Overview of Consumer Digital Radon Measurement Devices

Kansas State University College of Engineering, Engineering Extension Presented by: Alexandra Bahadori

Approved vs. Consumer Radon Devices

What does the ANSI/AARST Performance Specifications for Instrumentation Systems Designed to Measure Radon Gas in Air (MS-PC) Evaluate?

What does the MS-PC evaluate?

- "This standard specifies the minimum performance criteria and testing procedures for instruments and/or systems designed to quantify the concentration of Radon-222 gas in air."
- Testing Criteria
 - Accuracy and Precision
 - Minimum Detectable Concentration or Integrated Concentration
 - Proportionality
 - Temperature
 - Humidity
 - Compliance

What does the MS-PC evaluate?

- Accuracy and Precision
 - MS-PC Criteria
 - Each device shall demonstrate an Individual Percent Error (IPE) within 0 ± 25% when tested at:
 - A radon concentration in the range of 6-15 pCi/L
 - A temperature in the range of 65-75° F; and
 - A relative humidity in the range of 10-55% with radon concentration, temperature, and relative humidity held as constant as practicable
 - The precision of the devices shall be assessed using the Coefficient of Variation (CV) of the set of five devices which shall be less than or equal to 15%

What does the MS-PC evaluate?

- Individual Percent Error (IPE): The degree from which a single measure value (X) deviate from the conventionally true value (T) and it measures accuracy of the devices.
 - IPE = [100(X T)/T]]
- Coefficient of Variation (CV): The sample standard deviation (s) of a set of measurements expressed as a percentage of the arithmetic mean of the measurements and it measures the precision of the devices.

•
$$CV = 100 * \left(\frac{s}{mean}\right)$$

What do these devices look like?



EcoQube



EcoBlu



RadonEye



Lüft



View Radon



Wave Radon



Corentium Home

Device Output- EID/CRM

- Single Data Point (Daily, 7 day, long term)
 - Detector A
 - EcoBlu
 - Corentium Home
- Online Interface with Hourly Data
 - Ecosense EcoQube
 - Ecosense Radon Eye
 - SunRadon Lüft
 - Airthings View Radon
 - Airthings Wave Radon



EcoQube



1:42 PM C	G	•••			* 2 :0	2
≡		All devices 🔻				+
My Devices	4					
	KSU3 Manhattan, United States		34.5	pCi/I		
	KSU2 Manhattan, United States		1.4	pCi/I		
	KSU5 Manhattan, United States		0.9	pCi/I		
	KSU1 Manhattan, Canada		1.0	pCi/I		
	KSU4 Manhattan, United States		28.6	pCi/I		

■ KSU3 ▼ DASHBOARD Radon (pCl/l) Mean 0.6 06/2 1.1 06/2 1.1 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.7 06/2 0.8 06/2	E DATA Permenet time 3/2023 14:31 3/2023 13:31 3/2023 12:31
DASHBOARD Radon (pCl/f) Mean 0.6 06/2 1.1 06/2 1.1 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.12 06/2 0.8 06/2	DATA rement time * 3/2023 14:31 3/2023 13:31 3/2023 12:31
Radon (pCU7) Mean 0.6 06/2 1.1 06/2 1.1 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.1 0.9 0.8 06/2 0.8 06/2 0.8 06/2 0.7 06/2 0.8 06/2	arement time * 3/2023 14:31 3/2023 13:31 3/2023 12:31
0.6 06/2 1.1 06/2 1.1 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.7 06/2 0.8 06/2	3/2023 14:31 3/2023 13:31 3/2023 12:31
1.1 06/2 1.1 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 1.1 06/2 0.8 06/2 1.1 06/2 1.1 06/2 0.7 06/2 0.8 06/2	3/2023 13:31 3/2023 12:31
1.1 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 1.2 06/2 1.1 06/2 0.7 06/2 0.8 06/2	3/2023 12:31
0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 1.2 06/2 1.1 06/2 0.7 06/2 0.7 06/2	
0.8 06/2 0.8 06/2 0.8 06/2 0.8 06/2 1.2 06/2 1.1 06/2 0.7 06/2 0.7 06/2	3/2023 11:31
0.8 06/2 0.8 06/2 0.8 06/2 1.2 06/2 1.1 06/2 0.7 06/2 0.8 06/2	3/2023 10:31
0.8 06/2 0.8 06/2 1.2 06/2 1.1 06/2 0.7 06/2 0.8 06/2	3/2023 09:31
0.8 06/2 1.2 06/2 1.1 06/2 0.7 06/2 0.8 06/2	3/2023 08:31
1.2 06/2 1.1 06/2 0.7 06/2 0.8 06/2	3/2023 07:31
1.1 06/2 0.7 06/2 0.8 06/2	3/2023 06:31
0.7 06/2	3/2023 05:31
0.8 06/2	3/2023 04:31
	3/2023 03:31
0.7 06/2	3/2023 02:31
0.7 06/2	3/2023 01:31
0.7 06/2	3/2023 00:31
1.2 06/2	2/2023 23:31
1.1 06/2	2/2023 22:31
0.7 06/2	2/2023 21:31
0.9 06/2	2/2023 20:31
1.0 06/2	
	2/2023 19:31
FILTER(1)	2/2023 19:31



RadonEye

Rn



RADON DATA Radon Level Connected No Action Required 0.81 pc// 9 Measurement Time 77d 04h 25m 4 Peak Value 1.81 pc// 1 -day Average 0.95 pc// 30-day Average 0.68 pc//	Ŧ	GI01RE000104	\$
Radon Level Connected No Action Required 0.81 pc//?		RADON DATA	
No Action Required 0.81 pc/? Details Details Peak Value 1.81 pc/? 1-day Average 0.95 pc/? 30-day Average 0.68 pc/?	Radon Level		Connected
Details Measurement Time 77d 04h 25m Peak Value 1.81 pol/ℓ 1-day Average 0.95 pol/ℓ 30-day Average 0.68 pol/ℓ	No Action Required		① ■ 0.81 pci/ℓ
Measurement Time 77/d 04h 25m Peak Value 1.81 p0//² 1-day Average 0.95 p0/² 30-day Average 0.68 p0/²	Details		
Peak Value 1.81 pc/ℓ 1-day Average 0.95 pc/ℓ 30-day Average 0.68 pc/ℓ	Measurement Time		77d 04h 25m
30-day Average 0.68 pc//ł	Peak Value		1.81 pGi/8
30-day Average U.68 pore	D 00 day Average		0.95 pc//8

FTLAB RADON DATA FILE MODEL NAME: RD200 S/N: GI01RE000104 Unit: pCi/l Time step: 1hour Data No : 5225 1) 15.38 2) 19.41 3) 20.38 4) 21.43 5) 21.89 23.24 6) 7) 22.70 8) 25.24 9) 22.30 10) 21.70 11) 23.84 12) 23.65 13) 23.65 14) 24.43 15) 25.65 16) 28.59 17) 24.73 18) 26.14 19) 26.95 20) 25.16 21) 25.08 22) 26.16 23) 25.27 24) 24.73 25) 24.38 26) 24.27 27) 25.16 28) 25.14 29) 25.95 30) 24.46 31) 25.38 32) 25.65 33) 26.68 34) 24.95 35) 26.14 36) 25.32 37) 25.46 38) 25.03 39) 25.65 40) 26.03



SunRadon Lüft



Serialid	Location	DeviceName	Owner	Email	SyncDate	Radon	eC02	voc	Temperature	AirPressure	Humidity	LogIndex	BuildingType	MitigationSystem	DeviceTimeZone
Luft_5E3A	2323 Anderson Ave, Manhattan, KS 66502, USA	KSU16		radonchamber@ksu.edu	8/7/2023 14:43	0	403	0	71	30.01	29	616	6 Residential Single Family	None	CDT
Luft_5E3A	2323 Anderson Ave, Manhattan, KS 66502, USA	KSU16		radonchamber@ksu.edu	8/7/2023 15:43	2.1	405	0	73	29.99	27	617	Residential Single Family	None	CDT
Luft_5E3A	2323 Anderson Ave, Manhattan, KS 66502, USA	KSU16		radonchamber@ksu.edu	8/7/2023 16:43	10.1	407	0	73	29.97	26	618	Residential Single Family	None	CDT
Luft_5E3A	2323 Anderson Ave, Manhattan, KS 66502, USA	KSU16		radonchamber@ksu.edu	8/7/2023 17:43	12.2	415	1	73	29.96	26	619	Residential Single Family	None	CDT
Luft_5E3A	2323 Anderson Ave, Manhattan, KS 66502, USA	KSU16		radonchamber@ksu.edu	8/7/2023 18:43	15.1	425	3	73	29.95	25	620	Residential Single Family	None	CDT
Luft_5E3A	2323 Anderson Ave, Manhattan, KS 66502, USA	KSU16		radonchamber@ksu.edu	8/7/2023 19:43	17	437	5	73	29.95	25	621	Residential Single Family	None	CDT
Luft_5E3A	2323 Anderson Ave, Manhattan, KS 66502, USA	KSU16		radonchamber@ksu.edu	8/7/2023 20:43	19.6	451	7	73	29.94	25	622	Residential Single Family	None	CDT
Luft_5E3A	2323 Anderson Ave, Manhattan, KS 66502, USA	KSU16		radonchamber@ksu.edu	8/7/2023 21:43	20.4	462	9	73	29.95	25	623	Residential Single Family	None	CDT
Luft_5E3A	2323 Anderson Ave, Manhattan, KS 66502, USA	KSU16		radonchamber@ksu.edu	8/7/2023 22:43	20.9	467	9	72	29.97	25	624	Residential Single Family	None	CDT





View Radon













Indoor Environments [™] 2024 - Radon and Vapor Intrusion Symposium

Wave Radon









Performance

Procedure

- Five copies of each device model were exposed to:
 - Exposure 1: 12.8 pCi/L to 15.5 pCi/L
 - Ecosense (10 pCi/L), Lüft (4 pCi/L), Airthings (5.4 pCi/L)
 - Exposure 2: 0.6 pCi/L
 - Exposure 3: 27.7 pCi/L to 29.4 pCi/L
 - Detector A (25 pCi/L)
- For all three exposures the temperature and relative humidity was set at household ambient levels
- Exposures were 7 days long
- Data analysis used the device evaluation metrics in the ANSI/AARST Performance Specifications for Instrumentation Systems Designed to Measure Radon Gas in Air (MS-PC)

Understanding IPE Results

- It is anticipated that the absolute value of IPE will decrease as the radon concentration approaches the device model calibration range.
 - Seven of the eight device models have a reported specifications for accuracy and precision near the US EPA action level of 4 pCi/L Seven of the eight device models demonstrated an average IPE within ± 25%. (Exposure 1)
 - Detector A has reported specifications for accuracy and precision at 25 pCi/L. The ambient air radon concentration average was 0.6 pCi/L, well below the lower limit of the assumed calibration range, and therefore it is anticipated that the accuracy will suffer. (Exposure 2)

Individual Percent Error for Exposure 1 12.8 pCi/L to 15.5 pCi/L



- Individual Percent Error (IPE): The degree from which a single measure value (X) deviates from the conventionally true value (T)
- Average and standard deviation are show for each device model

Individual Percent Error for Exposure 2 0.6 pCi/L



- Individual Percent Error (IPE): The degree from which a single measure value (X) deviates from the conventionally true value (T)
- Average and standard deviation are show for each device model

Individual Percent Error for Exposure 3 27.7 pCi/L to 29.4 pCi/L



- Individual Percent Error (IPE): The degree from which a single measure value (X) deviates from the conventionally true value (T)
- Average and standard deviation are show for each device model

Coefficient of Variation



Anticipated that precision would worsen as the radon concentration decreased

Summary

- Exposure 1
 - Seven of the eight monitors fell within the 0 \pm 25% for IPE
 - Airthings View Radon was only device that did not meet the ± 25% IPE range with four of the five devices falling outside of these limits
 - All eight models fell within the ± 15% CV range
- Exposure 2
 - Six of the eight monitors fell within the 0 \pm 25% for IPE
 - Detector A and Wave Radon fell outside of the limits
 - Five of the eight monitors fell within the ± 15% CV range
 - Detector A, Lüft, and Wave Radon fell outside of the limits
- Exposure 3
 - All eight monitors performed within the 0 ± 25% IPE range
 - All eight monitors fell within the ± 15% CV range

Evaluation of consumer digital radon measurement devices: a comparative analysis

- Evaluation of 8 devices published recently in the Journal of Radiological Protection:
 - https://iopscience.iop.org/article/10.1088/1361-6498/ad4bf1

Contact Information

- Alexandra Bahadori
 - 785.532.6026 (general office)
 - 785.532.3957 (direct)
 - adbaha@ksu.edu
- Brian Hanson
 - 785.532.4996 (direct)
 - <u>bhandon@ksu.edu</u>
- NRPS Contact
 - radon@ksu.edu
- KSU Radon Training
 - <u>radoncourse@ksu.edu</u>
- KSU Radon Chamber
 - radonchamber@ksu.edu