RT-100 Safety Analysis Report, Rev 1

Pre-Application Meeting

November 18, 2014

- Discussion Summary:
  - Lead slump evaluation – Chapter 5
  - New shielding calculation results –Chapter 5
  - Addition of an optional pre-shipment leak test procedure, revision to the personnel qualification requirement – Chapter 8.
  - Clarification of the terms "dewatered" and "grossly dewatered". – Chapters 1, 4, 7.

Lead Slump – Summary

- Section 2.7.1.1.2
  - ANSYS End Drop Results – The total displacement of the lead column is 1.62 mm.
- Sections 3.4.1.3 and 3.4.2.3
  - Worst case HAC fire cases assumes pin puncture damage end/side.
  - No melting of the lead shield occurs during the HAC fire.
- Section 5.3.1.3
  - Lead slump calculated based on molten lead. Lead height reduced by 24.78 mm.
- Section 8.3.2.2
  - The gap between the inner and outer shells prior to lead pouring is required to be 90 +5 /–4 mm. This dimension is measured during the fabrication process to ensure that the minimum lead thickness of 85 mm will be maintained including the subsequent lead shrinkage during cooling, given that the thickness prior to lead pour is ensured to be at least 86 mm. The evaluation of lead shrinking during the cool-down process described above shows a final calculated gap between the outer shell and the lead of 0.687 mm.

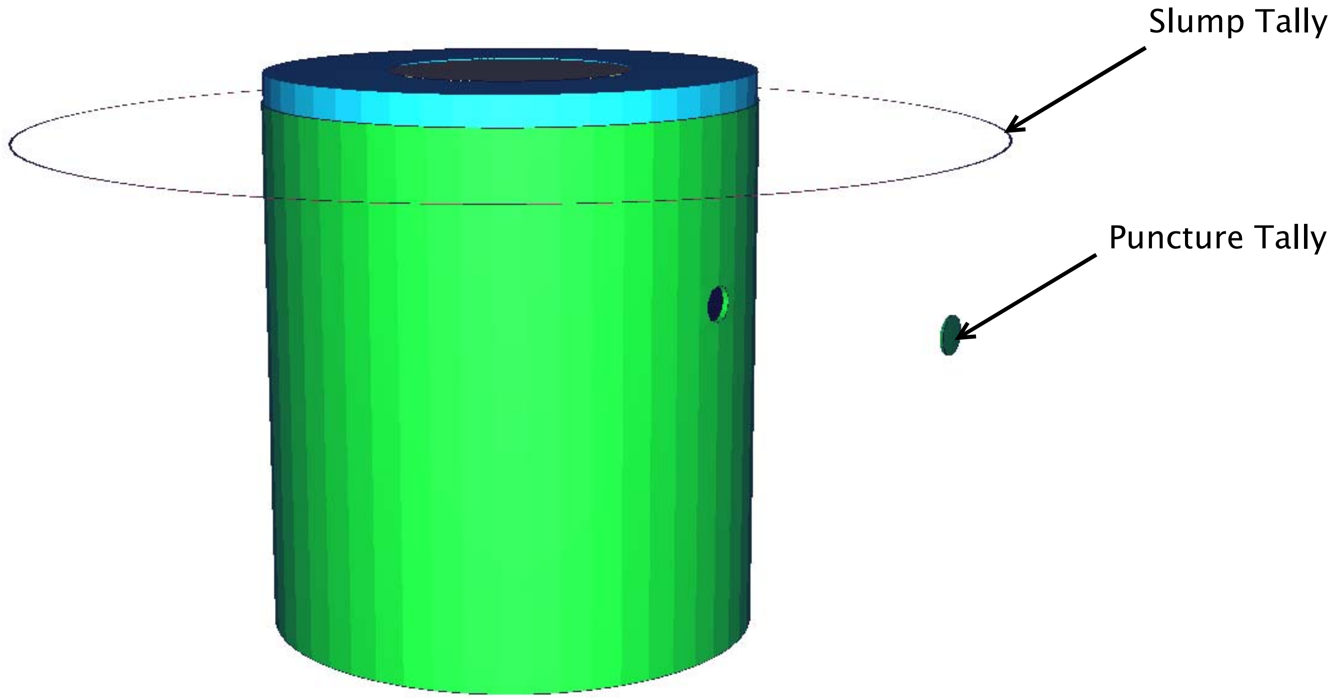
Lead Slump – Discussion

- Reconcile the differences between Chapter 2, 3, and 5
- Establish lead slump value based on stress analysis
- Provide additional supporting analyses
  - Thermal expansion during NCT to evaluate gap between steel shells and lead shield.
  - Calculate the compressive stresses along the axial length of the shield during the end drop.
  - Discuss incompressibility of lead – Poisson's Ratio = 0.44.

Changes to Analysis– Chapter 5

- New MCNP Files
  - MCNP6 instead of MCNP5
  - Removal of Resin Material from energy line method Inputs
  - Lead Slump in HAC Models Reduced to Calculated Value
  - Side 1-meter HAC tallies (slump and puncture) changed to segmented surface tallies rather than point detectors
  - New Inputs for 7 & 8 MeV energy Lines
- New Weight Windows
  - All 10 statistical checks passed in all outputs.
- Post Processing
  - All Post Processing in Excel Files (no AWK scripts)

New Side HAC Tallies



Convergence– Chapter 5

Energy Line Outputs

Output	All 10 Tests Passed on all Tallies?	Segements with fsd >0.1	nps	Run time
rptnGneric78	Yes	0	1.00E+08	4hrs 2min
rptnGenerich	Yes	0	2.00E+08	3hrs 44min
rptnGenericm	Yes	0	4.00E+08	5hrs 15min
rptnGenericl	Yes	0	2.00E+08	4hrs 23min
rpsnGeneric78	Yes	0	1.00E+08	2hrs 48min
rpsnGenerich	Yes	10*	2.00E+08	2hrs 43min
rpsnGenericm	Yes	0	4.00E+08	4hrs 24min
rpsnGenericl	Yes	1*	2.00E+08	5hrs 34min
rpbnGeneric78	Yes	0	1.00E+08	6hrs 7min
rpbnGenerich	Yes	0	2.00E+08	5hrs 46min
rpbnGenericm	Yes	0	3.00E+08	8hrs 27min
rpbnGenericl	Yes	0	2.00E+08	5hrs 37min
rptaGeneric78	Yes	0	1.00E+08	3hrs 55min
rptaGenerich	Yes	0	2.00E+08	3hrs 45min
rptaGenericm	Yes	0	2.00E+08	2hrs 37min
rptaGenericl	Yes	0	4.00E+08	8hrs 17min
rpsaGeneric78	Yes	0	1.00E+08	2hrs 48min
rpsaGenerich	Yes	0	1.00E+09	13hrs 42min
rpsaGenericm	Yes	0	5.00E+08	5hrs 34min
rpsaGenericl	Yes	0	5.00E+08	15hrs 29min
rpbaGeneric78	Yes	0	1.00E+08	6hrs 2min
rpbaGenerich	Yes	0	2.00E+08	5hrs 41min
rpbaGenericm	Yes	0	2.00E+08	5hrs 43min
rpbaGenericl	Yes	0	4.00E+08	3hrs 48min

*The only segments with fsd>0.1 are on the outer edges of the impact limiters, which are not used in the final dose rate calculations

Co-60 Outputs

Output	All 10 Tests Passed on all Tallies?	Segements with fsd >0.1	nps	Run time
rptnCo60	Yes	0	1.00E+09	13hrs 15min
rpsnCo60	Yes	0	2.00E+08	2hrs 53min
rpbnCo60	Yes	0	2.00E+08	5hrs 36min
rptaCo60	Yes	0	2.00E+08	1hr 51min
rpsaCo60	Yes	0	5.00E+08	5hrs 2min
rpbaCo60	Yes	0	2.00E+08	2hrs 8min

New Activity Limits– Chapter 5

Allowable Activity Limit Comparison:

Isotope	Performance Criteria (RTL-001-CALC-SH-0101)	Old Max Ci Limit (currently in SAR Rev.0)	New Max Ci Limit[1] (to be in SAR Rev.1)
Co-60	607	732.25	**723.4**
Zn-65	251	1486.67	**762.89**
Ag-110M	46.2	622.61	**256.46**
Fe-59	51.8	763.21	**398.87**
Cs-134	229	3,877.35	**2,730.61**
Co-58	467	10,738.12	**3,008.34**
Mn-54	422	16,373.56	**3,895.39**
Cs-137 (Ba-137m)	349	27,114.11	**43,908.19**[2]

[1] This activity limit comparison only demonstrates that each isotope meets the performance criteria individually, not as all isotopes a whole.

[2] The MCNP calculated dose rates for new analysis are significantly larger than for the current analysis, yet the new Curie limit is greater. The difference is in the post processing (see next slide).

Cesium-137 Calculation

Cs-137/Ba-137m (BR-0.95)-

ba 137m has 5. photon lines

4.83E-03	1.04E-02
3.18E-02	2.07E-02
3.22E-02	3.82E-02
3.63E-02	1.40E-02
6.62E-01	9.01E-01

round up

E (MeV)	I(E)
0.7	0.901

Current Analysis MCNP 2m Result:

E	R(E)	σ
0.7	3.47E-05	3.33E-07

Maximum Curie Content Calculation:

$$r(E) = R(E) \cdot I(E) = (0.901 \cdot 0.95) \cdot (3.47E-5) = \mathbf{2.97E-5}$$

$$\sigma_{r(E)} = \sqrt{I(E)^2 \sigma^2_{R(EH)}} = \sqrt{(0.901 \cdot 0.95)^2 \cdot (3.33E-7)^2} = \mathbf{2.85E-7}$$

$$DR = r + 2\sigma = (2.97E-5) + 2(2.85E-7) = \mathbf{3.027E-5}\ \frac{\mathbf{mrem/hr}}{\mathbf{Ci}}$$

$$Activity\ Limit = \frac{9.5\ mrem/hr}{\left(3.027E-5\ \frac{mrem/hr}{Ci}\right) \cdot (1.12)^*} = \boxed{\mathbf{280,216\ Ci}}$$

*Material Correction Factor

New Analysis MCNP 2m Result:

E	R(E)	σ
0.7	2.49E-04	1.67E-06

Maximum Curie Content Calculation:

$$r(E) = R(E) \cdot I(E) = (0.901 \cdot 0.95) \cdot (2.49E-4) = \mathbf{2.1313E-4}$$

$$\sigma_{r(E)} = \sqrt{I(E)^2 \sigma^2_{R(EH)}} = \sqrt{(0.901 \cdot 0.95)^2 \cdot (1.67E-6)^2} = \mathbf{1.4294E-6}$$

$$DR = r + 2\sigma = (2.13E-4) + 2(1.43E-6) = \mathbf{2.159E-4}\ \frac{\mathbf{mrem/hr}}{\mathbf{Ci}}$$

$$Activity\ Limit = \frac{9.5\ mrem/hr}{\left(2.1443E-4\ \frac{mrem/hr}{Ci}\right)} = \boxed{\mathbf{43,983\ Ci}^*}$$

*Difference from value on previous slide is simply rounding error

Conclusions – Chapter 5

- Errors in the AWK scripts from the current analysis cause the calculated dose rates to be significantly larger than they should be.
- Using the energy line method, the new Curie limits for the largest dose contributors meet the performance criteria individually. However, they virtually reduce the current performance of the cask.
- MCNP Models will analyze each of the highest contributing isotopes individually for the NCT doses (including resin material). This should reduce the calculated dose rates such that the performance of the cask will be kept optimal.

Leakage Testing Qualification

- Revision of the leakage testing qualifications:
  - Section 8.2.2: (no change)

    The procedure shall be approved by an ASNT SNT-TC-1A or COFREND level III inspector for leakage testing –

  - Section 8.2.2.2:

    Trained and qualified personnel shall perform leakage testing in accordance with written procedures and document the results. [ANSI N14.5 Section 8.5]. Removal of the level II requirement. Facilities will use knowledgeable personnel, as the current standard practice.

Gas-Pressure Drop Pre-Shipment Leakage Test

- Addition of an optional pressure drop pre-shipment leakage test (Section 8.2.2.2):
  - Per ANSI N14.5 Section A.5.1
  - The method involves pressurizing the test item cavity, or interspace, and measuring the pressure drop.
  - The method is particularly useful for testing double O-ring seals, where the small interspace volume makes the method most sensitive, and the primary seal of the cavity does not have to be broken.
  - The total leakage rate is indicated by a pressure drop over a given period of time from a known initial pressure.

Gas-Pressure Drop
Pre-Shipment Leakage Test (cont.)

General Procedure

1) Pressurize the test volume to its specified test pressure.

2) Measure the change of pressure and temperature within the test volume during a specified time period.

3) Calculate the leakage rate.

NOTE: The pre-shipment leakage rate sensitivity is the same for both the Gas-Pressure Rise (current procedure) and Gas-Pressure Drop (optional addition) leakage tests.

Contents Description

- Clarification of the "grossly dewatered"/ "dewatered":
  - The SAR (section 1.2.2.10) currently gives the following content description:

  The type and form of material is defined as byproduct, source, or special nuclear material in the form of dewatered resins, spent filters, or mixtures of resins/filters, contained within secondary container(s).

  - The CoC similarly gives the following content description:

  Type and form of material: dispersible solids, in the form of dewatered resins and filters, contained within secondary containers.

  - Further clarification is necessary.

Contents Description (cont.)

- Two terms are used in the industry:
  - "**Gross Dewatering**" – Water is pumped from the secondary container via suction. This may be done in stages – as suction is lost in the upper stages the valves are closed. The container is considered "grossly dewatered" when suction is lost at the lowest stage.
  - "**Dewatering**" – After gross dewatering, air is evacuated from the secondary container and the moisture is removed. Dry air is pumped back to the container. The container is considered "dewatered" when the freestanding liquid is less 0.5% of the waste volume (NRC requirement for shallow burial).

Contents Description (cont.)

- Users are confused by the term “dewatered”. We prefer to replace the phrase with “grossly dewatered”.
- The hydrogen gas generation analysis in Chapter 4 of the SAR assumes a free water volume of 25.75% of waste volume, consistent with the gross dewatering method.
- The maximum waste volume is 130 ft^3.
- Thus, the analysis assumes a free water volume of up to 33.475 ft^3, or 250 gallons.
  - It is the responsibility of the shipper to ensure that the limit is not exceeded.