Elevation Influence on Two different Radon Monitors

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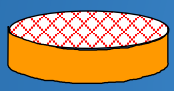
Big Thanks to the following individuals for making the following elevation measurements:
Henry Boyea (2150 ft) Leo Moorman (5100 ft) Brad Turk (7170 ft)

We know Environmental can influence measurement

Are we correcting for Detector Environmental influences?



We know Open Face Charcoal detectors are influenced by Humidity but the lab corrects it.

No correction is made for Exposure Variation during the measurement

Some Labs correct Exposure Temperature
50F + 40% | 60F + 20% | 80F - 20% | 90F - 40%

Do CRM's Measure differently at High Elevations?

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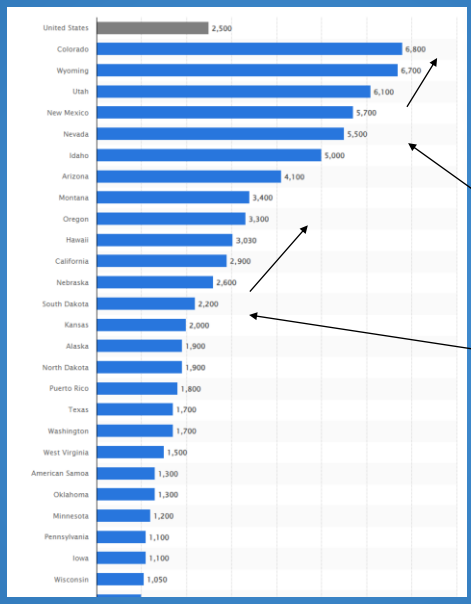
Air is less dense at higher elevations

Colorado 6,800 ft avg



Average Elevation of US states

6 states average above 5000 feet

13 states average above 2000 feet

2005 paper by
Phil Jenkins & Jim Burhart

8% to 10% Higher Counts at 6000-ft versus 820-ft of elevation

Alpha emission	820-ft (266-m)	6000-ft (1969-m)
Radon-222	4.12 cm	4.99 cm
Polonium-218	4.70 cm	5.70 cm
Polonium-214	6.70 cm	8.13 cm

Alpha's Travel

5 cm = 2 in

7.6 cm = 3 in

Alpha Particles travel 21% farther at 6000 feet versus 820 feet

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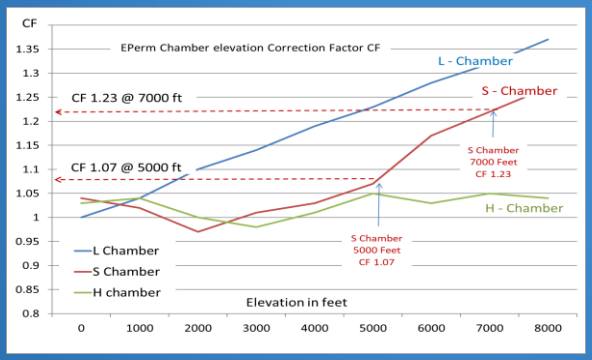
35 Years ago
Kotrappa 1991 paper:
E-Perm's required a Correction Factor CF

EPERM is a Pulse Ion Detector

Correction Factor CF

Linear Line at higher elevations



L-Chamber CF
5000 ft + 1.23
7000 ft + 1.32

S-Chamber CF
5000 ft + 1.07
7000 ft + 1.23

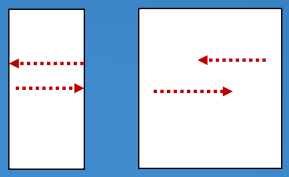
H-Chamber
N/C

Pulse Ion Detectors -> Count Ionization from alpha travel path

Small Chamber
Alpha's mostly hit the wall

300 foot elevation Test

Ion Chambers



Bigger Ion Chamber
Many alpha's don't hit the wall

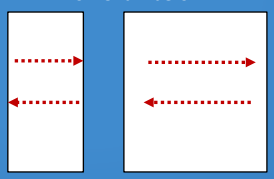
Alpha's hit wall in less dense air

Alpha's travel farther in less dense air

Small Chamber
Alpha travel is the same but less ionization

5000 foot elevation Test

Ion Chambers

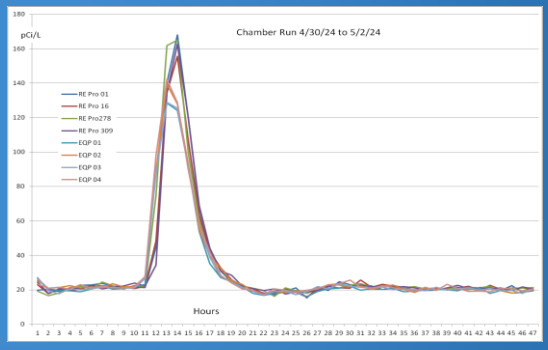


Bigger Chamber
Alpha's still don't hit the wall
Same Ionization takes place

Chamber size and shape make the difference

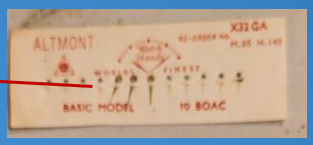
Elevation Test spiked
4-EcoQube Pro & 4-RadonEye Pro
Both are Pulse Ion Detectors

Radon Monitors
were re-calibrated to be within
a few percent of each other
and spiked to 140 to 160 pCi/L



WPB Chamber monitors were
recently spiked at KSU radon chamber

Two Identical Radon Chambers
Radium Watch Hands was radon source



Three or Four
watch hands
suspended
in each chamber

Air circulating fan

4 RadonEye
Pro's

4 EcoQube
Pro's

Mathematical Ingrowth compared to Measured
Fall Off around 100 pCi/L
3rd to 10th Hr used for ingrowth

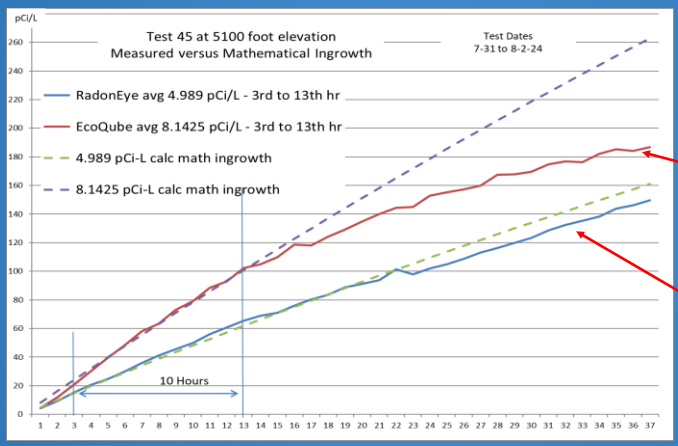
Reason for fall off after 100 pCi/L not determined

Detector Ingrowth

End 60-100 pCi/L

Difference/10

Start 20 pCi/L

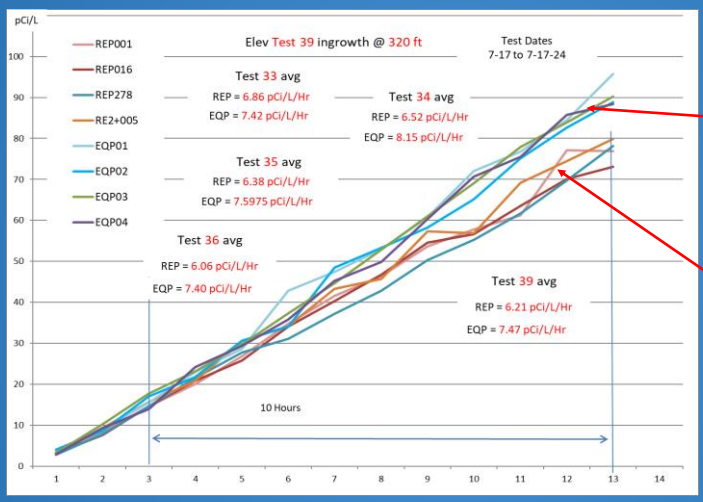


EcoQube Pros

RadonEye Pros

(3rd hour subtracted from 10th hour) / 10 = pCi/L ingrowth/hr

Each Test run 1st - 14 hours was plotted
Radon climbed to 100 pCi/L

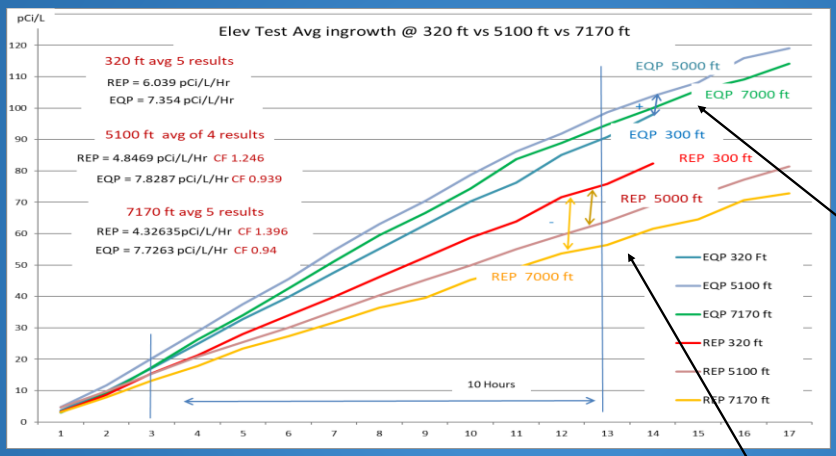


EcoQube Pros

RadonEye Pros

Ingrowth Results at 320 foot elevation

Detector Type averaged by Elevation Location



EcoQube Pro increased by +6% at higher elevations

Need to retest at 320 feet

To match 320 feet - RadonEye needs CF
1.08 CF at 2150 feet
1.25 CF at 5100 feet
1.40 CF at 7170 feet

RadonEye Decreased by -7% & -20% & -28 %

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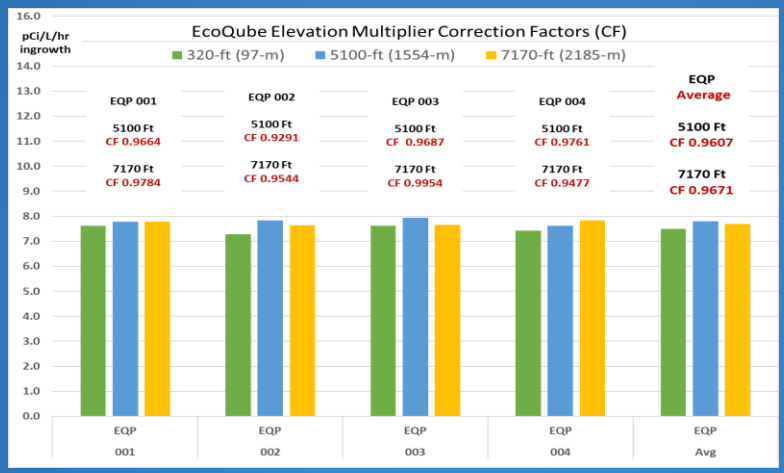
Minimal Individual EcoQube Pro test variation



Note:
Repeat testing at 320 feet needs to be done to confirm reference ingrowth

Good precision between EcoQube Pro monitors
Very little elevation change

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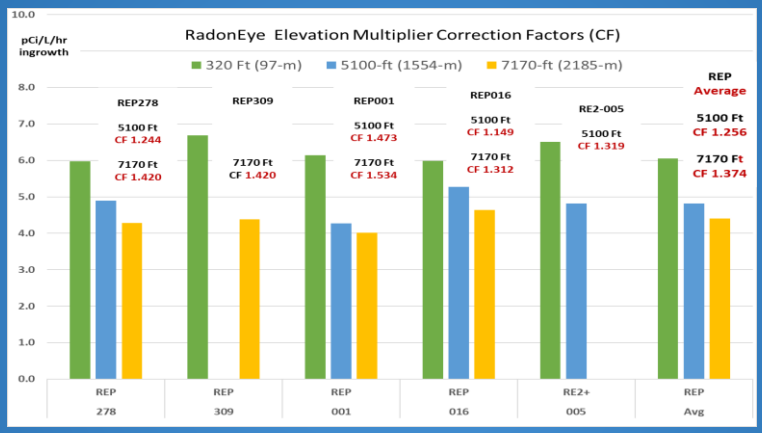
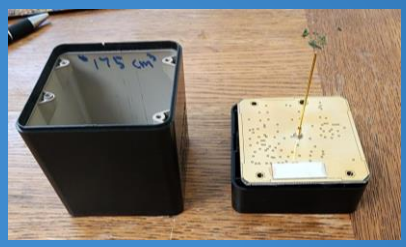
Greater variation in 5 Individual RadonEye test averages



RadonEye's had greater variation in elevation CF
5100 feet CF 1.15 to CF 1.47
7170 feet CF 1.312 to CF 1.534

Two Pulse Ion Radon Detectors
from the same company
had very different performances

RadonEye Pro



EcoQube Pro

The best way to determine environmental influence on Radon Monitors is to test them.

Individual Radon Detectors may vary .

Conference Papers on

Commercial PFE Testing
Calculating Piping Pressure Drop
Onsite Radon in Water Measurements
Elevation Influence

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Big thanks to Ecosense for providing radon monitors and testing volunteers