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Verifying Minimum Detectable Activity of the Whole-Body Counting System

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Overview

Sandia National Laboratories (SNL) accredited whole-body counting (WBC) program *may* soon be required to test MDA.

Overview

Driven by possible DOELAP response to ANSI/HPS N13.30-2011, Performance Criteria for Radiobioassay:

"To ensure that the MDA has been estimated properly, the service laboratory shall test the estimate by analyzing identical control samples spiked with an analyte concentration equal to the estimated MDA or making replicate measurements of an appropriate phantom containing such an amount."

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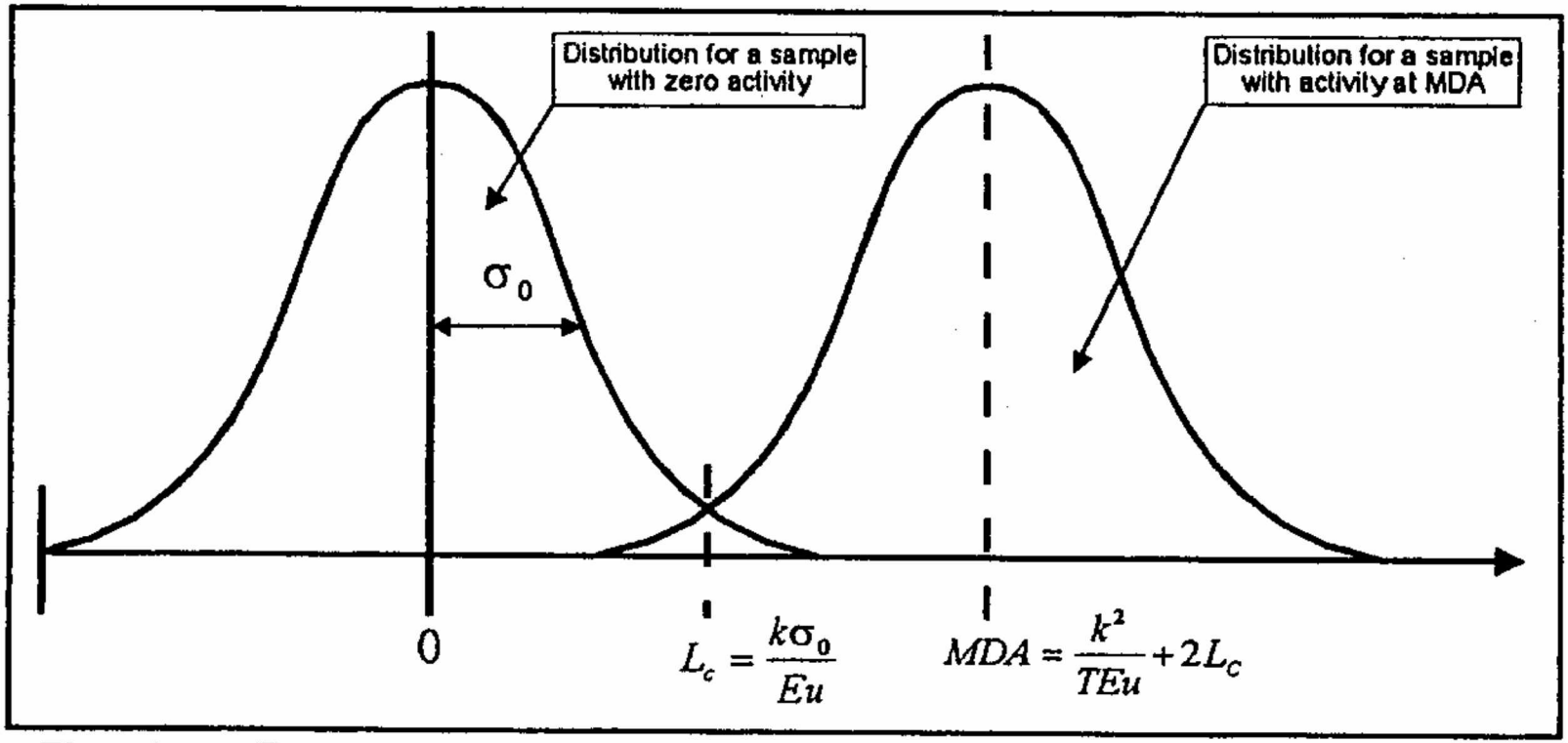
- This initially caused some worry:
  - "Identical"
  - "Equal"
- Then some relaxing:
  - "Appropriate phantom"

So there is apparently some flexibility in the word "identical."
Perhaps there is flexibility in the word "equal."

Ask any CHP: "Isn't radiological counting inherently uncertain, especially at values near the MDA?"



So they gave us some wiggle room:

"Table 1 may be used to determine the maximum number of acceptable non-detections for samples or a phantom containing a quantity of analyte equal to the MDA…."

Maximum acceptable number of incorrect detection decisions out of N measurements (5% significance level).

	Assumed detection error (α or β)		
N	0.05	0.02	0.01
5	1	1	1
10	2	1	1
15	2	1	1
20	3	2	1
25	3	2	1
30	4	2	1
35	4	2	1
40	4	2	2
45	5	3	2
50	5	3	2

What is the MDA for RPSD's WBC system?

Here are ten years of "real people" (twelve per year) with their average calculated MDAs assumed to be twice their critical levels:

	Co-60		Cs-137	
Year	L_C (pCi)	MDA (pCi)	L_C (pCi)	MDA (pCi)
2007	4330	8660	5370	10700
2008	3650	7300	4470	8940
2009	3530	7060	4700	9400
2010	3590	7180	4540	9080
2011	3840	7680	5000	10000
2012	3180	6360	4780	9560
2013	3500	7000	5200	10400
2014	3780	7560	5060	10100
2015	3460	6920	5030	10100
2016	3890	7780	5040	10100
Average:	3680	7350	4920	9840

That's 120 "non detections" of Co-60 and Cs-137 in presence of K-40.

But back to worrying:

- Phantoms are rare and expensive.
- Spiking at MDA is dicey.
  - Source activity is expensive.
  - Will we create lots of radioactive waste?
  - What if we're wrong about the calculated MDA? Then back to square one. Can we use one phantom repeatedly?
- What does this word "periodic" mean?

First insight:

“Maybe we could put a source in the shield somewhere, so it just barely registers.” – S. Fournier

Second insight:

“Put a source where the neck usually goes, and add shielding.” – Yours Truly

Methods

“Accuscan II," originally set up in 1992

(Yes, we are replacing this system very soon.)

Barrango Industries water BOMAB from molds lent to SNL by LLNL (DOELAP Equivalent)

(At 58 kg, a little small for “standard man”)

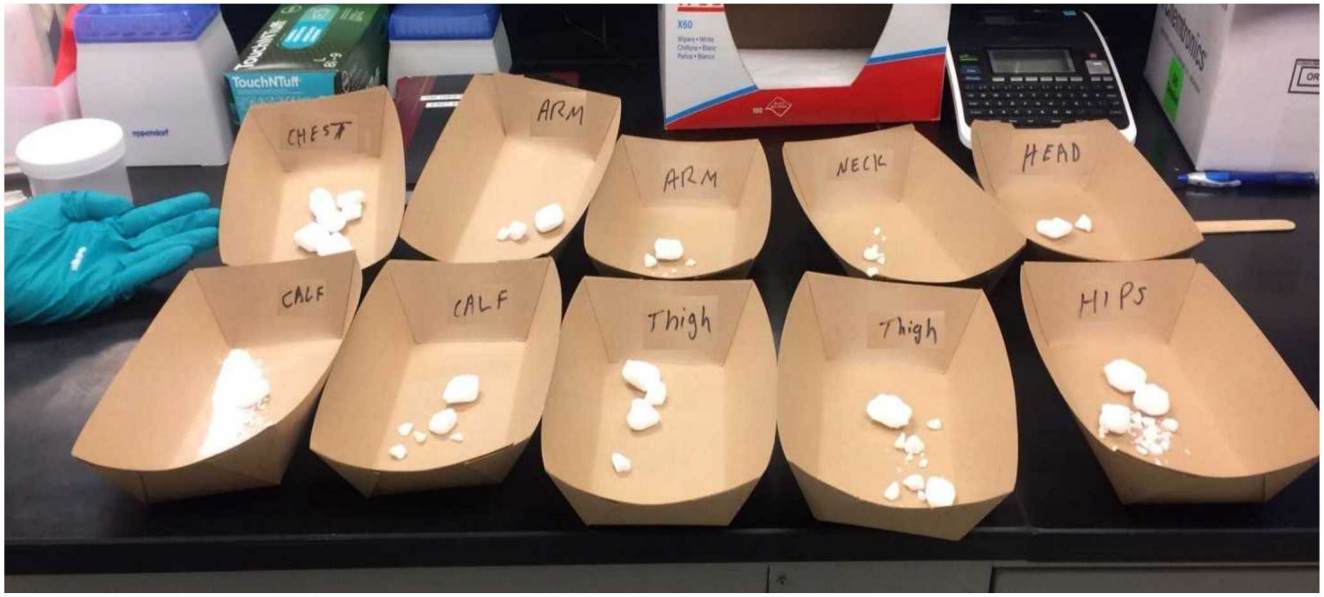
"To make the test realistic, the service laboratory shall ensure that the physical and chemical characteristics of the control samples, including ***potential interferences***...." [emphasis added]

- They mean K-40, but how much?
- Information sources vary… HPS, ORAU, ANL, etc.
- But… here are ten "real people" analyzed at SNL in 2017:

Date	Activity (pCi)	Error (pCi)
2/28/2017	3.13E+05	4.93E+04
3/7/2017	1.52E+05	4.37E+04
3/15/2017	8.61E+04	3.83E+04
3/16/2017	9.91E+04	3.86E+04
3/16/2017	2.07E+05	4.76E+04
3/16/2017	1.91E+05	4.46E+04
3/30/2017	1.35E+05	4.34E+04
5/3/2017	2.98E+05	5.13E+04
5/3/2017	7.46E+04	3.91E+04
5/16/2017	8.35E+04	4.09E+04

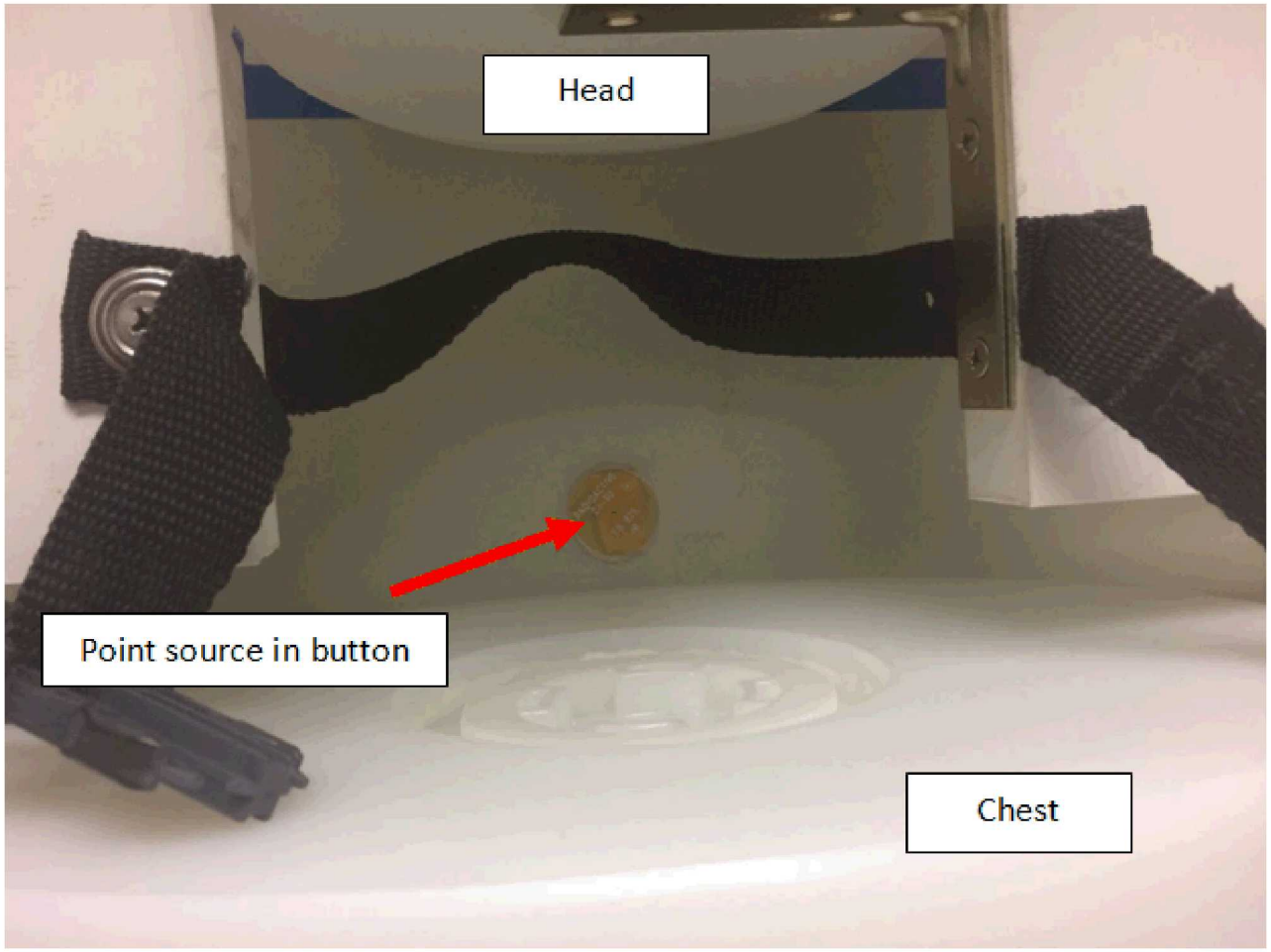
(Average164, 000 +/- 44,000 pCi)

“potential interferences”



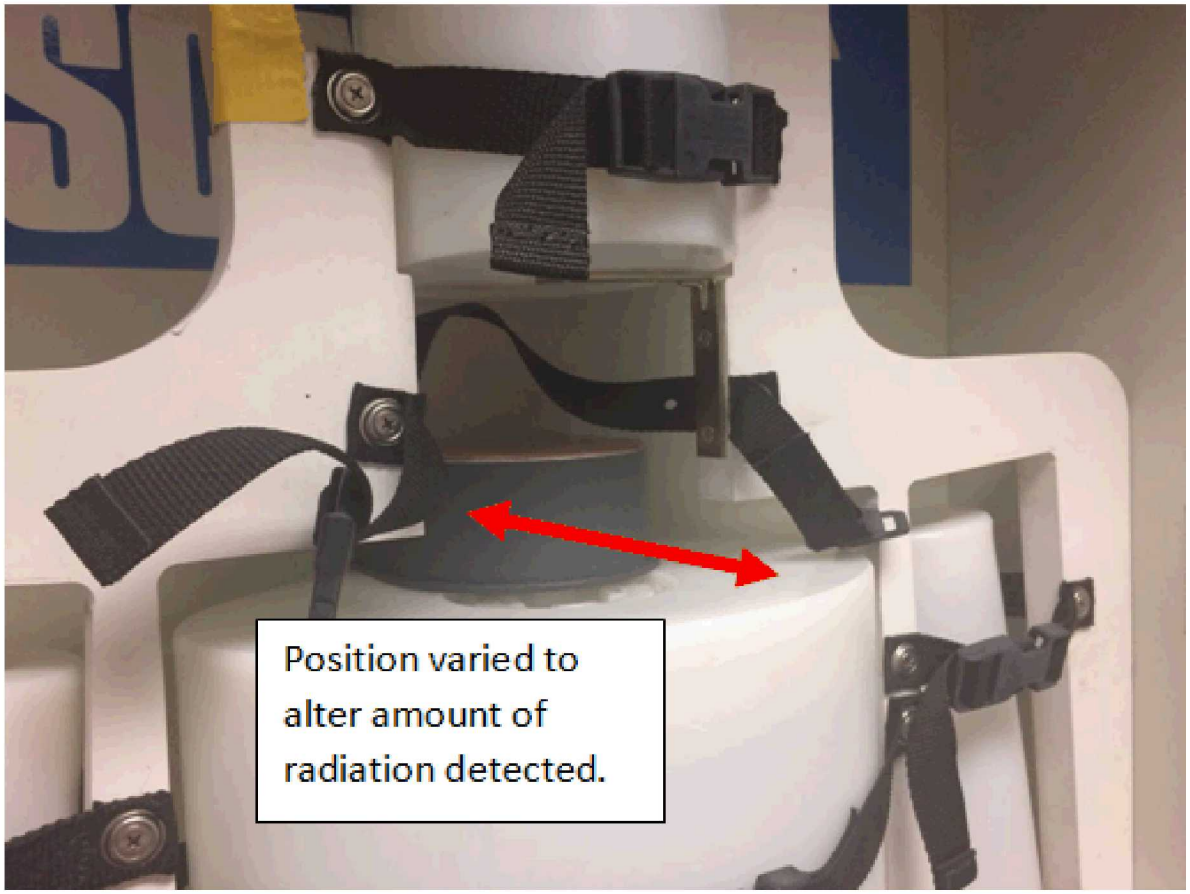
200 g KCL ~ 100 g K ~ 85,000 pCi K-40

Support the head, remove the neck, add the spike:



~ 40,000 pCi Co-60 or 600,000 pCi Cs-137

Add shielding and “tune” it so spike “signal” is just above the “noise”:



Results: Cs-137

Twenty trials in “barely spiked” condition:

Trial	662 Peak Area	Area Error	Reported Activity (pCi)	1σ Error	L_c	*a-Priori* MDA	Activity Above L_c?	Positive Detection?	Near MDA?
1	36	12	5.71E+03	2.65E+03			yes	yes	yes
2	28	7	9.78E+03	2.78E+03			yes	yes	yes
3	29	7	1.02E+04	2.87E+03			yes	yes	yes
4	21	7	7.17E+03	2.74E+03			yes	yes	yes
5	32	8	1.13E+04	3.05E+03			yes	yes	yes
6	30	7	1.06E+04	2.92E+03			yes	yes	yes
7	20	8	6.97E+03	2.92E+03			yes	yes	yes
8	0	NA	1.35E+04	3.75E+03			yes	no	yes
9	29	6	1.02E+04	2.64E+03			yes	yes	yes
10	21	8	7.19E+03	2.80E+03	4.92E+03	9.84E+03	yes	yes	yes
11	0	NA	9.73E+03	3.31E+03			yes	no	yes
12	30	8	1.04E+04	3.17E+03			yes	yes	yes
13	16	7	5.75E+03	2.70E+03			yes	yes	yes
14	26	7	9.15E+03	3.67E+03			yes	yes	yes
15	36	8	1.26E+04	3.36E+03			yes	yes	yes
16	24	7	8.28E+03	2.65E+03			yes	yes	yes
17	38	8	1.33E+04	3.34E+03			yes	yes	yes
18	33	7	1.16E+04	3.01E+03			yes	yes	yes
19	29	7	1.00E+04	2.72E+03			yes	yes	yes
20	0	NA	1.26E+04	3.61E+03			yes	no	yes

Results: Co-60

Twenty trials in “barely spiked” condition:

Trial	1173 Peak Area	Area Error	1332 Peak Area	Area Error	Reported Activity (pCi)	1σ Error	L_c	*a-Priori* MDA	Activity Above L_c?	Positive Detection?	Near MDA?
1	43	7	0	NA	1.04E+04	3.38E+03	3.68E+03	7.35E+03	yes	yes	yes
2	35	7	31	7	1.23E+04	3.07E+03			yes	yes	yes
3	42	8	43	7	1.71E+04	3.72E+03			yes	yes	no
4	28	7	31	7	1.23E+04	2.71E+03			yes	yes	yes
5	36	7	0	NA	7.48E+03	2.56E+03			yes	yes	yes
6	0	NA	28	6	1.01E+04	2.90E+03			yes	yes	yes
7	37	7	0	NA	1.61E+04	3.68E+03			yes	yes	no
8	0	NA	0	NA	1.14E+04	3.08E+03			yes	no	yes
9	42	7	0	NA	1.67E+04	3.84E+03			yes	yes	no
10	39	7	0	NA	8.97E+03	3.12E+03			yes	yes	yes
11	29	7	28	7	1.12E+04	3.05E+03			yes	yes	yes
12	24	7	0	NA	1.65E+04	3.91E+03			yes	yes	no
13	33	7	38	7	1.51E+04	3.35E+03			yes	yes	no
14	0	NA	35	7	1.68E+04	3.82E+03			yes	yes	no
15	0	NA	29	7	1.15E+04	3.01E+03			yes	yes	yes
16	30	7	0	NA	1.44E+04	3.85E+03			yes	yes	yes
17	34	7	42	7	1.66E+04	3.61E+03			yes	yes	no
18	41	8	45	8	1.79E+04	3.89E+03			yes	yes	no
19	20	6	0	NA	1.64E+04	3.85E+03			yes	yes	no
20	37	10	0	NA	1.36E+04	3.45E+03			yes	yes	yes

Conclusion

"By this new method, Cs-137 was consistently detected near the *a-priori* MDA and the results indicated an appropriate rate of false negative reporting. Verifying the *a-priori* MDA of Co-60 proved to be more challenging, but still achievable. The results of this experiment demonstrate that this is a satisfactory method for meeting the new DOELAP standard MDA verification requirements." – Mark Allen

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Questions and Comments