

REPORT DOCUMENTATION PAGE			<i>Form Approved</i> <i>OMB No. 0704-0188</i>		
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1. REPORT DATE (DD-MM-YYYY) 21 Nov 2013		2. REPORT TYPE Consultative Letter		3. DATES COVERED (From – To) May 2013 – August 2013	
4. TITLE AND SUBTITLE Radon Assessment of Occupational Facilities, Homestead ARB, FL			5a. CONTRACT NUMBER		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S) SSgt Michael Ames			5d. PROJECT NUMBER		
			5e. TASK NUMBER		
			5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) USAF School of Aerospace Medicine Occupational & Environmental Health Dept Consultative Services Division 2510 Fifth St. Wright-Patterson AFB, OH 45433-7913			8. PERFORMING ORGANIZATION REPORT NUMBER AFRL-SA-WP-CL-2013-0025		
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSORING/MONITOR'S ACRONYM(S)		
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)		
12. DISTRIBUTION / AVAILABILITY STATEMENT Distribution A: Approved for public release; distribution is unlimited. Case Number: 88ABW-2013-4919, 21 Nov 2013					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT An assessment of indoor radon concentrations was conducted in 46 facilities at Homestead ARB, FL. In total, 103 detectors were deployed throughout the installation. The detectors used were passive, electret ion chamber type monitors manufactured by Rad Elec Inc. Monitors were deployed for a period of at least 91 days to satisfy the requirements established in AFI 48-148 for long-term monitoring. Historical results indicate a radon risk characterization category of "medium," requiring all occupied facilities on the installation to be monitored. All results from this survey were less than the Environmental Protection Agency's recommended action level of 4 pCi/L.					
15. SUBJECT TERMS Radon, Homestead ARB, electret ion chamber, picocuries per liter					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Col Mark E. Smallwood
U	U	U	SAR	16	19b. TELEPHONE NUMBER (include area code)



DEPARTMENT OF THE AIR FORCE
USAF SCHOOL OF AEROSPACE MEDICINE (AFMC)
WRIGHT-PATTERSON AFB OH

21 November 2013

MEMORANDUM FOR 482 MSG/SGPB

ATTN: MR. MICHAEL SCHMIDT
29050 CORAL SEA BLVD, BOX 16
HOMESTEAD ARB, FL 33039-1299

FROM: USAFSAM/OEC
2510 Fifth Street
Wright-Patterson AFB, OH 45433-7913

SUBJECT: Consultative Letter, AFRL-SA-WP-CL-2013-0025, Radon Assessment of
Occupational Facilities, Homestead ARB, FL

1. INTRODUCTION:

a. *Purpose:* At the request of 482 MSG/SGPB, the U.S. Air Force School of Aerospace Medicine, Consultative Services Division (USAFSAM/OEC), Radiation Health Consulting Branch completed a radon assessment of occupational facilities from 1 May through 22 August 2013 at Homestead ARB to quantify radon exposures. This assessment was performed with the assistance of the Installation Radiation Safety Officer.

b. *Background:* Homestead Air Force Base was assessed originally under the Radon Assessment and Mitigation Program (RAMP) from 2 December 1987 to 1 March 1988 and again from 6 September 1990 to 17 January 1992 using Alpha Track long-term detectors. Based on the RAMP results, the installation was assigned a risk rating of "medium." In accordance with Air Force Instruction 48-148, *Ionizing Radiation Protection*, a medium risk rating requires the monitoring of all newly constructed or acquired facilities. In addition, all buildings not identified under the RAMP assessment shall be monitored. In 1994, the base was transferred to the Air Force Reserve Command and reduced in size. As the new installation boundary is smaller and contains fewer housing and dormitory units, most of the facilities assessed under the RAMP as Homestead AFB are considered outside the installation at this time.

c. *Survey Personnel:*

- (1) Health Physicist, USAFSAM/OEC
- (2) Health Physics Technician, USAFSAM/OEC
- (3) Health Physics Technician, USAFSAM/OEC

d. *Personnel Contacted:*

- (1) Installation Radiation Safety Officer (IRSO), 482 MSG/SGPB
- (2) Real Property Officer, 482 CES/CER

e. *Radon Survey Measurement Equipment:*

- (1) Fluke Biomedical – 451P Pressurized Ion Chamber (Serial Number 3885, calibrated 29 November 2012)
- (2) Rad Elec Inc. – Electret Voltage Reader SPER-1 E (Serial number E0361, calibrated 2 April 2013)
- (3) Rad Elec Inc. – Electret Voltage Reader SPER-1 E (Serial number E0384, calibrated 16 May 2013)
- (4) Rad Elec Inc. – Reference Electrets (Serial numbers RE3921 and RE4098, certified 2 April 2013)
- (5) Rad Elec Inc. – Reference Electrets (Serial numbers RE4163 and RE4248, certified 16 May 2013)
- (6) Rad Elec Inc. – Zero Electret
- (7) Rad Elec Inc. – Electret Passive Environmental Radon Monitor (E-PERM) Standard Chambers (S-chambers) (210 mL)
- (8) Rad Elec Inc. – E-PERM long-term electrets, ≥ 90 days

2. METHODOLOGY:

a. *Process:* Facilities were tested using the E-PERM system from Rad Elec Inc. The E-PERM system is identified by the Environmental Protection Agency as an electret ion chamber. This system was configured with an S-chamber and long-term electret. An electret is a charged Teflon disk that produces an electrostatic field within the 210-mL S-chamber. Radon gas passively enters this chamber and emits alpha particles that ionize the air molecules. These ions are then collected by the electrets, causing a reduction of their surface charge. The reduction of the charge on the electrets is directly measured and used to calculate radon levels. The radon detectors were placed in the test locations for greater than 90 days in accordance with the following measurement device protocols outlined in the Environmental Protection Agency's 402-R-92-004 and 402-R-92-014.

- (1) 3 feet from heating, ventilation, and air conditioning, doors, fans, and windows
- (2) In an area outside of excessive heat (fireplace, direct sunlight, and high humidity)
- (3) 1 foot from exterior walls
- (4) 20 inches from floor and 4 inches from objects
- (5) If suspended (ceiling), placed in general breathing zone (6-8 feet above floor)
- (6) Frequently occupied rooms with contact to the ground
- (7) When in an open floor plan, deployed every 2000 square feet
- (8) Not placed in restrooms, hallways, stairwells, elevator shafts, utility closets, or storage closets

The background gamma readings were measured with a Fluke Biomedical 451P ion chamber. These measurements were utilized when correcting radon data to the environmental factors observed at the time of placement and collection.

b. *Quality Assurance Program:* To ensure quality data and uphold the confidence in the assessment of Homestead ARB, the following quality controls were used.

- (1) Performance Tests: A biennial performance test from commercial vendors evaluates the proficiency of USAFSAM’s radon analysis. A proficiency test was last performed and passed on 18 July 2012.
- (2) Blanks: Six field blanks were used during the Homestead ARB assessment.
- (3) Duplicates: Ten duplicates were used during this assessment. Duplicate analysis allows for the measurement of precision, using the relative percent difference (RPD) between a co-located sample and the associated duplicate. RPD can be calculated using Equation 1:

$$\%RPD = \frac{X_1 - X_2}{X_{avg}} \times 100 \tag{1}$$

%RPD = relative percent difference
 X_1 = concentration observed with the sample, in pCi/L
 X_2 = concentration observed with the duplicate, in pCi/L
 X_{avg} = average concentration, given as $\frac{X_1 + X_2}{2}$, in pCi/L

- (4) Calibration: Please see Attachment for calibration certificates
- (5) Equipment Checks: Proper operation of the Rad Elec Inc. SPER-1 voltage reader was verified using the three reference electrets calibrated for use with the instrument. See Section 3 for results.

c. *Calculations:* Calculations were performed using guidance from Rad Elec Inc. Equation 2 below illustrates how radon levels are calculated. Constants are utilized in the calculations based on the E-PERM configuration. The gamma background is measured at each location. The measured radon concentration value is then corrected for the elevation above sea level using Equation 3. The elevation for Homestead ARB, FL, is listed at 7 feet above sea level. For this altitude the elevation correction factor is 1. See below for details.

$$MRC\left(\frac{pCi}{L}\right) = \frac{(I - F)}{(CF \times D)} - BG \tag{2}$$

MRC = measured radon concentration in pico-Curies per Liter ($\frac{pCi}{L}$)
 I = initial voltage of electret
 F = final voltage of electret
 D = exposure duration in days
 $CF = A + B \times ((I + F)/2)$
 BG = gamma background in micro-Roentgens per hour ($\mu R/h$) x constant-G

Constants for configuration:

A = 1.40E-01

B = 5.25E-05

G = 8.70E-02

$$MRC_E \left(\frac{pCi}{L} \right) = (MRC)_x(ACF) \quad (3)$$

MRC_E = elevation corrected radon concentration

ACF = altitude correction factor

3. RESULTS:

a. *Radon Sampling Results:* In total, 103 radon monitors were placed in 46 facilities at Homestead ARB for analysis and quality control. The locations of the monitors are depicted in Figure 1. Out of the 103 radon monitors, 10 were used as duplicates and 6 were used as field blanks. All radon monitors were below the remedial action level for radon of 4 pCi/L. The results of the survey are detailed in Table 1. The uncertainty values listed are the geometric mean of the relative errors associated with system component imperfections, electret voltage uncertainty, and background gamma uncertainty.

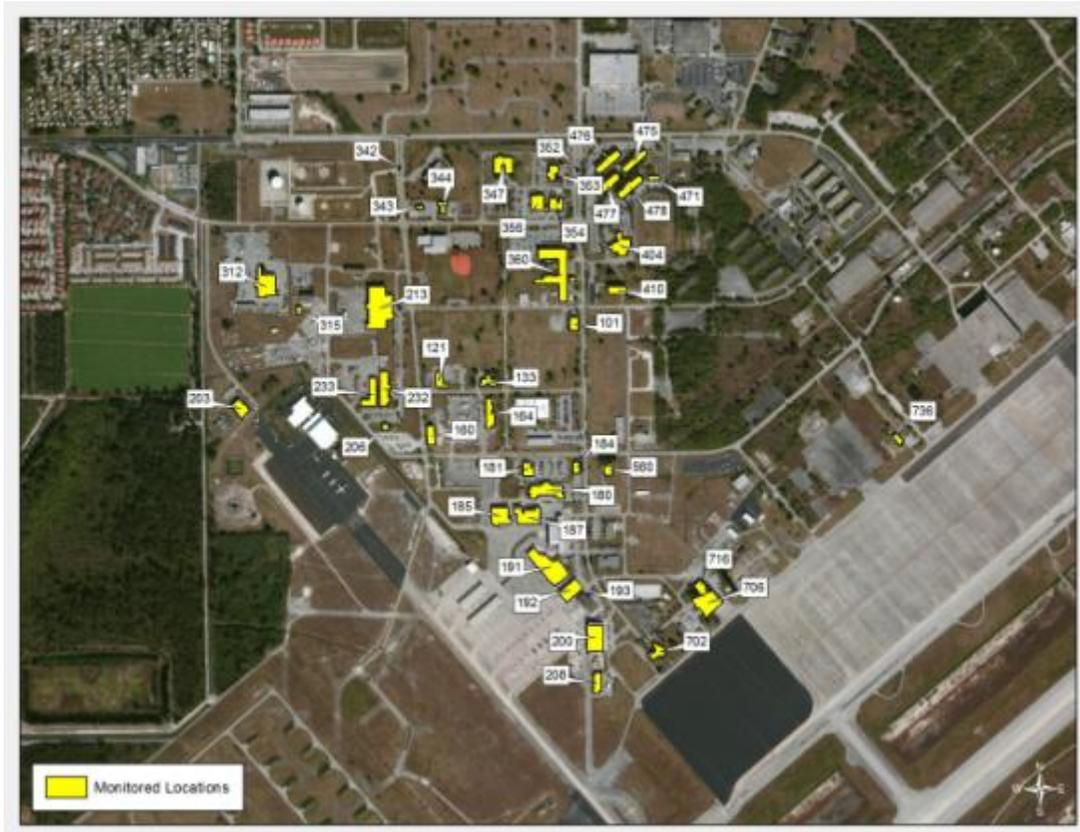


Figure 1. Map of Monitored Locations

Table 1. Radon Sampling Results

Building	Room	Type	Start Date	Stop Date	Avg. Gamma Background (μR/h)	Radon Conc. ± Uncertainty (pCi/L)
101	Lobby	Sample	2-May-13	21-Aug-13	4.5	2.62 ± 0.17
121	119	Sample	3-May-13	21-Aug-13	4.0	1.57 ± 0.14
121	119	Duplicate ^a	3-May-13	21-Aug-13	4.0	1.60 ± 0.14
133	Orderly Rm	Sample	3-May-13	21-Aug-13	5.0	1.76 ± 0.14
133	Learning Ctr	Sample	3-May-13	21-Aug-13	5.5	Invalid ^b
160	Office Rm	Sample	3-May-13	21-Aug-13	5.0	1.14 ± 0.12
164	Office Rm	Sample	3-May-13	20-Aug-13	4.5	2.01 ± 0.15
180	134	Sample	1-May-13	20-Aug-13	7.0	1.56 ± 0.13
180	112	Sample	1-May-13	20-Aug-13	7.0	1.35 ± 0.13
180	112	Duplicate ^b	1-May-13	20-Aug-13	7.0	1.39 ± 0.13
181	Asst Mgr Office	Sample	1-May-13	20-Aug-13	2.5	2.03 ± 0.15
184	109	Sample	1-May-13	20-Aug-13	4.5	1.41 ± 0.13
185	3	Sample	2-May-13	21-Aug-13	7.0	1.19 ± 0.12
185	36	Sample	2-May-13	21-Aug-13	5.0	1.12 ± 0.12
187	119	Sample	2-May-13	20-Aug-13	8.0	1.31 ± 0.13
187	130	Sample	2-May-13	21-Aug-13	6.0	1.48 ± 0.13
187	103	Sample	2-May-13	21-Aug-13	6.5	1.22 ± 0.12
191	150	Sample	2-May-13	20-Aug-13	5.0	2.28 ± 0.16
191	145	Sample	2-May-13	20-Aug-13	7.0	2.83 ± 0.18
191	187	Sample	2-May-13	20-Aug-13	7.0	1.37 ± 0.13
191	132	Sample	2-May-13	20-Aug-13	6.5	1.26 ± 0.13
191	138	Sample	2-May-13	20-Aug-13	4.5	1.26 ± 0.13
191	199	Sample	2-May-13	20-Aug-13	5.5	1.33 ± 0.13
191	230	Sample	2-May-13	20-Aug-13	6.0	1.40 ± 0.13
191	230	Blank	2-May-13	20-Aug-13	6.0	<LLD ^c
191	140	Sample	2-May-13	20-Aug-13	5.5	1.57 ± 0.14
191	109	Sample	2-May-13	20-Aug-13	6.0	1.33 ± 0.13
191	127	Sample	2-May-13	20-Aug-13	7.0	1.69 ± 0.14
192	117	Sample	2-May-13	20-Aug-13	5.5	1.02 ± 0.12
193	106	Sample	2-May-13	20-Aug-13	5.5	1.56 ± 0.14
193	106	Duplicate ^b	2-May-13	20-Aug-13	5.5	1.58 ± 0.14
200	102	Sample	2-May-13	20-Aug-13	8.0	0.96 ± 0.12

^a All duplicates read below 2 pCi/L and statistical analysis cannot be performed.

^b Sample invalidated as evidence of tampering was observed.

^c The actual value is not being reported because it is less than the lower limit of detection (LLD) for the measurement technique, given by the manufacturer as 0.275 pCi/L.

Table 1. Radon Sampling Results (continued)

Building	Room	Type	Start Date	Stop Date	Avg. Gamma Background (μR/h)	Radon Conc. ± Uncertainty (pCi/L)
203	117	Sample	3-May-13	21-Aug-13	6.0	1.50 ± 0.13
206	Locker Rm	Sample	3-May-13	21-Aug-13	4.5	2.29 ± 0.16
208	AGE Office	Sample	2-May-13	20-Aug-13	6.0	1.54 ± 0.13
213	Office Rm	Sample	3-May-13	21-Aug-13	4.5	1.31 ± 0.13
213	Office Rm	Duplicate ^b	3-May-13	21-Aug-13	4.5	1.35 ± 0.13
213	102	Sample	3-May-13	21-Aug-13	5.0	1.42 ± 0.13
232	131	Sample	3-May-13	21-Aug-13	4.0	1.96 ± 0.15
232	124	Sample	3-May-13	21-Aug-13	3.5	1.92 ± 0.15
232	124	Duplicate ^b	3-May-13	21-Aug-13	3.5	2.00 ± 0.15
232	112	Sample	3-May-13	21-Aug-13	3.5	2.01 ± 0.15
232	112	Blank	3-May-13	21-Aug-13	3.5	<LLD ^d
233	172	Sample	3-May-13	21-Aug-13	5.0	1.53 ± 0.14
251	102	Sample	3-May-13	21-Aug-13	3.5	1.06 ± 0.12
312	112	Sample	3-May-13	21-Aug-13	4.5	1.23 ± 0.13
315	Break Rm	Sample	3-May-13	21-Aug-13	4.5	1.13 ± 0.12
342	ECP Office	Sample	1-May-13	21-Aug-13	6.0	2.68 ± 0.18
343	Supervisor Office	Sample	1-May-13	21-Aug-13	6.5	1.58 ± 0.14
344	Barber Shop	Sample	1-May-13	21-Aug-13	3.5	1.62 ± 0.14
347	152	Sample	2-May-13	21-Aug-13	6.0	1.12 ± 0.12
347	152	Duplicate ^b	2-May-13	21-Aug-13	6.0	1.19 ± 0.12
347	130	Sample	2-May-13	21-Aug-13	5.5	Invalid ^d
347	109	Sample	2-May-13	22-Aug-13	7.5	1.04 ± 0.12
352	Guard Shack	Sample	1-May-13	21-Aug-13	9.0	1.27 ± 0.12
353	121	Sample	1-May-13	21-Aug-13	3.5	1.14 ± 0.12
353	121	Blank	1-May-13	21-Aug-13	3.5	<LLD ^d
353	118	Sample	1-May-13	21-Aug-13	4.0	1.25 ± 0.13
354	107	Sample	1-May-13	21-Aug-13	2.5	2.76 ± 0.18
354	119	Sample	1-May-13	21-Aug-13	4.0	1.39 ± 0.13
354	119	Duplicate ^b	1-May-13	21-Aug-13	4.0	1.38 ± 0.13
354	Break Rm	Sample	1-May-13	21-Aug-13	3.5	2.35 ± 0.16
356	118	Sample	1-May-13	21-Aug-13	6.0	1.67 ± 0.14
356	105	Sample	1-May-13	21-Aug-13	4.0	2.46 ± 0.17

^d E-PERM was moved during sampling, which invalidated measurement

Table 1. Radon Sampling Results (continued)

Building	Room	Type	Start Date	Stop Date	Avg. Gamma Background (μR/h)	Radon Conc. ± Uncertainty (pCi/L)
360	130	Sample	1-May-13	21-Aug-13	4.0	1.24 ± 0.13
360	127	Sample	1-May-13	21-Aug-13	4.0	2.22 ± 0.16
360	127	Blank	1-May-13	21-Aug-13	4.0	<LLD ^d
360	123	Sample	1-May-13	21-Aug-13	6.0	1.43 ± 0.13
360	137	Sample	1-May-13	21-Aug-13	6.5	1.43 ± 0.13
360	122	Sample	1-May-13	21-Aug-13	4.0	1.34 ± 0.13
360	141	Sample	1-May-13	21-Aug-13	6.5	1.12 ± 0.12
360	116	Sample	1-May-13	21-Aug-13	5.0	1.37 ± 0.13
360	112	Sample	1-May-13	21-Aug-13	5.0	1.36 ± 0.13
360	112	Duplicate ^b	1-May-13	21-Aug-13	5.0	1.35 ± 0.13
360	108	Sample	1-May-13	21-Aug-13	4.0	1.29 ± 0.13
360	106	Sample	1-May-13	21-Aug-13	6.0	1.12 ± 0.12
404	105	Sample	1-May-13	21-Aug-13	5.5	1.41 ± 0.13
404	108	Sample	1-May-13	21-Aug-13	5.5	1.60 ± 0.14
404	108	Duplicate ^b	1-May-13	21-Aug-13	5.5	1.60 ± 0.14
404	125	Sample	1-May-13	21-Aug-13	5.0	1.62 ± 0.14
404	118	Sample	1-May-13	21-Aug-13	5.5	1.69 ± 0.14
410	Break Rm	Sample	1-May-13	21-Aug-13	7.5	2.35 ± 0.16
471	Chp Office	Sample	3-May-13	22-Aug-13	4.5	2.10 ± 0.16
471	Chp Office	Blank	3-May-13	22-Aug-13	4.5	<LLD ^d
475	5112	Sample	1-May-13	21-Aug-13	6.5	1.51 ± 0.13
475	5112	Blank	1-May-13	21-Aug-13	6.5	<LLD ^d
475	5118	Sample	1-May-13	21-Aug-13	4.5	1.53 ± 0.13
476	6107	Sample	1-May-13	21-Aug-13	7.0	1.59 ± 0.14
476	Locker Rm	Sample	1-May-13	21-Aug-13	3.5	1.58 ± 0.14
477	7111	Sample	1-May-13	21-Aug-13	3.0	1.32 ± 0.13
477	7112	Sample	1-May-13	21-Aug-13	6.5	1.31 ± 0.13
477	Break Rm	Sample	2-May-13	20-Aug-13	5.0	1.86 ± 0.15
478	8133	Sample	1-May-13	21-Aug-13	4.0	3.22 ± 0.20
560	4	Sample	1-May-13	21-Aug-13	6.0	2.17 ± 0.16
702	117	Sample	2-May-13	20-Aug-13	6.5	1.32 ± 0.13
702	109	Sample	2-May-13	20-Aug-13	4.0	1.13 ± 0.12
706	Conf Rm	Sample	2-May-13	20-Aug-13	5.0	1.70 ± 0.14
706	Conf Rm	Duplicate ^b	2-May-13	20-Aug-13	5.0	1.72 ± 0.14
706	Sleep Qtrs	Sample	2-May-13	20-Aug-13	6.5	1.26 ± 0.13
716	Lrng Ctr	Sample	2-May-13	20-Aug-13	8.5	1.39 ± 0.13
736	Office Rm	Sample	2-May-13	20-Aug-13	4.0	1.11 ± 0.12

Table 1. Radon Sampling Results (concluded)

Building	Room	Type	Start Date	Stop Date	Avg. Gamma Background (μR/h)	Radon Conc. ± Uncertainty (pCi/L)
873	Comm Rm	Sample	2-May-13	20-Aug-13	4.0	1.24 ± 0.13
874	Office Rm 2	Sample	2-May-13	20-Aug-13	4.5	1.51 ± 0.13

b. *SPER-1 Voltage Reader Response Check Results:* The SPER-1 voltage reader was verified for proper operation using reference electrets with a predetermined voltage calibrated by the manufacturer. Voltages of reference electrets were verified prior to the deployment of survey electrets and prior to the final voltage readings of survey electrets. All reference electret voltages were within allowable limits, as seen in Table 2.

Table 2. SPER-1 Voltage Reader Response Check Results

Date	Voltage Reading with Ref Electret “Zero”	Voltage Reading with Ref Electret	Allowable Range	Voltage Reading with Ref Electret	Allowable Range
1-May-13	0	238 (RE3921)	235-241	257 (RE4098)	254-260
20-Aug-13	0	256 (RE4163)	253-259	257 (RE4248)	256-262

4. DISCUSSION:

a. The relative percent difference measures the precision of the results between a survey sample and the associated duplicate. RPD goals are established for measurements greater than 4 pCi/L, and therefore exceed the action limit of 4 pCi/L. Since no duplicate sample exceeded this concentration, statistical interpretation of RPD is not applicable.

b. Two samplers were invalidated during the assessment. Both were moved from their initial monitoring location over the survey period. In accordance with recommended guidelines, samplers that are moved may be invalidated. In addition, there is evidence that one monitor was tampered with and the charged Teflon disk discharged, indicated by a sharp decrease in voltage.

5. CONCLUSIONS AND RECOMMENDATIONS:

a. All 46 facilities tested had radon concentrations below the action limit of 4 pCi/L; no radon mitigation is required.

b. Any new structures at Homestead ARB should be tested in accordance with AFI 48-148. Please allow 1 year of foundation settling before testing these facilities.

6. If you have any further questions regarding this report, please contact SSgt Michael Ames at DSN 798-3411, commercial 937-938-3411, or michael.ames.2@us.af.mil.

A handwritten signature in black ink, reading "Brian D. Shuler". The signature is written in a cursive style with a horizontal line extending to the right.

BRIAN D. SHULER, Capt, USAF, BSC
Chief, Radiation Health Consulting Branch

Attachment:
Instrument Calibration Certificates

**Attachment
Instrument Calibration Certificates**



Rad Elec Inc.

www.radelec.com

5716-A Industry Lane
Frederick, MD 21704 USA
Ph: 301-694-0011 Fax: 301-694-0013

SPER-1 READER CALIBRATION CERTIFICATE

Calibration Date: *04/02/13*

Next Calibration Due: *04/02/14*

Reader Serial Number: *E0361*

Reference Instrument: Fluke 189, Serial No. 91920602

Calibration Conditions: Temperature: *75°* Relative Humidity: *24%*

NIST Traceable Voltage Source <u>Volts</u>	Pre-calibration Readings <u>Volts</u>	Post-calibration Readings <u>Volts</u>
000	<i>0</i>	<i>-0</i>
250	<i>252</i>	<i>250</i>
350	<i>352</i>	<i>350</i>
450	<i>453</i>	<i>450</i>
550	<i>553</i>	<i>550</i>
650	<i>653</i>	<i>650</i>
750	<i>754</i>	<i>750</i>

Rad Elec Inc. certifies that the above Sper-1 Reader, s/n *E0361*, has been calibrated using a reference instrument whose accuracies are traceable to the National Institute of Standards and Technology. This reader meets Rad Elec Inc.'s QA/QC Standards to an accuracy of + or - 1 volt, as specified in the E-PERM® System Manual.

Certifying Technician: *John Davis*

Date: *04/02/13*



Rad Elec Inc.

5716-A Industry Lane
Frederick, MD 21704 USA
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**CERTIFIED READINGS OF REFERENCE
ELECTRETS**

ELECTRET SERIAL NUMBER	DATE CERTIFIED	READING VOLTS	SPER-1 READER #
<i>RE3921</i>	<i>4/2/13</i>	<i>238</i>	<i>E0361</i>
<i>RE4098</i>	<i>4/2/13</i>	<i>257</i>	<i>E0361</i>

Reference Electrets read and certified by:

Rad Elec Inc.

4/2/13

Next Calibration Due Date: 4/2/14



Rad Elec Inc.

www.radelec.com

5716-A Industry Lane

Frederick, MD 21704 USA

Ph: 301-694-0011 Fax: 301-694-0013

SPER-1 READER CALIBRATION CERTIFICATE

Calibration Date: *05/16/13*

Next Calibration Due: *05/16/14*

Reader Serial Number: *E0384*

Reference Instrument: Fluke 189, Serial No. 91920602

Calibration Conditions: Temperature: *75°* Relative Humidity: *35%*

NIST Traceable Voltage Source <u>Volts</u>	Pre-calibration Readings <u>Volts</u>	Post-calibration Readings <u>Volts</u>
000	<i>0</i>	<i>-0</i>
250	<i>250</i>	<i>250</i>
350	<i>350</i>	<i>350</i>
450	<i>450</i>	<i>450</i>
550	<i>550</i>	<i>550</i>
650	<i>650</i>	<i>650</i>
750	<i>749</i>	<i>750</i>

Rad Elec Inc. certifies that the above Sper-1 Reader, s/n *E0384*, has been calibrated using a reference instrument whose accuracies are traceable to the National Institute of Standards and Technology. This reader meets Rad Elec Inc.'s QA/QC Standards to an accuracy of + or - 1 volt, as specified in the E-PERM® System Manual.

Certifying Technician: *John Davis*

Date: *05/16/13*



Rad Elec Inc.

5716-A Industry Lane
Frederick, MD 21704 USA
(800) 526-5482 (301) 694-0011
Fax (301) 694-0013
www.radelec.com

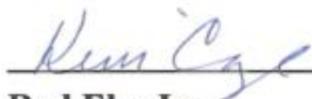
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CERTIFIED READINGS OF REFERENCE

ELECTRETS

ELECTRET #	DATE	READING VOLTS	SPER-1 READER #
RE4163	5/16/13	256	E0384
RE4248	5/16/13	259	E0384

Reference Electrets read and certified by:



Rad Elec Inc.

5/16/13

Next Calibration Due Date: 5/16/14

AIR FORCE PRIMARY STANDARDS LABORATORY
CERTIFICATE OF CALIBRATION

Report Number: 123320180 **Department:** Photonics/Nucleonics **Date of Issue:** 20121129

Calibration Item:

Manufacturer: FLUKE BIOMEDICAL
Model/Part No.: 451P SERIES
Equipment Type: ION CHAMBER SURVEY METER

Equipment Submitted by:

88 MSG/LGRMD
5060 PEARSON ROAD
WRIGHT PATTERSON AFB, OH, 45433-5517

Serial Number: 000003885
ID Number: F162863

Item Condition:

As Received: IN-TOLERANCE
The measured values of all parameters tested or calibrated were found to be within specification limits.

As Returned: IN-TOLERANCE
Item was calibrated and returned in-tolerance. This includes TO directed limitations.

Room Ambient Conditions:

Temperature: 73 °F Relative Humidity: 36 % Barometric Pressure: N/A

Remarks:

Traceability: Measurement standards and test equipment used are traceable to the International System of Units (SI) through the National Institute of Standards and Technology, to the extent allowed by the Institute's calibration facilities; or to other National Metrology Institutes (NMI); or have been derived from accepted values of natural physical constants; or mutual consent standards; or have been derived by the ratio or reciprocity type measurement techniques.

General Conditions:

1. The standards and calibration program of the AFPSL, as operated by The Bionetics Corporation, Newark Metrology Operations, complies with the requirements of the current version of ISO/IEC 17025 on the date of calibration.
2. This report may not be reproduced, except in full, without written approval of The Bionetics Corporation, Newark Metrology Operations.

Calibrated By:

Chris Morris **Metrology Technician**

Approved By:

Donald M. Hayes **Lead Metrology Technician**



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813 Irving-Wick Drive West, Heath, Ohio 43056-6118 TEL: (740) 788-5400 FAX: (740) 788-5404

Report Number: 123320180
Date of Issue: 20121129
Model/Part No.: 451P SERIES
Serial Number: 0000003885

Procedures and Equipment Used

PROCEDURES

Procedure
33K7-4-93-1

Date
30 Nov 2003

EQUIPMENT

Nomenclature
CESIUM-137 STANDARD

Model/Part No.
81-10

ID No.
P71063

NIST Report No.
N/A

Cal Due Date
20151010

The reported value(s) and uncertainties resulting from the measurement process are:

Report of Measurement

Range mR/hr	Applied mR/hr	T.I. Reading mR/hr
0 - 0.5	0.4	0.398
0 - 5	1.0	0.96
0 - 5	4.0	3.9
0 - 50	10.0	9.9
0 - 50	40.0	39.3
0 - 500	100	100
0 - 500	400	390
R/hr	R/hr	R/hr
0 - 5	1.0	0.98
0 - 5	4.0	4.16

- The instrument calibration results are accurate to within $\pm 10\%$ of reading between 10 and 100% full scale on any range, exclusive of energy response.



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