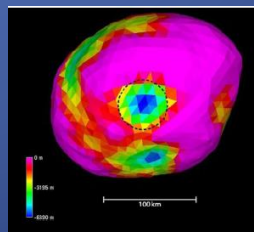
Modified Kusnetz Method

Discussion of the method and revisions to it in the paper entitled *Corrections to Kusnetz Method for Measurements of Radon Progeny Concentrations in Air* by Dr. Omar Nusair

Oscar Paulson, P.G.
16 Psyche Group, LLC.



16 Psyche Group, LLC
P.O. Box 1043
Rawlins, Wyoming 82301-1043
Tel: +1-307-320-8269
Email: oscar.paulson@16psychegroup.com

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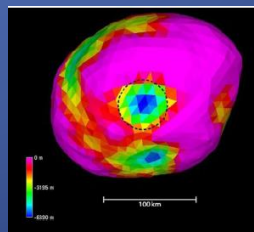
Modified Kusnetz Method

- Description:
  - A method designed to measure the activity of radon-222 progeny in air described in H.L Kusnetz, *Radon Daughters in Mine Atmospheres – A Field Method for Determining Concentrations – 1956.*
  - This method includes collection of an air sample by pumping a volume of air through a filter over a fixed period of time, holding the filter (hold time) for between forty (40) to ninety (90) minutes and counting the filter for alpha decay for a fixed period of time.
  - The activity of the radon progeny is then calculated from the alpha activity, the volume of air sampled, a Kusnetz factor based upon the filter hold time and a self-absorption factor based on the self-absorption of the filter media used.
  - The Kusnetz factor is taken from a table included in the aforementioned paper.



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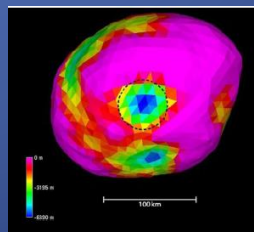
Problems with the Method

- In the process of the preparation of the State of Wyoming's *Radon Public Dose Draft Guidance* Dr. Omar Nusair the program's health physicist examined the modifed Kusnetz Method.
- The following problems were evident:
  - The decay of 214Bi during the sampling period cannot be accounted for during the alpha counting phase of the air filter;
  - the method assumes that 214Bi activity during the counting period is constant and;
  - The method assumes that the presence of 100% equilibrium condition between radon progeny.
  - These problems impact the values of the Kusnetz factors in the time factor table.



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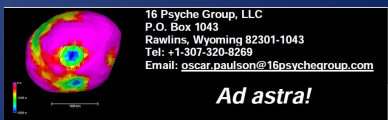
Solution to the Problems
Creation of Revised Kusnetz Factor Tables

- A revised Kusnetz Factor table is proposed in the paper which is as follows:

Table 1. Time-corrected Kusnetz factors for different equilibrium conditions at different sum times.

delay time (min)	K (dpm/L/WL)	sum time sampling + counting (min)											
		aged air (100:100:100) (pCi/L)				indoor [4] (177:106:71) (pCi/L)				outdoor [5] (125:97:97) (pCi/L)			
		4	6	10	20	4	6	10	20	4	6	10	20
40	150	154	152	147	135	152	151	147	137	152	150	145	134
45	140	142	140	135	124	143	141	137	127	141	139	134	123
50	130	131	128	124	114	133	131	127	117	130	127	123	113
55	120	120	118	113	104	123	121	117	108	119	117	113	103
60	110	109	107	103	94	113	111	108	99	109	107	103	94
65	100	100	98	94	85	104	102	98	90	99	97	94	85
70	90	90	89	85	77	95	93	90	82	90	88	85	77
75	83	82	80	77	70	87	85	82	74	82	80	77	70
80	75	74	73	70	63	79	77	74	67	74	72	69	63
85	68	67	65	63	57	71	70	67	61	67	65	63	57
90	60	60	59	57	51	65	63	61	55	60	59	56	51

Note: Ratio (e.g. 177:106:71) is the equilibrium ratio of 218Po, 214Pb, and 214Bi



Revised Table as Graphs

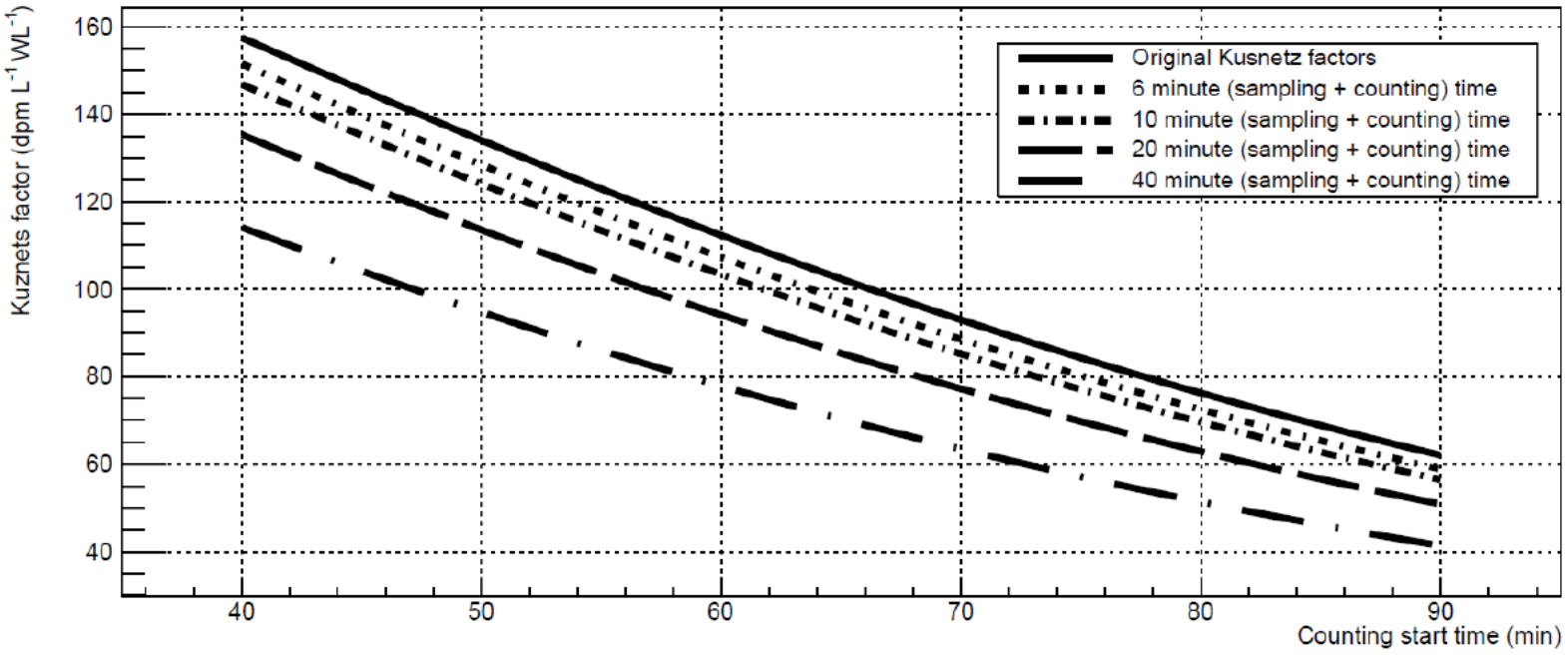
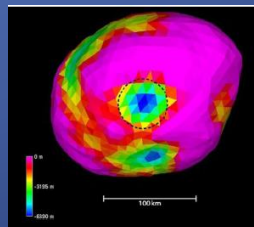


Figure 2. Original Kusnetz factors (solid curve) and different time-corrected factors (several dashed curves) from this work.



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Revised Self Absorption and Lower Limit of Detection (LLD) Formulas are Also Proposed

$$SA = \frac{B - C}{2A + B - C}$$

Currently Used Formula

$$SA = \frac{\frac{B}{K_B} - \frac{C}{K_C}}{\frac{2A}{K_A} + \frac{B}{K_B} - \frac{C}{K_C}}$$

Proposed Formula for Use When count Times Exceed Three (3) Minutes

K_A - Kusnetz Factor - Front
K_B - Kusnetz Factor - Back
K_C - Kusnetz Factor - Covered

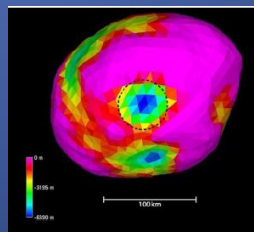
$$LLD\ (WL) = \frac{3 + 3.29\sqrt{R_B \cdot \frac{V_{sample}}{V_B} \cdot T_{sample} \cdot (1 + \frac{T_{sample}}{T_B})}}{K_B \cdot \varepsilon \cdot V_{sample} \cdot T_{sample}}$$

Lower Limit of Detection (LLD) Formula
(Requires Use of Established Background Air Sampling Location)

$$Sum\ Time = T_{sample}(1 + \frac{T_{sample}}{T_B})$$

Formula for Calculation of Time for K_B

R_B - volumetric background counting rate (cpm)
$Vsample$ and VB - the sample and background air volumes
$Tsample$ and TB - the sample and background counting times
ε - alpha-particle detection efficiency (dpm/cpm)
K_B -updated Kusnetz factor



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References

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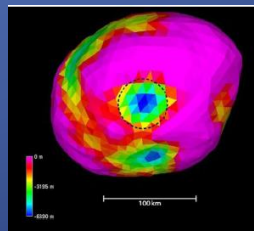
Thank you!
Any Questions?



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