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14. ABSTRACT A radon assessment of 42 buildings on Grissom ARB was performed to meet the monitoring requirements outlined in Air Force Instruction 48-148. Radon monitors were in place for a period of 91 days and then analyzed. All results were below the action level for radon.					
15. SUBJECT TERMS Radon, E-PERM, RAMP, Grissom					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 15	19a. NAME OF RESPONSIBLE PERSON TSgt Samuel Ortiz
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U			19b. TELEPHONE NUMBER (include area code)



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

28 November 2012

MEMORANDUM FOR 434 MSG/SGPB
1941 W. Mustang Avenue
Grissom ARB, IN 46971-5000

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

SUBJECT: Consultative Letter AFRL-SA-WP-CL-2012-0065, Radon Assessment of
Occupational Facilities, Grissom ARB, IN

1. INTRODUCTION:

a. *Purpose:* The U.S. Air Force School of Aerospace Medicine Consultative Services Division (USAFSAM/OEC) completed a radon assessment of occupational facilities during the time span from 28 June 2012 through 28 September 2012 at Grissom ARB to quantify radon exposures. This assessment was performed with the assistance of Mr. Jeffrey Castleberry, an Environmental Health Technician from Bioenvironmental Engineering. Grissom ARB was assessed originally under the Radon Assessment and Mitigation Program on 1 December 1987 through 22 October 1990 and was characterized as a medium risk base. A medium risk rating requires the monitoring of all newly constructed or acquired facilities. In addition, all buildings not identified under the Radon Assessment and Mitigation Program assessment shall be monitored. A summary of the radon assessment results can be found in Attachment 1.

b. *Equipment:*

- (1) Inovision 451P (serial number 212, calibrated 15 May 2012)
- (2) Rad Elec Inc. Electret Voltage Reader SPER-1 E (serial number E0385, calibrated 8 June 2012)
- (3) Rad Elec Inc. Reference Electrets (serial numbers RE4149 and RE4269, certified 8 June 2012)
- (4) Rad Elec Inc. Zero Electret

2. **METHODOLOGY:** The team from USAFSAM monitored 42 buildings. A complete listing of the buildings and associated rooms monitored is provided in Attachment 2. This radon assessment was performed in accordance with the Radiation Health Consulting Branch's Radon Quality Assurance Plan, Air Force Policy, and instructions (see listed references in para 2.a.). Facilities were tested using the E-PERM¹ system from Rad Elec Inc. The E-PERM system was configured with a standard chamber (S chamber) and long-term electret. The long-term 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 electret, causing a reduction of its surface charge. The reduction of the charge on the electret is measured using an electret voltage reader. The background gamma readings, measured with an Inovision 451P, and elevation are additional factors when measuring radon. These parameters were utilized when correcting radon data.

a. *References:*

- (1) AF Instruction (AFI) 48-148, *Ionizing Radiation Protection*, 21 September 2011
- (2) HQ USAF Policy Letter, *Implementation of the Radon Assessment and Mitigation Program (RAMP)*, 23 October 1987
- (3) Environmental Protection Agency (EPA) 402-R-92-004, *Indoor Radon and Radon Decay Product Measurement Device Protocols*, July 1992 (revised)
- (4) EPA 402-R-92-014, *Radon Measurements in Schools*, July 1993

b. *Measurement Device Protocols:* The following protocols were used when placing radon monitors in the occupational facilities. Specifically, the protocols outlined in EPA's 402-R-92-004 and 402-R-92-014 publications were used.

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

c. *Quality Assurance Program:* To ensure quality assurance and uphold the confidence in our assessment of Grissom 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.

¹ E-PERM = electret passive environmental radon monitor, which is identified by the EPA as an electret ion chamber.

- (2) Blanks: Ten field blanks were used during the Grissom ARB assessment. The average field blank reading was -0.71 picocuries per liter (pCi/L). Please see Attachment 3 for a full listing of field blanks.
- (3) Duplicates: Eighteen duplicates were used during the Grissom ARB assessment. Precision can be evaluated with duplicate analysis. Please see Attachment 3 for a full listing of duplicates and analysis.
- (4) Calibration Tests: Please see Attachment 4 for calibration certificates.

3. RESULTS: In total, 106 radon monitors were placed in 42 facilities at Grissom ARB for analysis and quality control. Out of the 106 radon monitors, 18 were used as duplicates and 10 were used as blanks. All radon monitors were below the remedial action level for radon of 4 pCi/L. Therefore, in accordance with AFI 48-148, no radon mitigation of facilities is necessary. In addition, all facilities were monitored as long-term tests except for one facility. Due to a renovation project in Bldg 597, long-term radon monitoring was ended early to avoid construction interference.

4. RECOMMENDATIONS AND CONCLUSIONS: All facilities of Grissom ARB meeting the criteria of AFI 48-148 were evaluated for radon as detailed in Attachment 2. Once renovation is complete in Bldg 597, please request additional radon monitors to conclude radon surveillance. To maintain compliance with AFI 48-148, please identify and monitor any newly constructed or acquired facilities after this assessment. Please allow 1 year of foundation settling before testing these facilities.

5. If you have any further questions regarding this report, please contact TSgt Samuel Ortiz at DSN 798-3410 or samuel.ortiz@wpafb.af.mil. Please direct any questions or comments regarding the Consultative Services Division's support to Lt Col David Sonntag at DSN 798-3328 or david.sonntag@wpafb.af.mil.



ALAN C. HALE, Maj, USAF, BSC
Chief, Radiation Health Consulting Branch

4 Attachments:

1. Summary of Results
2. Radon Sampling Results
3. Quality Control Checks
4. Calibration Certificates

Attachment 1 Summary of Results

Table: Summary

Building	Placed	Collected	Number Above 4 pCi/L	Highest Reading ² (pCi/L)	Action
209	4	4	0	3.68 ± 0.22	None
233	3	3	0	0.57 ± 0.11	None
394	1	1	0	1.17 ± 0.12	None
396	2	2	0	1.18 ± 0.12	None
420	3	3	0	0.84 ± 0.11	None
426	3	3	0	1.15 ± 0.12	None
427	3	3	0	0.68 ± 0.11	None
430	3	3	0	0.68 ± 0.11	None
431	3	3	0	0.73 ± 0.11	None
435	3	3	0	1.34 ± 0.13	None
436	2	2	0	0.89 ± 0.11	None
437	1	1	0	1.12 ± 0.12	None
438	2	2	0	0.41 ± 0.1	None
439	3	3	0	0.73 ± 0.11	None
443	1	1	0	1.29 ± 0.13	None
448	3	3	0	0.88 ± 0.12	None
453	2	2	0	0.76 ± 0.11	None
470	2	2	0	0.67 ± 0.11	None
471	1	1	0	1.13 ± 0.12	None
474	3	3	0	0.8 ± 0.11	None
563	2	2	0	0.54 ± 0.11	None
591	2	2	0	0.86 ± 0.11	None
592	3	3	0	1.33 ± 0.13	None
593	1	1	0	0.5 ± 0.11	None
595	3	3	0	0.75 ± 0.11	None
596	4	4	0	1.11 ± 0.12	None
597	3	3	0	1.35 ± 0.15	Resurvey ³
600	4	4	0	1.13 ± 0.12	None
639	2	2	0	2.19 ± 0.16	None

² The uncertainty or error is the plus/minus (±) value listed. There are three variables used to calculate the error. The first error is associated with radon monitor system imperfections and is calculated at 5%. The second error is based on the difference in voltage readings. The third error is calculated based on the accuracy of the background gamma measurement. Total error is based on the square root of the sum of these errors.

³ These units were pulled before the 91-day mark. To meet regulatory requirements, a resurvey should be accomplished.

Attachment 1 (cont'd)
Summary of Results

Building	Placed	Collected	Number Above 4 pCi/L	Highest Reading² (pCi/L)	Action
641	5	5	0	0.74 ± 0.11	None
648	3	3	0	1.1 ± 0.12	None
663	4	4	0	1.66 ± 0.14	None
667	3	3	0	0.74 ± 0.11	None
668	3	3	0	0.59 ± 0.11	None
669	3	3	0	1.46 ± 0.13	None
670	3	3	0	1.06 ± 0.12	None
671	3	3	0	0.76 ± 0.11	None
683	1	1	0	0.81 ± 0.11	None
688	1	1	0	1.51 ± 0.13	None
760	3	3	0	1.33 ± 0.13	None
762	1	1	0	0.63 ± 0.11	None
767	1	1	0	1.55 ± 0.14	None

Attachment 2 Radon Sampling Results

Table: Radon Sampling Results

Building	Room	Type	Start Date	Stop Date	Avg. Gamma Background ($\mu\text{R}/\text{h}^4$)	Radon Concentration (pCi/L)
209	26	Sample	29-Jun-12	28-Sep-12	9	1.07 ± 0.12
209	17	Sample	29-Jun-12	28-Sep-12	8	1.29 ± 0.13
209	17	Duplicate	29-Jun-12	28-Sep-12	8	0.91 ± 0.12
209	4	Sample	29-Jun-12	28-Sep-12	9.5	3.68 ± 0.22
233	1	Sample	28-Jun-12	27-Sep-12	9	0.57 ± 0.11
233	6	Sample	28-Jun-12	27-Sep-12	9	0.38 ± 0.1
233	1	Duplicate	28-Jun-12	27-Sep-12	9	0.44 ± 0.11
394	104	Sample	28-Jun-12	27-Sep-12	10.5	1.17 ± 0.12
396	113	Sample	28-Jun-12	27-Sep-12	10.5	1.18 ± 0.12
396	101	Sample	28-Jun-12	27-Sep-12	11	1.13 ± 0.12
420	101	Duplicate	28-Jun-12	28-Sep-12	10.5	0.27 ± 0.1
420	101	Sample	28-Jun-12	28-Sep-12	10.5	0.37 ± 0.1
420	122	Sample	29-Jun-12	28-Sep-12	9.5	0.84 ± 0.11
426	130	Sample	29-Jun-12	28-Sep-12	11	0.53 ± 0.11
426	130	Duplicate	29-Jun-12	28-Sep-12	11	1.15 ± 0.12
426	119	Sample	29-Jun-12	28-Sep-12	9.5	0.72 ± 0.11
427	1409	Sample	29-Jun-12	28-Sep-12	10	0.68 ± 0.11
427	1409	Blank	29-Jun-12	28-Sep-12	10	-1.0 ± 0.37
427	1101	Sample	29-Jun-12	28-Sep-12	8.5	0.67 ± 0.11
430	7	Blank	28-Jun-12	27-Sep-12	10	-0.87 ± 0.23
430	7	Sample	28-Jun-12	27-Sep-12	10	0.68 ± 0.11
430	BDOC	Sample	28-Jun-12	27-Sep-12	8	0.66 ± 0.11
431	1030	Sample	28-Jun-12	27-Sep-12	11	0.52 ± 0.11
431	1030	Blank	28-Jun-12	27-Sep-12	11	-1.02 ± 0.31
431	1006	Sample	28-Jun-12	27-Sep-12	10	0.73 ± 0.11
435	111	Sample	29-Jun-12	28-Sep-12	9.5	1.34 ± 0.13
435	111	Duplicate	29-Jun-12	28-Sep-12	9.5	0.79 ± 0.11
435	103	Sample	29-Jun-12	28-Sep-12	10.5	0.69 ± 0.11
436	1001	Duplicate	29-Jun-12	28-Sep-12	11	0.89 ± 0.11
436	1001	Sample	29-Jun-12	28-Sep-12	11	0.52 ± 0.11
437	100	Sample	29-Jun-12	28-Sep-12	9	1.12 ± 0.12
438	101	Sample	29-Jun-12	28-Sep-12	11.5	0.36 ± 0.1
438	104	Sample	29-Jun-12	28-Sep-12	12	0.41 ± 0.1
439	117	Sample	29-Jun-12	28-Sep-12	10	0.61 ± 0.11
439	117	Duplicate	29-Jun-12	28-Sep-12	10	0.73 ± 0.11
439	126	Sample	29-Jun-12	28-Sep-12	12	0.50 ± 0.11

⁴ $\mu\text{R}/\text{h}$ = micro roentgens per hour

Attachment 2 (cont'd)
Radon Sampling Results

Building	Room	Type	Start Date	Stop Date	Avg. Gamma Background ($\mu\text{R}/\text{h}^4$)	Radon Concentration (pCi/L)
443	1	Sample	28-Jun-12	27-Sep-12	11.5	1.29 ± 0.13
448	110	Sample	28-Jun-12	27-Sep-12	9	0.88 ± 0.12
448	102	Sample	28-Jun-12	27-Sep-12	10	0.48 ± 0.11
448	102	Blank	28-Jun-12	27-Sep-12	10	-0.94 ± 0.28
453	103	Sample	29-Jun-12	28-Sep-12	9	0.76 ± 0.11
453	103	Sample	29-Jun-12	28-Sep-12	10.5	0.50 ± 0.11
470	168	Sample	28-Jun-12	27-Sep-12	8.5	0.55 ± 0.11
470	168	Duplicate	28-Jun-12	27-Sep-12	8.5	0.67 ± 0.11
471	136	Sample	28-Jun-12	27-Sep-12	9	1.13 ± 0.12
474	116	Sample	28-Jun-12	27-Sep-12	8.5	0.80 ± 0.11
474	144	Duplicate	28-Jun-12	27-Sep-12	11	0.53 ± 0.11
474	144	Sample	28-Jun-12	27-Sep-12	11	0.52 ± 0.11
563	1007	Duplicate	28-Jun-12	27-Sep-12	11.5	0.47 ± 0.11
563	1007	Sample	28-Jun-12	27-Sep-12	11.5	0.54 ± 0.11
591	4	Blank	29-Jun-12	28-Sep-12	10	-0.69 ± 0.15
591	4	Sample	29-Jun-12	28-Sep-12	10	0.86 ± 0.11
592	7	Duplicate	29-Jun-12	28-Sep-12	11	0.77 ± 0.11
592	7	Sample	29-Jun-12	28-Sep-12	11	1.33 ± 0.13
592	17	Sample	29-Jun-12	28-Sep-12	9	0.82 ± 0.11
593	112	Sample	29-Jun-12	28-Sep-12	10.5	0.50 ± 0.11
595	120	Sample	29-Jun-12	28-Sep-12	10	0.67 ± 0.11
595	120	Blank	29-Jun-12	28-Sep-12	10	-0.57 ± 0.13
595	105	Sample	29-Jun-12	28-Sep-12	7	0.75 ± 0.11
596	115	Duplicate	29-Jun-12	28-Sep-12	10.5	0.88 ± 0.11
596	115	Sample	29-Jun-12	28-Sep-12	10.5	0.75 ± 0.11
596	102	Sample	29-Jun-12	28-Sep-12	8.5	1.11 ± 0.12
596	132	Sample	29-Jun-12	28-Sep-12	8.5	0.80 ± 0.11
597	15	Sample	29-Jun-12	21-Aug-12	5	1.2 ± 0.15
597	11	Blank	29-Jun-12	21-Aug-12	7	0.29 ± 0.11
597	11	Sample	29-Jun-12	21-Aug-12	7	1.35 ± 0.15
600	1109	Duplicate	29-Jun-12	28-Sep-12	10.5	0.50 ± 0.11
600	1109	Sample	29-Jun-12	28-Sep-12	10.5	0.70 ± 0.11
600	1124	Sample	29-Jun-12	28-Sep-12	10	0.61 ± 0.11
600	1412	Sample	29-Jun-12	28-Sep-12	9	1.13 ± 0.12
639	1	Sample	29-Jun-12	28-Sep-12	11	1.90 ± 0.15
639	28	Sample	29-Jun-12	28-Sep-12	9	2.19 ± 0.16
641	131	Sample	29-Jun-12	28-Sep-12	8.5	0.68 ± 0.11

Attachment 2 (cont'd)
Radon Sampling Results

Building	Room	Type	Start Date	Stop Date	Avg. Gamma Background ($\mu\text{R}/\text{h}^4$)	Radon Concentration (pCi/L)
641	131	Duplicate	29-Jun-12	28-Sep-12	8.5	0.56 ± 0.11
641	102	Sample	29-Jun-12	28-Sep-12	9	0.25 ± 0.1
641	212	Sample	29-Jun-12	28-Sep-12	8.5	0.74 ± 0.11
641	221	Sample	29-Jun-12	28-Sep-12	9.5	0.59 ± 0.11
648	107	Duplicate	28-Jun-12	27-Sep-12	9.5	0.53 ± 0.11
648	107	Sample	28-Jun-12	27-Sep-12	9.5	1.10 ± 0.12
648	132	Sample	28-Jun-12	27-Sep-12	10	0.72 ± 0.11
663	155	Duplicate	28-Jun-12	27-Sep-12	9	1.66 ± 0.14
663	155	Sample	28-Jun-12	27-Sep-12	9	1.24 ± 0.13
663	171	Sample	28-Jun-12	27-Sep-12	10	1.04 ± 0.12
663	101	Sample	28-Jun-12	27-Sep-12	9.5	1.64 ± 0.14
667	130	Sample	28-Jun-12	27-Sep-12	12	0.74 ± 0.11
667	110	Sample	28-Jun-12	27-Sep-12	10	0.74 ± 0.11
667	110	Blank	28-Jun-12	27-Sep-12	10	-0.75 ± 0.17
668	119	Sample	28-Jun-12	27-Sep-12	11.5	0.48 ± 0.11
668	103	Duplicate	28-Jun-12	27-Sep-12	9.5	0.59 ± 0.11
668	103	Sample	28-Jun-12	27-Sep-12	9.5	0.46 ± 0.11
669	62	Sample	28-Jun-12	27-Sep-12	10.5	0.75 ± 0.11
669	3	Sample	28-Jun-12	27-Sep-12	11	1.46 ± 0.13
669	25	Sample	28-Jun-12	27-Sep-12	9.5	0.65 ± 0.11
670	111	Sample	29-Jun-12	28-Sep-12	8.5	1.06 ± 0.12
670	111	Blank	29-Jun-12	28-Sep-12	8.5	-0.62 ± 0.15
670	129	Sample	29-Jun-12	28-Sep-12	9.5	0.90 ± 0.12
671	112	Duplicate	29-Jun-12	28-Sep-12	10	0.61 ± 0.11
671	112	Sample	29-Jun-12	28-Sep-12	10	0.61 ± 0.11
671	122	Sample	29-Jun-12	28-Sep-12	7.5	0.76 ± 0.11
683	3	Sample	28-Jun-12	27-Sep-12	9.5	0.81 ± 0.11
688	102	Sample	28-Jun-12	27-Sep-12	9.5	1.51 ± 0.13
760	108	Blank	29-Jun-12	28-Sep-12	11	-0.96 ± 0.25
760	108	Sample	29-Jun-12	28-Sep-12	11	1.33 ± 0.13
760	125	Sample	29-Jun-12	28-Sep-12	11	1.04 ± 0.12
762	303	Sample	29-Jun-12	28-Sep-12	10.5	0.63 ± 0.11
767	100	Sample	29-Jun-12	28-Sep-12	10.5	1.55 ± 0.14

Attachment 3 Quality Control Checks

Table 1: Field Blanks

Blank	Building	Electret	Start Date	Stop Date	Avg. Gamma Background (μR/h)	Reading (pCi/L)
1	427	LL2901	29 Jun 12	28 Sep 12	10	-1.0 ± 0.37
2	430	LT2153	28 Jun 12	27 Sep 12	10	-0.87 ± 0.23
3	431	LT2106	28 Jun 12	27 Sep 12	11	-1.02 ± 0.31
4	448	LT2042	28 Jun 12	27 Sep 12	10	-0.94 ± 0.28
5	591	LT2021	29 Jun 12	28 Sep 12	10	-0.69 ± 0.15
6	595	LT2187	29 Jun 12	28 Sep 12	10	-0.57 ± 0.13
7	597	LT2104	29 Jun 12	21 Aug 12	7	0.29 ± 0.11
8	667	LT2204	28 Jun 12	27 Sep 12	10	-0.75 ± 0.17
9	670	LT2125	29 Jun 12	28 Sep 12	8.5	-0.62 ± 0.15
10	760	LT2050	29 Jun 12	28 Sep 12	11	-0.96 ± 0.25

Table 2: Duplicates

Duplicate	Building	Room	Electret w/ Highest Conc.	pCi/L	Electret w/ Lowest Conc.	pCi/L	RPD ⁵
1	209	17	LT1989	1.29	LT2207	0.906	N/A
2	233	1	LT2033	0.573	LT2221	0.441	N/A
3	420	101	LT2188	0.367	LT3168	0.27	N/A
4	426	130	LT2054	1.149	LT1995	0.527	N/A
5	435	111	LT1988	1.344	LT2206	0.786	N/A
6	436	1001	LT1958	0.895	LT2031	0.523	N/A
7	439	117	LT2232	0.733	LT2064	0.609	N/A
8	470	168	LT1963	0.668	LT2040	0.554	N/A
9	474	144	LT2134	0.527	LT2179	0.522	N/A
10	563	1007	LT1980	0.539	LT1974	0.473	N/A
11	592	7	LT2056	1.334	LT2016	0.77	N/A
12	596	115	LT1987	0.879	LT1996	0.753	N/A
13	600	1109	LT2065	0.695	LT1977	0.504	N/A
14	641	131	LT1992	0.677	LT2146	0.555	N/A
15	648	107	LT2097	1.099	LT1997	0.528	N/A
16	663	155	LT2170	1.66	LT2201	1.244	N/A
17	668	103	LT2002	0.591	LT2022	0.462	N/A
18	671	112	LT1990	0.609	LT2114	0.608	N/A

⁵ RPD = The relative percent difference measures the precision of the results. All duplicates were below 2 pCi/L, and statistical analysis cannot be performed at this level.

Attachment 3 (cont'd)
Quality Control Checks

Table 3: Voltage Response Check

Date	Tech	Room Temp (°F)	Zero Reading	Voltage Reading (RE4149)	Allowable Range	Voltage Reading (RE4269)	Allowable Range
27 Jun 12	TSgt Ortiz	70	0	255	251 - 257	250	246 - 252
27 Sep 12	TSgt Ortiz	74	0	254	251 - 257	249	246 - 252
28 Sep 12	SSgt Lacombe	74	0	251	251 - 257	249	246 - 252

**Attachment 4
Calibration Certificates**

05687

AIR FORCE PRIMARY STANDARDS LABORATORY

CERTIFICATE OF CALIBRATION

Report Number: 121320033 **Department:** Photonics/Nucleonics **Date of Issue:** 20120515

Calibration Item:

Manufacturer: INOVISION
Model/Part No.: 481P SERIES
Equipment Type: ION CHAMBER SURVEY METER

Equipment Submitted by:

88 MSG/LGRMD
5080 PEARSON ROAD
WRIGHT PATTERSON AFB, OH, 45433-5517

Serial Number: 0000000212
ID Number: F284450

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 tolerances.

Room Ambient Conditions:

Temperature: 72 °F Relative Humidity: 45 % 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:

Curtis A. Brissette Metrology Technician



Approved By:

Donald M. Hayes Lead Metrology Technician



Phone: (740) 788-5451

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813 Irving-Wick Drive West, Heath, Ohio 43056-8118 TEL: (740) 788-5400 FAX: (740) 788-5404

Attachment 4 (cont'd)
Calibration Certificates

Report Number: 121320033
Date of Issue: 20120515
Model/Part No.: 451P SERIES
Serial Number: 0000000212

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.

P71064

NIST Report No.

N/A

Cal Due Date

20130602

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	0.41
0 - 5	1.0	0.94
0 - 5	4.0	3.79
0 - 50	10.0	9.9
0 - 50	40.0	38.6
0 - 500	100	99
0 - 500	400	391
R/hr	R/hr	R/hr
0 - 5	1.0	0.95
0 - 5	4.0	4.25

- 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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Rad Elec

Attachment 4 (cont'd) Calibration Certificates

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: 06/08/12

Reader Serial Number: E0385

Reference Instrument: Fluke 189, Serial No. 91920602

Calibration Conditions: Temperature: 74° Relative Humidity: 35%

NIST Traceable Voltage Source	Pre-calibration Readings	Post-calibration Readings
<u>Volts</u>	<u>Volts</u>	<u>Volts</u>
000	0	0
250	252	250
350	353	350
450	454	450
550	555	550
650	655	650
750	756	750

Rad Elec Inc. certifies that the above Sper-1 Reader, s/n E0385, 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: 06/08/12

**Rad Elec****Attachment 4 (cont'd)
Calibration Certificates**

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

**CERTIFIED READINGS OF REFERENCE
ELECTRETS**

ELECTRET SERIAL NUMBER	DATE	READING VOLTS	SPER-1 READER #
RE4149	6/8/12	254	E0385
RE4269	6/8/12	249	E0385

Reference Electrets read and certified by:

Rad Elec Inc.**6/8/2012**