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Figure-1

SHORT-TERM ELECTRET ION CHAMBER "BLIND" TESTING PROGRAM

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INTRODUCTION

In an attempt to assess the quality of radon measurement results provided to Pennsylvania residents a "blind" testing program was conducted on all currently certified users of short-term electret ion chambers. From June 2001 to January 2003 known radon exposures were carried out on 100 certified testing firms. Twelve separate exposures were performed with as few as one firm to as many as 20 firms devices being exposed at one time. Devices were exposed in both a radon chamber and a basement environment. Radon concentration, temperature, relative humidity, background gamma radiation, and elevation above sea level were measured and determined for each exposure. Participants success in this program required that all four submitted devices have a relative percent error of less than or equal to +/- 25 percent of the reference concentration.

All short-term electret ion chamber users in this study used products manufactured by Rad Elec, Inc. of Frederick, Maryland. The trade name of their product, E-PERM stands for Electret

Passive Environmental Radon Monitor. It was not determined during the study which participants used recharged electrets. At least several participants reported using recharged electrets.

Materials and Methods

All exposures were carried out in either the Wilkes University radon chamber or a Radon Division employee basement. The Wilkes chamber is a large walk in type chamber. It is computer controlled for radon concentration, temperature, and relative humidity. This chamber does not provide for radon progeny exposures. The basement environment was a typical ranch style house with a full, walkout basement. The house was maintained under closed-house conditions during all exposures. Radon concentration, temperature, relative humidity, and background gamma radiation were measured, but not controlled during these exposures. The background gamma radiation at both chamber and basement was approximately equal to the US Environmental Protection Agency (EPA) preferred value for Pennsylvania of 9 micro roentgens per hour. Although the elevation above sea level was determined and provided to all participants it was not necessary for calculations since it was well below the value where elevation corrections come into play. The elevation of both exposure locations was about 550 feet above sea level.
The Eberline RGM-3 was the primary instrument used to provide the reference radon concentration during exposures, however, on several occasions the Pylon AB-5 Passive Radon Detector using scintillation technology and the Alpha Guard PQ 2000PRO using ion chamber technology with digital signal processing were also used. The Eberline was previously calibrated at the Bowser-Morner radon chamber and the Pylon was calibrated by Radon Division staff and intercompared to the Eberline. The Alpha Guard was calibrated by the manufacturer, Genitron Instruments. Pylon scintillation cells, model 300A were used to take grab samples during the beginning and just prior to ending each exposure. The average from the four cells were compared to the continuous monitor result for that time period. These cells are calibrated at the EPA Las Vegas facility. A digital sling Psychrometer was used to check both temperature and relative humidity. The Ludlum Model 19 Micro R Meter was used for background gamma measurements. Finally, during all exposures a digital camera was used to document placement and position of open screw tops.

During all exposures Radon Division staff would place four of our short-term electret ion chambers. These devices would provide one additional backup to our continuous monitors as well as show us how well we are performing in these exposures.

Total integrated exposures ranged from 58 pCi/L-day to 17.7 pCi/L-day, which also corresponds to average voltage drops for short-term electrets in standard chambers of 125 to 42 volts, respectively. Additionally, these integrated exposures equate to 19.2 to 5.9 pCi/L. Exposure times ranged from three to five days, with most exposures at three days.

To evaluate participant results the relative percent error (RPE) of each submitted result was calculated. The RPE is the measured result minus the reference value divided by the reference value and multiplied by 100 to get percent. This value could be either positive or negative. The average relative percent error (ARPE) is the sum of the individual RPE's divided by four. The RPE of each submitted result must be less than or equal to +/- 25% to pass. The coefficient of variation (COV), the standard deviation divided by the mean of the group of four electrets was also calculated to estimate precision.

Participants were sent letters advising them to prepare four short-term electret ion chambers for exposure and have them mailed to our office during a certain week. The following week all devices for that exposure were placed in the radon environment for exposure. After exposure, devices were returned to participants via United Parcel Service with data showing exposure start and stop times, background gamma radiation, and elevation above sea level. Participants were required to report their results using their standard reporting form as usually supplied to their clients.

Results

From the total 100 participants 87 passed the initial round of testing, for an 87% pass rate and 13 participants failed during the initial rounds of testing, for a 13% fail rate. All participants who failed were required to investigate the reason(s) for the failure, provide the Radon Division in writing the results of the investigation and then send four additional devices for another round of exposures. During retesting all 13 initial failures produced passing results. Listed below are the results from the investigation of the participants who failed and why they think they failed. This list should not be considered a definitive list, but rather a best guess of possible causes of poor performance. Many participants were not absolutely sure what accounted for their poor performance.

- Electret not initially stabilized
- Electrets not initially stabilized
- SPER-1 reader recalibrated, modify nitrogen cleaning process to stay further away from electret surface during cleaning.
- Electret losing voltage, unstable
- Dust on chambers and electrets
- Could not determine any reason for failure
- Shipping through mail/ups, "extra handling"
- Due to recharged electrets
- Shipping and handling
- Dust on electrets. Bowser-Morner noted dust on chambers during a previous exposure.
- Problems with SPER-1 reader
- Investigated, but could not find any problem. Possible dust on electrets.

Table 1 shows participant ID codes, range of radon concentrations reported, average and one standard deviation for reported results, coefficient of variation, reference value, and the average relative percent error and one standard deviation. Highlighted rows show participants who failed initial test.

Table 1 shows that 53 participants produced ARPE's of less than 5 percent, 24 participants had ARPE's between five and ten percent, 14 participants had ARPE's between 10 and 20 percent, and eight participants had ARPE's greater than 20 percent. The grand average for all ARPE's plus/minus one standard deviation was 4.5 +/- 10%, and the grand average for all COV's was 5.5 +/- 6.4%. These values compare very favorably with the Third AARST Radon Measurement Intercomparison Exercise, August-September 2000, for short-term electret ion chamber devices, which reported a grand average ARPE of 5.9 +/- 5.5%, and a grand average COV of 6.6 +/- 5.3%. As a comparison all of the DEP Radon Division test results (n=12) had a grand average relative percent error of 0.5 +/- 5.9% and a grand average coefficient of variation of 3.2 +/- 1.3%.

An examination of the individual results from the 13 participants who failed the initial "blind" test shows that seven participants failed by only one result greater than the +/- 25% criteria, two participants failed with two results, three participants failed with three results and one participant had all four reported results greater than +/- 25 percent.

Figure 1 shows the distribution of the 100 participants average relative percent error plus or minus one standard deviation. This figure includes all passing and failing results. It does not include retest data.
Figure 2 shows the distribution of the 100 participants average relative percent error plus or minus one standard deviation. This figure now includes all initial passing results and retest results, all of which have passing scores. A comparison of Figures 1 and 2 shows the marked improvement in performance results after investigation and retesting.

Table 2 depicts the data in a different format in order to give a "grade" to individual participants. As already stated, for each result a relative percent error (RPE) was calculated and then from the four reported results and their RPE's an average relative percent error was also calculated. Additionally, from the four results the COV was also determined. Grades were established such that an A was given if both the absolute value (Abs) of the APRE and the COV were both less than five percent, a B was given if both were less than 10%, a C if both were less than 15%, a D if both were less than or equal to 25% and an F was given if either the Abs ARPE or COV was greater than 25%. Within each grade participants were also ranked by the sum of the APRE and the COV.

Discussion

A review of the exposures on the devices during this study show that the lowest cumulative exposure group was 17.7 pCi/L-day, which for the required two day exposure would equate to a radon concentration of 8.9 pCi/L. This would be a good concentration of exposure for the Pennsylvania testers since our statewide average is just about 8.0 pCi/L. However, this would not challenge the electret ion chambers at the EPA guideline of 4.0 pCi/L or at post-mitigation concentrations of well less than 4.0 pCi/L. It would be interesting to see if the devices could hold up to the high standards that they set throughout this study at these lower concentrations. As would be expected performance for any device will be less at the lower concentrations.

The US EPA Radon Measurement Proficiency Program collected data on pass/fail rates of all test devices that went through their proficiency program. Data collected from January 1, 1991 through July 8, 1997, is compiled for short-term electret ion chambers. The EPA data was broken down into test sets and test devices. For the electret ion chambers a set usually consisted of four devices. If one or more of the devices from the set failed that was considered a set failure. For the dates mentioned, EPA data showed that 77.7% of the sets (n=470) passed and 92.2% of the devices (n=2223) passed. This would compare with this study's 87% pass rate for sets (n=100) and a 94.3% pass rate for devices (n=400). The higher percentage pass rate for this study may reflect lessons learned and good practices incorporated and better attention to quality assurance procedures. The better attention to good QA procedures may be due to the fact that this state radon program performs regular inspections of testers and laboratories. The manufacturer has also made improvements over the years and has a commitment to high standards. The pass rates for individual devices showed very good agreement with EPA data.

An examination of the suspected reasons for poor results confirmed that, as required by protocol, stability checks on new electrets must be properly performed. Cleanliness must be maintained with all electrets, chambers, and even the reader, and as with all measurement methods adherence to both protocols and good QA procedures are absolutely critical. The failures also show that whereas most testers (87%) are making good measurements there are a few "out there" who are not. Finding these poor performers, having them investigate the reasons for their failure(s) and then retesting them may have been the greatest benefit of this blind study.

The analysis of all data from the initial rounds of testing show that the overall grand average of all 100 participants average relative percent error is 4.5 +/- 10% and that the coefficient of variation averaged 5.5 +/- 6.4%. This data is in very good agreement with the Third AARST Radon Measurement Intercomparison Exercise conducted during August-September 2000 at the Bowser-Morner radon chamber. Their average relative percent error for the group (n=12) of short-term electret ion chamber users averaged 5.9 +/- 5.5%, and their coefficient of variation averaged 6.6 +/- 5.3%. This close agreement would tend to suggest that this study was providing good reference radon values and that electret ion chamber users are continuing to provide very accurate and precise results. It is also interesting to compare the grand average ARPE's (0.5 +/- 5.9%) and COV's (3.2 +/- 1.3%) from the DEP Radon Division test data with the group as a whole. The most significant difference between these two data sets was that the DEP electrets did not go through the mail. They were placed and retrieved by Radon Division staff. It may be

expected that Radon Division staff would also be more "expert" in the use of electret ion chambers and make "better" measurements. If this is the case then industry as a whole could certainly also make better measurements.

Figure 1 shows that most testers produce accurate (<10% RPE) and precise results with a slight positive bias. The figure also shows that a few participants produce accurate but imprecise results and a few others produce inaccurate and imprecise results. The slight positive bias is due to the fact that it is much easier for the electret to lose rather than gain voltage, producing a slightly larger voltage differential and consequentially a higher radon concentration, relative to the reference value.

Conclusions

A blind testing program carried out on 100 state certified electret ion chamber users showed that most users are producing accurate and precise measurement results, and that, assuming protocols are followed can be used to make family health and remediation decisions. The electret ion chambers are continuing to show a history of being a very reliable test method and the users are continuing to show proficiency in their use. Where problems where found, investigation and retesting showed marked improvement in performance.

Performance testing for two-day exposures and at concentrations at or less than 4.0 pCi/L were not undertaken in this study and would be an interesting follow-up study.

This blind testing program greatly benefited the residents of the Commonwealth and the testers providing test results by helping to assure that measurement results were of the highest possible quality.

References

Jenkins, Phillip, Intercomparison 2000. The Third AARST Radon Measurement Intercomparison Exercise. Bowser-Morner, Inc., November 14, 2001.

US Environmental Protection Agency, National Radon Proficiency Program Cumulative Data, January 1, 1991 to July 8, 1997.

Table 1 - Individual Participant Results

ID Num.	Range	Avg. +/- s	COV(%)	RV	ARPE(%) +/-s
1	20.0 – 22.1	20.8 +/- 0.9	4.4	19.2	8.4 +/- 4.7
2	18.2-19.4	18.6 +/- 0.6	3.0	19.2	-3.0 +/- 2.9
3	19.8-20.7	20.4 +/- 0.4	2.1	19.2	6.0 +/- 2.3
4	19.2-20.4	19.9 +/- 0.5	2.6	19.2	3.4 +/- 2.7
5	19.0-20.3	19.6 +/- 0.6	3.1	19.2	1.8 +/- 4.7
6	19.4-20.2	19.8 +/- 0.4	1.9	19.2	2.9 +/- 1.9
DEP	20.2-20.8	20.4 +/- 0.3	1.4	19.2	6.4 +/- 1.5
8	12.3-12.4	12.3 +/-0.05	0.4	12.2	1.0 +/- 0.4
9	12.4-12.6	12.5 +/-0.09	0.7	12.2	2.3 +/- 0.8

10	11.7-12.3	12.1 +/-0.3	2.2	12.2	-1.2 +/- 2.2
DEP	11.9-12.9	12.4 +/- 0.4	3.3	12.2	1.4 +/- 3.4
11	12.2-12.9	12.7 +/- 0.3	0.9	12.2	4.9+/- 0.9
12	12.3-13.0	12.7 +/- 0.3	2.4	12.2	3.9 +/- 2.5
13	11.4-12.3	11.9 +/- 0.4	3.1	12.2	-2.5 +/- 3.1
14	9.6-10.9	10.5 +/- 0.6	5.7	10.1	3.4 +/- 6.0
15	9.7-10.3	10.1 +/- 0.3	6.3	10.1	3.5 +/- 6.5
16	10.6-13.0	11.7 +/- 1.3	10.8	10.1	15.6 +/- 12.4
17	10.7-11.3	11.0 +/- 0.3	3.1	10.1	8.9 +/- 3.5
18	10.5-17.0	12.3 +/- 3.2	25.8	10.1	21.2 +/- 31.3
19	10.1-10.2	10.2 +/- 0.06	0.6	10.1	0.5 +/- 0.6
20	10.3-10.9	10.5 +/- 0.3	2.7	10.1	4.2 +/- 2.8
21	9.6-11.8	10.9 +/- 1.0	9.2	10.1	7.4 +/- 9.9
22	10.8-11.4	11.1 +/- 0.3	2.3	10.1	9.9 +/- 2.6
23	10.4-10.9	10.7 +/- 0.2	2.0	10.1	5.9 +/- 2.1
24	10.4-12.3	11.2 +/- 0.9	8.1	10.1	10.6 +/- 8.9
DEP	9.6-10.7	10.3 +/- 0.5	4.8	10.1	1.7 +/- 4.9
25	8.0-8.3	8.2 +/- 0.1	1.6	8.2	-0.6 +/- 1.5
26	8.5-8.9	8.8 +/- 0.4	4.1	8.2	7.5 +/- 4.4
27	10.0-10.6	10.4 +/- 0.3	2.7	8.2	26.8 +/- 3.4
28	8.7-9.4	9.0 +/- 0.3	3.3	8.2	10.0 +/- 3.6
29	7.6-10.0	8.4 +/- 1.1	13.0	8.2	2.1 +/- 13.4
30	8.2-8.6	8.5 +/- 0.2	2.2	8.2	3.3 +/- 2.3
31	6.0-6.6	6.4 +/- 0.3	4.4	8.2	-22.0 +/- 3.4
32	8.2-9.6	9.1 +/- 0.6	6.7	8.2	10.6 +/- 7.4
33	7.1-8.3	7.7 +/- 0.5	6.3	8.2	-6.1 +/- 8.1
34	7.7-7.4	7.2 +/- 0.1	1.7	8.2	-12.0 +/- 1.5
35	7.5-9.3	8.6 +/- 0.8	9.2	8.2	9.2 +/- 9.6
DEP	7.9-8.5	8.1 +/- 0.3	3.2	8.2	-1.0 +/- 3.2
36	8.5-9.9	9.4 +/- 0.6	6.9	8.3	12.6 +/- 7.7
37	9.0-9.1	9.0 +/- 0.05	0.6	8.3	8.7 +/- 0.6

Table 1 - Continued

ID Num.	Range	Avg. /- 1 s	COV (%)	RV	ARPE (%) +/- s
38	8.0-15.7	12.6 +/- 3.3	26.0	8.3	51.0 +/- 36.2
39	8.4-8.7	8.5 +/- 0.2	1.8	8.3	2.4 +/- 1.8
40	9.0-10.0	9.4 +/- 0.5	4.8	8.3	12.9 +/- 5.4
DEP	8.4-8.9	8.7 +/- 0.2	2.7	8.3	5.1 +/- 2.8
41	4.2-18.6	11.1 +/- 5.9	53.0	10.6	4.7 +/- 55.6
42	10.6-12.9	11.9 +/- 1.0	8.7	10.6	11.6 +/- 9.7
43	11.6-13.2	12.1 +/- 0.7	6.0	10.6	14.3 +/- 6.8

44	10.4-11.1	10.7 +/- 0.4	3.3	10.6	0.9 +/- 3.3
45	10.5-11.2	10.8 +/- 0.3	2.9	10.6	1.6 +/- 2.9
46	11.4-13.4	12.1 +/- 0.9	7.6	10.6	13.9 +/- 8.7
47	10.9-12.2	11.9 +/- 0.7	6.0	10.6	12.4 +/- 6.9
48	10.6-12.1	11.3 +/- 0.6	5.5	10.6	6.4 +/- 5.9
49	9.8-13.8	11.5 +/- 1.7	15.3	10.6	8.5 +/- 16.6
50	10.8-15.6	13.8 +/- 2.1	15.8	10.6	30.2 +/- 20.5
51	12.3-13.9	13.2 +/- 0.7	5.0	10.6	24.2 +/- 6.2
DEP	10.9-11.4	11.2 +/- 0.2	2.0	10.6	5.8 +/- 2.2
52	15.4-20.2	17.3 +/- 2.1	11.9	16.3	6.3 +/- 12.6
53	16.0-16.2	16.2 /- 0.1	0.6	16.3	-0.9 +/- 0.6
54	16.3-17.2	16.6 +/- 0.4	2.4	16.3	2.0 +/- 2.4
55	16.4-17.0	16.6 +/- 0.3	1.6	16.3	2.0 +/- 2.2
56	16.7-19.5	17.6 +/- 1.3	7.3	16.3	8.0 +/- 7.8
57	16.3-19.1	17.0 +/- 1.4	7.9	16.3	4.8 +/- 8.3
58	14.6-16.3	15.6 +/- 0.7	4.8	16.3	-3.8 +/- 4.5
59	16.6-19.9	18.1 +/- 1.4	7.6	16.3	10.9 +/- 8.5
60	16.4-17.3	16.8 +/- 0.5	3.2	16.3	2.8 +/- 3.2
61	16.5-18.6	17.0 +/- 1.1	6.2	16.3	4.4 +/- 6.4
62	16.2 -18.1	16.8 +/- 0.9	5.3	16.3	2.9 +/- 5.4
63	15.0-16.9	16.2 +/- 0.8	5.1	16.3	-0.8 +/- 5.1
64	16.2-17.0	16.6 +/- 0.3	2.0	16.3	1.8 +/- 2.0
65	16.3-18.6	17.1 +/- 1.0	6.0	16.3	5.1 +/- 6.3
DEP	14.7-17.3	16.1 +/- 1.0	6.3	16.3	-1.1 +/- 6.2
66	5.9-7.6	6.9 +/- 0.7	10.4	7.4	-7.5 +/- 9.7
67	6.2-9.5	7.4 +/- 1.4	19.7	7.4	-0.4 +/- 19.6
DEP	6.0-6.5	6.2 +/- 0.2	3.5	7.4	-16.2 +/- 2.9
68	15.9-17.2	16.6 +/- 0.5	3.3	15.7	5.8 +/- 3.5
69	14.7-15.4	15.1 +/- 0.4	2.3	15.7	-4.1 +/- 2.2
70	17.4-23.9	18.9 +/- 3.4	17.9	15.7	20.0 +/- 21.5
71	16.1-17.5	16.8 +/- 0.6	3.4	15.7	7.0 +/- 3.7
72	15.6-16.2	15.9 +/- 0.3	1.6	15.7	1.3 +/- 1.6

Table 1 - Continued

ID Num.	Range	Avg. +/- 1s	COV (%)	RV	ARPE (%) +/- s
73	15.1-15.9	15.7 +/- 0.7	4.4	15.7	0.0 +/- 4.4
74	16.5-16.8	16.7 +/- 0.1	0.8	15.7	6.4 +/- 0.9
75	14.9-18.2	16.3 +/- 1.5	9.0	15.7	3.5 +/- 9.3
76	15.5-17.4	16.2 +/- 0.9	5.5	15.7	3.7 +/- 5.7
77	15.2-15.4	15.4 +/- 0.1	0.8	15.7	-2.2 +/- 0.8

78	14.5-15.7	15.1 +/- 0.5	3.5	15.7	-3.3 +/- 3.4
79	14.9-16.0	15.6 +/- 0.5	3.1	15.7	-0.8 +/- 3.1
DEP	15.5-16.3	15.8 +/- 0.3	2.2	15.7	0.8 +/- 2.1
80	15.8-17.5	16.5 +/- 0.7	4.5	15.7	4.9 +/- 4.7
81	15.0-18.7	16.1 +/- 1.7	10.8	15.7	2.6 +/- 11.1
82	14.2-15.1	14.8 +/- 0.4	2.7	15.7	-6.1 +/- 2.6
83	15.7-16.4	16.1 +/- 0.3	1.9	15.7	2.3 +/- 2.0
84	15.2-16.5	15.9 +/- 0.7	4.2	15.7	1.4 +/- 4.3
85	15.9-16.8	16.3 +/- 0.4	2.3	15.7	3.8 +/- 2.4
86	13.9-16.3	15.0 +/- 1.0	6.7	9.4	59.9 +/- 10.6
87	9.6-10.6	10.2 +/- 0.4	4.1	9.4	8.0 +/- 4.5
DEP	9.4-10.1	9.6 +/- 0.3	3.3	9.4	2.4 +/- 3.3
88	5.8-6.1	6.0 +/- 0.1	2.2	5.9	0.9 +/- 1.4
89	5.9-6.2	6.0 +/- 0.2	2.5	5.9	1.3 +/- 2.5
90	5.9-6.3	6.3 +/- 0.4	6.2	5.9	6.4 +/- 6.5
91	5.0-5.9	5.6 +/- 0.4	7.1	5.9	-5.5 +/- 6.7
92	5.3-5.8	5.5 +/- 0.2	4.1	5.9	-7.2 +/- 3.7
93	5.5-5.9	5.7 +/- 0.2	3.1	5.9	-4.3 +/- 2.9
94	5.9-6.5	6.2 +/- 0.3	4.2	5.9	5.1 +/- 4.3
95	5.1-5.4	5.3 +/- 0.2	3.3	5.9	-11.0 +/- 2.9
96	5.8-6.1	5.9 +/- 0.1	2.1	5.9	0.4 +/- 2.1
97	5.8-6.1	5.9 +/- 0.2	3.2	5.9	-3.4 +/- 3.1
98	5.6-6.0	5.7 +/- 0.3	4.7	5.9	-0.4 +/- 4.6
99	6.2-6.8	6.5 +/- 0.3	3.9	5.9	10.1 +/- 4.3
100	5.8-6.2	5.9 +/- 0.2	3.2	5.9	0.4 +/- 3.2
101	5.4-6.1	5.7 +/- 0.3	5.5	5.9	-3.8 +/- 5.2
DEP	5.5-5.9	5.8 +/- 0.2	3.3	5.9	-2.1 /- 3.2

Table 2 - Results ranked by score

Score	ID Num.	ARPE (%)	COV	Sum	Retest (**)
A	19	0.5	0.6	1.1	
A	8	1	0.4	1.4	

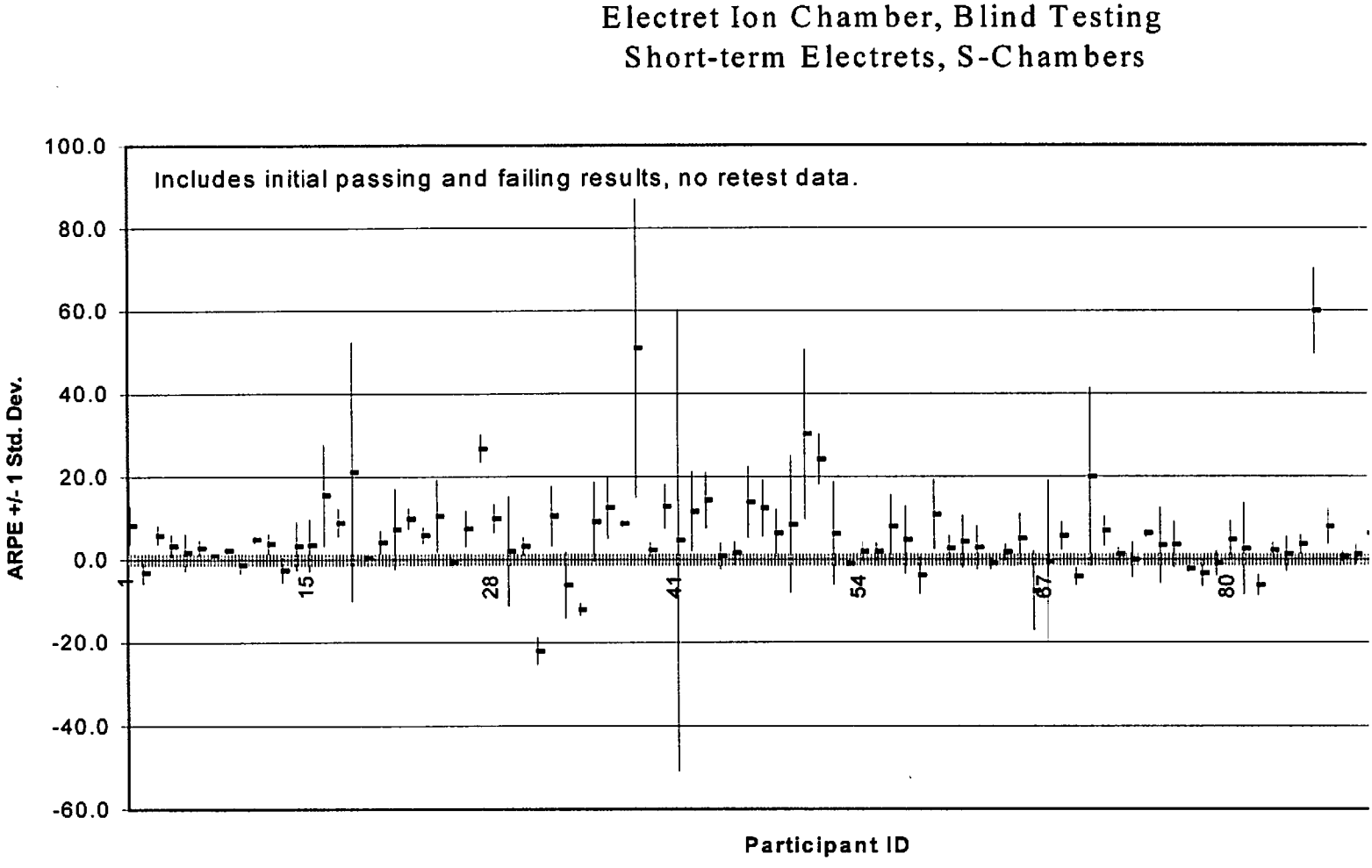
A	53	0.9	0.6	1.5	
A	50	1.2	0.5	1.7	**
A	25	0.6	1.6	2.2	
A	96	0.4	2.1	2.5	
A	72	1.3	1.6	2.9	
A	9	2.3	0.7	3	
A	77	2.2	0.8	3	
A	88	0.9	2.2	3.1	
A	10	1.2	2.2	3.4	
A	55	2	1.6	3.6	
A	100	0.4	3.2	3.6	
A	51	2.9	0.9	3.8	**
A	64	1.8	2	3.8	
A	89	1.3	2.5	3.8	
A	79	0.8	3.1	3.9	
A	83	2.3	1.9	4.2	
A	39	2.4	1.8	4.2	
A	44	0.9	3.3	4.2	
A	49	0.5	3.9	4.4	**
A	54	2	2.4	4.4	
A	73	0	4.4	4.4	
A	45	1.6	2.9	4.5	
A	67	1.6	3.1	4.7	**
A	6	2.9	1.9	4.8	
A	5	1.8	3.1	4.9	
A	98	0.4	4.7	5.1	
A	30	3.3	2.2	5.5	
A	86	3	2.5	5.5	**
A	13	2.5	3.1	5.6	
A	84	1.4	4.2	5.6	
A	11	4.9	0.9	5.8	
A	63	0.8	5.1	5.9	
A	2	3	3	6.0	
Score	ID Num.	| ARPE | (%)	**COV**	**Sum**	**Retest (**)**

A	4	3.4	2.6	6.0	
A	60	2.8	3.2	6.0	
A	85	3.8	2.3	6.1	
A	12	3.9	2.4	6.3	
A	69	4.1	2.3	6.4	
A	97	3.4	3.2	6.6	
A	78	3.3	3.5	6.8	
A	20	4.2	2.7	6.9	
A	93	4.3	3.1	7.4	
A	80	4.9	4.5	9.4	
B	74	6.4	0.8	7.2	
B	23	5.9	2.0	7.9	
B	3	6.0	2.1	8.1	
B	62	2.9	5.3	8.2	
B	58	3.8	4.8	8.6	
B	82	6.1	2.7	8.8	
B	14	3.4	5.7	9.1	
B	68	5.8	3.3	9.1	
B	76	3.7	5.5	9.2	
B	37	8.7	0.6	9.3	
B	94	5.1	4.2	9.3	
B	101	3.8	5.5	9.3	
B	41	5.7	3.7	9.4	**
B	15	3.5	6.3	9.8	
B	18	8.4	2.0	10.4	**
B	71	7.0	3.4	10.4	
B	61	4.4	6.2	10.6	
B	65	5.1	6.0	11.1	
B	92	7.2	4.1	11.3	
B	16	8.7	2.7	11.4	**
B	26	7.5	4.1	11.6	
B	48	6.4	5.5	11.9	
B	17	8.9	3.1	12.0	
B	31	8.7	3.3	12.0	**
B	87	8.0	4.1	12.1	
Score	**ID Num.**	**ARPE (%)**	**COV**	**Sum**	**Retest**

					(**)
B	22	9.9	2.3	12.2	
B	33	6.1	6.3	12.4	
B	75	3.5	9.0	12.5	
B	91	5.5	7.1	12.6	
B	90	6.4	6.2	12.6	
B	57	4.8	7.9	12.7	
B	1	8.4	4.4	12.8	
B	38	9.4	4.4	13.8	**
B	56	8.0	7.3	15.3	
B	21	7.4	9.2	16.6	
B	35	9.2	9.2	18.4	
C	28	10.0	3.3	13.3	
C	81	2.6	10.8	13.4	
C	34	12.0	1.7	13.7	
C	99	10.1	3.9	14.0	
C	95	11.0	3.3	14.3	
C	29	2.1	13.0	15.1	
C	56	8.0	7.3	15.3	
C	32	10.6	6.7	17.3	
C	40	12.9	4.8	17.7	
C	66	7.5	10.4	17.9	
C	52	6.2	11.9	18.1	
C	47	12.4	6.0	18.4	
C	59	10.9	7.6	18.5	
C	24	10.6	8.1	18.7	
C	46	13.9	5.0	18.9	**
C	36	12.6	6.9	19.5	
C	42	11.6	8.7	20.3	
C	43	14.3	6.0	20.3	
C	46	13.9	7.6	21.5	
D	27	15.9	1.5	17.4	**
D	67	0.4	19.7	20.1	
D	70	15.3	5.6	20.9	
D	49	8.5	15.3	23.8	

Score	ID Num.	ARPE (%)	COV	Sum	Retest (**)
D	16	15.6	10.8	26.4	
D	31	22.0	4.4	26.4	
D	51	24.2	5.0	29.2	
D	70	20.0	17.9	37.9	
F	27	26.8	2.7	29.5	
F	50	30.2	15.8	46.0	
F	18	21.2	25.8	47.0	
F	41	4.7	53.0	57.7	
F	86	59.9	6.7	66.6	
F	38	51.0	26.0	77.0	

Fi


Electret Ion Chamber, Blind Testing
Short-term Electrets, S-Chambers
Includes initial passing and failing results, no retest data.
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
-40.0
-60.0
ARPE +/- 1 Std. Dev.
1
15
28
41
54
67
80
Participant ID

gure 1

Figure 2

Electret Ion Chamber, Blind Testing
Short-term Electrets, S-Chambers

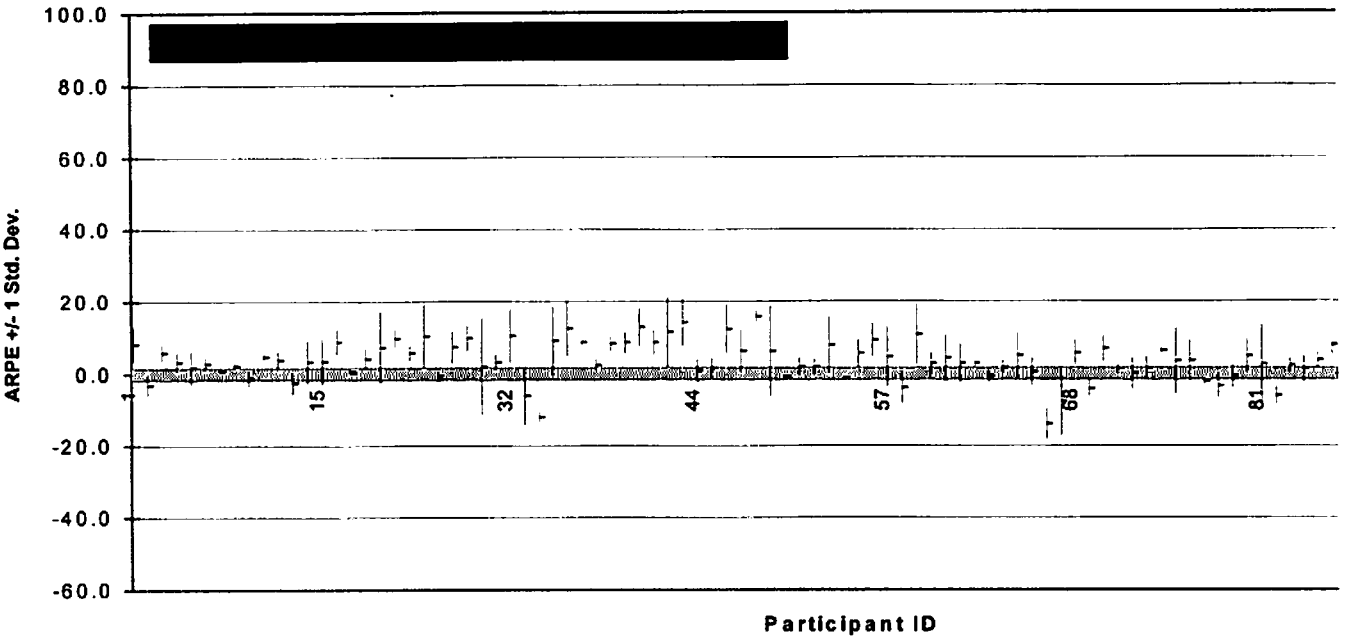


Figure 1

Electret Ion Chamber, Blind Testing
Short-term Electrets, S-Chambers

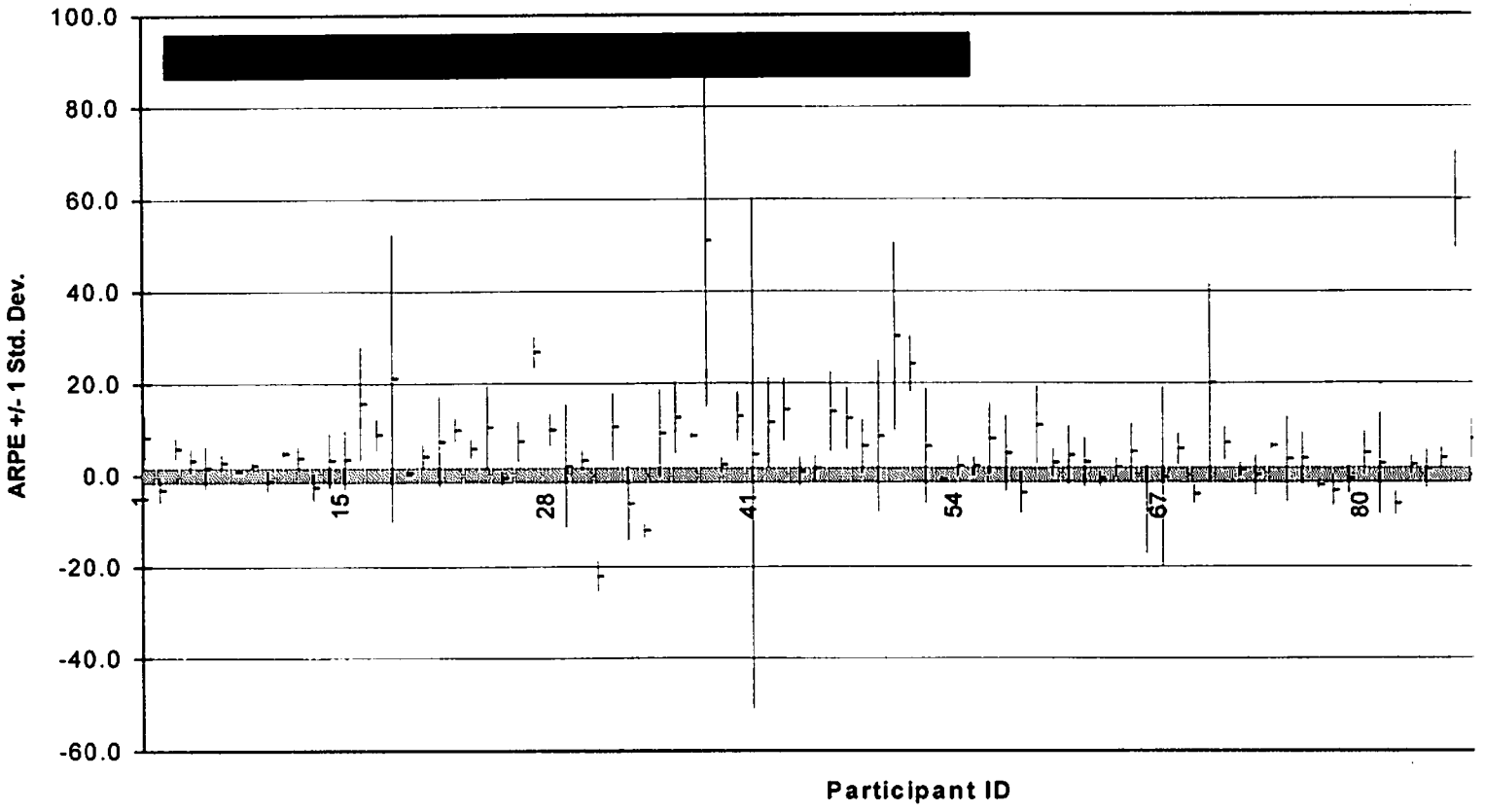


Figure 2

Electret Ion Chamber, Blind Testing
Short-term Electrets, S-Chambers