

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***

- ***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***

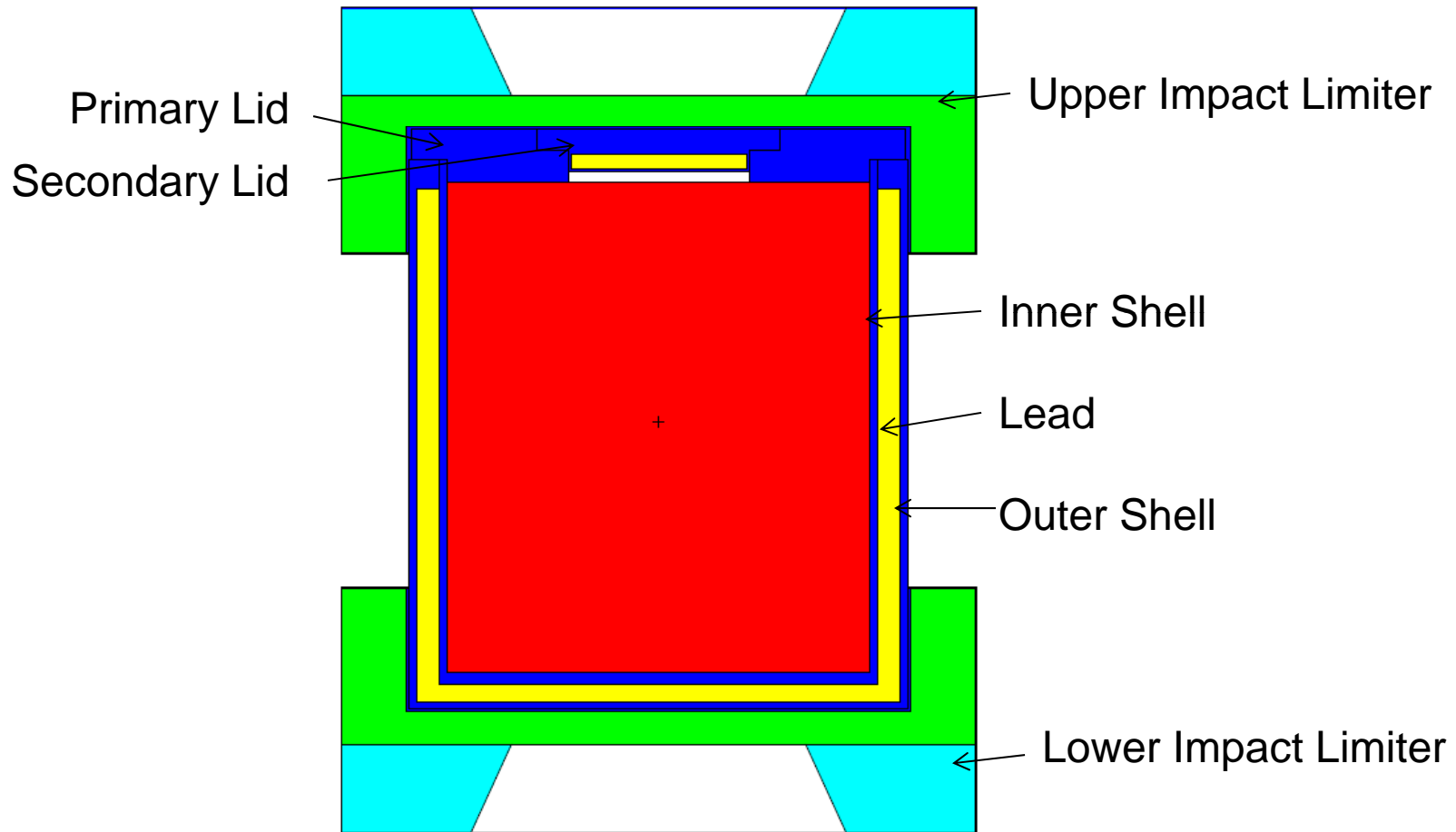
➤ ***Normal Conditions of Transport (NCT)***

- ❖ 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 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

ROBATEL GROUP



Shielding Evaluations

NCT Results (mrem/hr/Curie)

ROBATEL GROUP



		Surface	2 Meter
Gamma	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
Beta/Brem	SR-90/Yr-90	2.79E-06	3.92E-07
Neutron	CM-242	4.23E-03	2.27E-04
(Alpha-n + Spon. Fiss.)	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

ROBATEL GROUP

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					44.96	6.12
Beta/Brem	SR-90/Yr-90	2.79E-06	3.92E-07	18.2	5.08E-05	7.13E-06
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					0.0008	0.0000
Total					44.96	6.12
Limit					200	10

June 27, 2012

RT-100 Pre-Application Meeting

18

This information is company confidential and may not be used without written consent of Robatel Technologies.

Shielding Evaluations

ROBATEL GROUP

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***

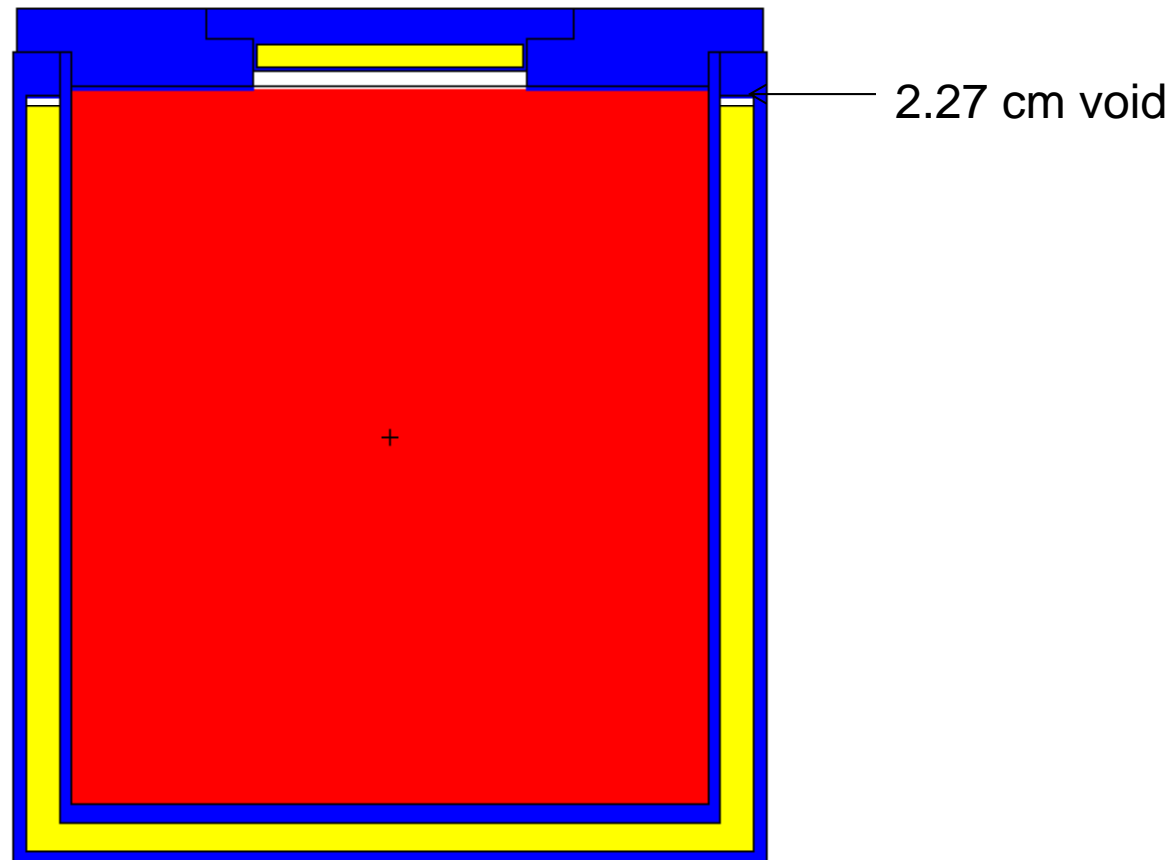
✦ Initial Evaluations with Co-60

- ✓ 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

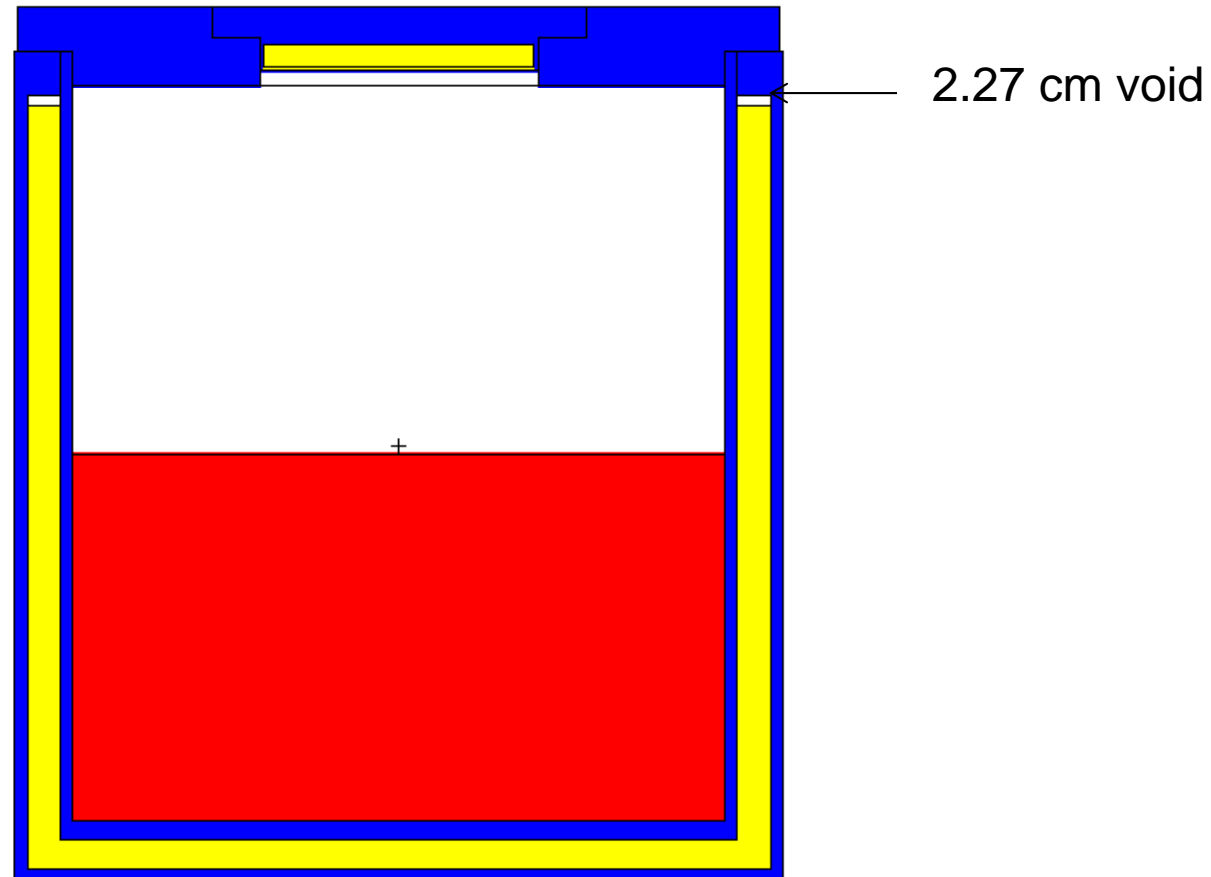
ROBATEL GROUP



HAC Shielding Evaluations

MCNP5 Model – Annular Void

ROBATEL GROUP



Shielding Evaluations

HAC Results for Co-60 (mrem/hr)

ROBATEL GROUP



Configuration	Nuclide	Response (mrem/hr/curie)	Postulated Worst Case	Dose Rate (mrem/hr)	Limit
			Inventory (Ci)		
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

ROBATEL GROUP

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

ROBATEL GROUP

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)***

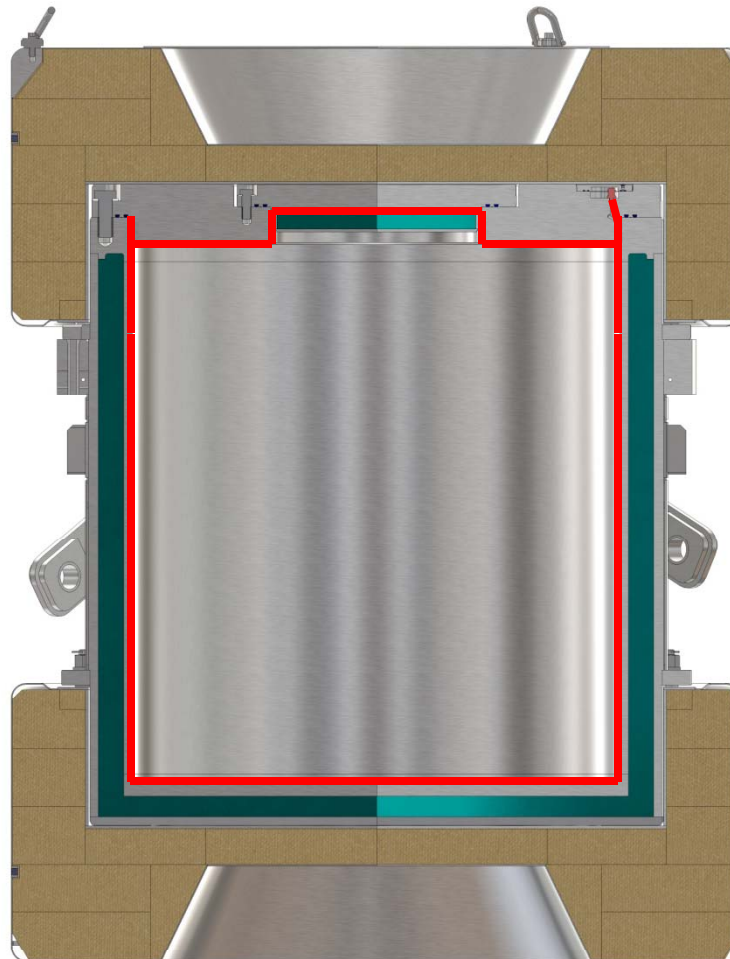
- ❖ Response Function for Beta/Bremstrahlung nuclides that do not produce a response will be assigned 1E-6 mrem/hr/curie on surface and 3E-7 mrem/hr/curie on the 2 meter surface
- ❖ Response Function for weak gamma/X-ray nuclide that do not produce a response will be assigned 1E-6 mrem/hr/curie on surface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

ROBATEL GROUP



June 27, 2012

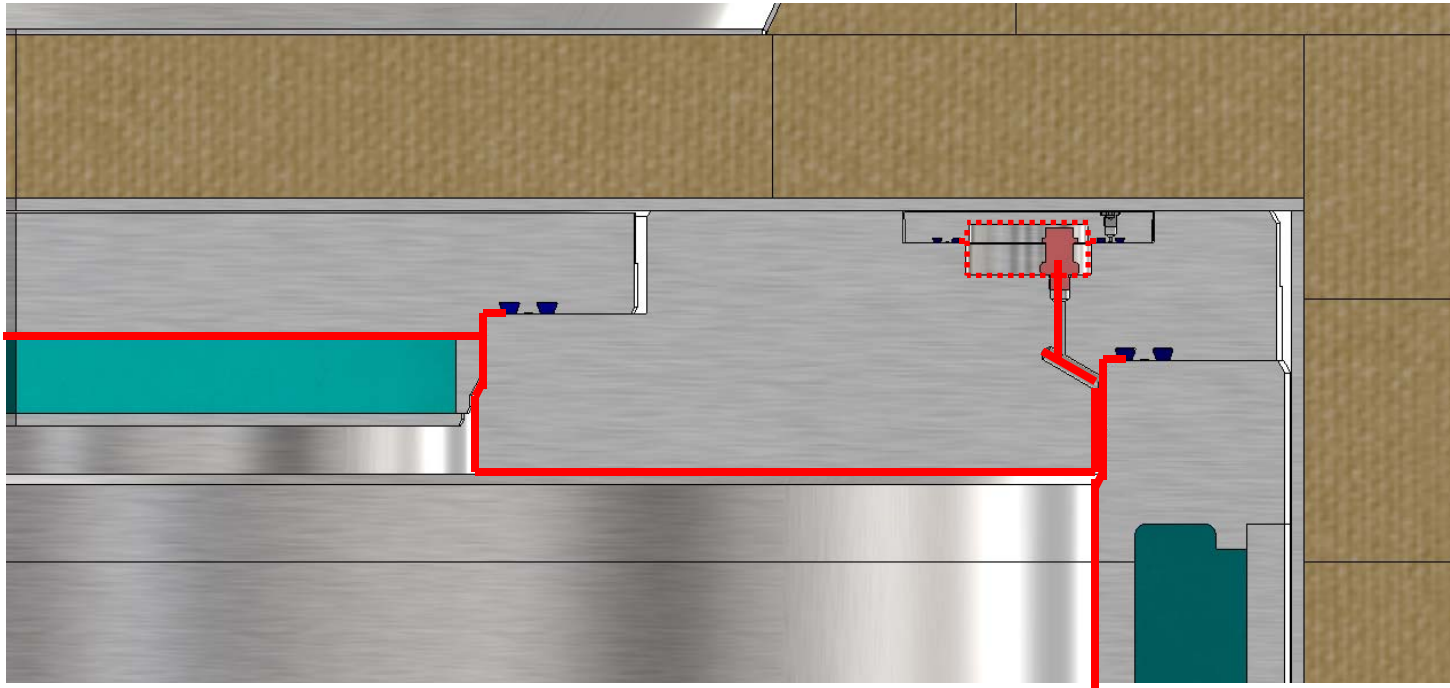
RT-100 Pre-Application Meeting

31

This information is company confidential and may not be used without written consent of Robatel Technologies.

Containment Evaluation

ROBATEL GROUP



June 27, 2012

RT-100 Pre-Application Meeting

32

This information is company confidential and may not be used without written consent of Robatel Technologies.

➤ ***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***