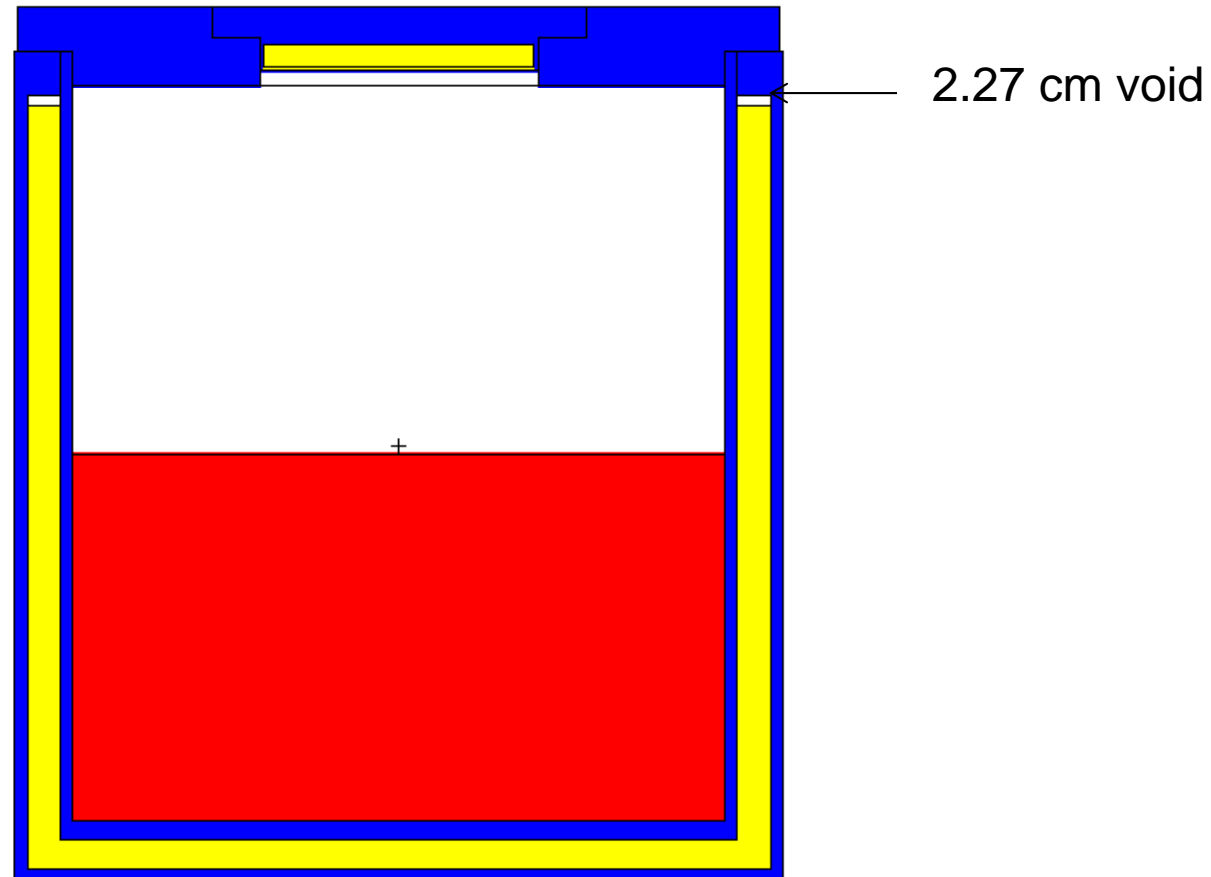
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# *HAC Shielding Evaluations*

## *MCNP5 Model – Annular Void*

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# ***Shielding Evaluations***

## ***HAC Results for Co-60 (mrem/hr)***

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Configuration	Nuclide	Response (mrem/hr/curie)	Postulated Worst Case Inventory (Ci)	Dose Rate (mrem/hr)	Limit
Case A	CO-60	1.51E-01	606.5	91.34	1000
Case B	CO-60	1.94E-02	606.5	11.78	1000
Case C	CO-60	1.75E-01	607.5	106.17	1000

# Shielding Evaluations

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## Preliminary Loading Table Based on HAC Response

Based on 1000 mrem/hr at 1 meter			Postulated Worst Case		User fills In this column with the contents of their package
	Nuclide	Max. Ci/g	Ci/g	% of Max.	
	CO-60	0.001915	2.029E-04	10.6	
			Sum	10.6	
			Limit	100	

## Shielding Evaluations

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### Preliminary Loading Table based on Shielding Results

Nuclide	NCT	HAC	Cask Content	NCT	HAC
	Max. Ci/g	Max. Ci/g	Ci/g	% of Max.	% of Max
AG-110M	0.007354		1.546E-05	0.2	
CO-58	0.016899		1.563E-04	0.9	
CO-60	0.00037	0.001915	2.029E-04	54.8	0.002
CS-134	0.004849		7.666E-05	1.6	
CS-137	0.350008		1.169E-04	0.0	
FE-59	0.002078		1.733E-05	0.8	
MN-54	0.029096		1.412E-04	0.5	
ZN-65	0.003726		8.409E-05	2.3	
SR-90/Yr-90	8.535906		6.090E-06	0.0	
CM-242	0.01474		2.011E-08	0.0	
Cm-243	0.020157		1.529E-08	0.0	
Cm-244	0.004497		2.443E-09	0.0	
Am-241	0.025543		2.513E-08	0.0	
PU-238	0.025543		1.205E-08	0.0	
			Sum	61.2	0.002
			Limit	100	100

## ➤ **Conclusions**

- ❖ Preliminary evaluations show the RT-100 is acceptable to transport postulated worst case inventory
- ❖ Complete loading tables will be created for NCT and HAC and the more limiting condition will determine acceptability
- ❖ Response functions will be calculated for all nuclides
- ❖ Minor contributors will be grouped and assigned a minimum dose rate response per gram

### ➤ **Conclusions (Continued)**

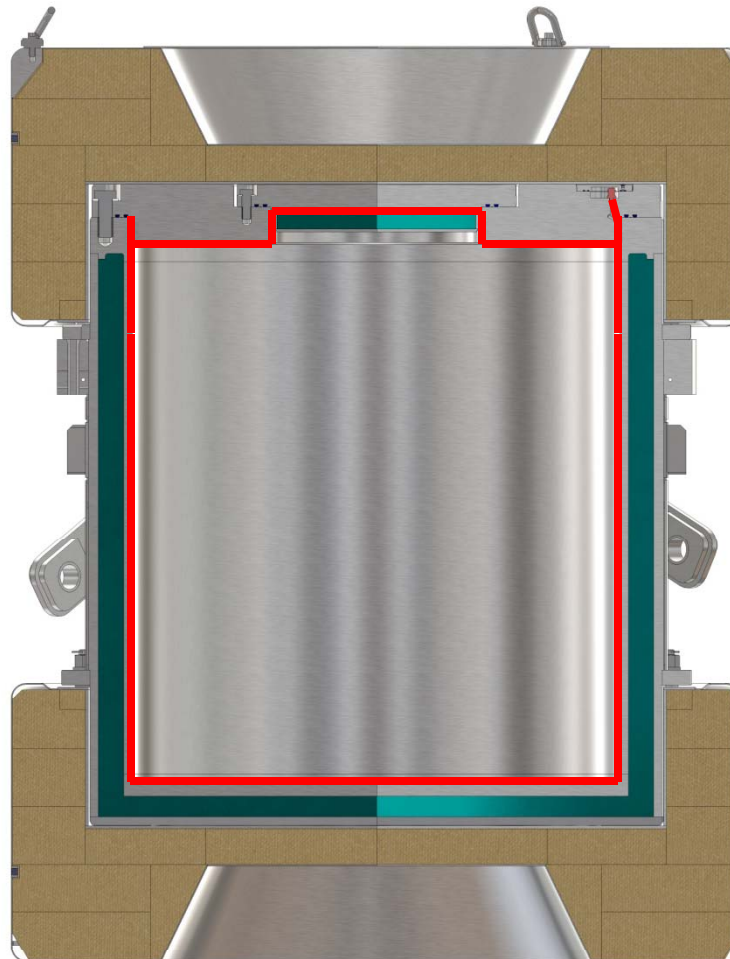
- ❖ Response Function for Beta/Bremstrahlung nuclides that do not produce a response will be assigned 1E-6 mrem/hr/curie on surface and 3E-7 mrem/hr/curie on the 2 meter surface
- ❖ Response Function for weak gamma/X-ray nuclide that do not produce a response will be assigned 1E-6 mrem/hr/curie on surface and 3E-7 mrem/hr/curie on the 2 meter surface

### ***Containment Boundary***

- ❖ Inner Shell and Bottom Plate
- ❖ Primary and Second Lids
- ❖ Primary Lid Inner O-Ring
- ❖ Secondary Lid Inner O-Ring
- ❖ Vent Port Cover Plate
- ❖ Vent Port Cover Plate Inner O-Ring

# *Containment Evaluation*

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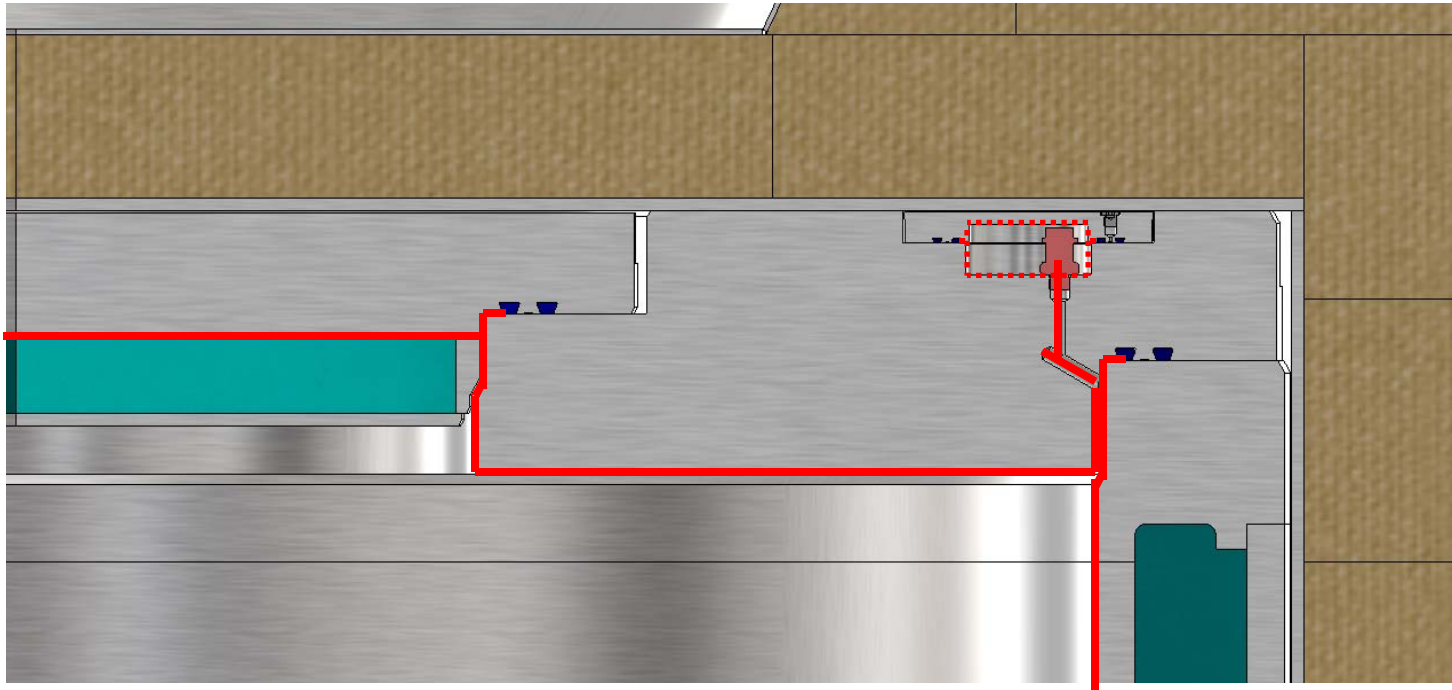
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# *Containment Evaluation*

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➤ ***NCT Limit:***

❖  $A_2 * E-6/hr$

➤ ***HAC Limits:***

❖ no escape of krypton-85 exceeding  $10A_2$  in a week,

❖ no escape of other radioactive material exceeding a total amount  $A_2$  in a week

- ***ANSI N14.5-1997, American National Standard for Leakage Tests on Packages for Shipment of Radioactive Materials***
- ***NUREG/CR-6487, Containment Analysis for Type B Packages Used to Transport Various Contents, Section 3, Powder Radioactive Materials***