



Radon Testing Results for Multifamily Radon Testing

- 4pCi/L and above is considered an action level
- At this time, radon levels at tested locations were considered low and safe for this building.
- ALL RADON TESTS WERE SIGNIFICANTLY BELOW 4 pCi/L

To: JOE SAMPLE
2014 Sample Dr.
Sample, Ohio 44107

From: Marko E. Vovk (RT259)
Ambassador Construction Consultants LLC.
1501 Spring Garden
Lakewood, Ohio 44107
216-431- TEST (8378) office
216-924-TEST (8378) cell
www.houseinvestigations.com (Radon information and downloads)
clevelandmold@aol.com email

RADON RESULTS FOR 2014 Sample Drive, Sample Ohio

- All below 4 pci/l
- Most results were less than 1 pci/l
- Spikes and blanks not included in below data.

Room #	Result pCi/L	Room #	Result pCi/L	Room #	Result pCi/L	Room #	Result pCi/L
1543	0.5	540	< 0.3	1046	< 0.3	140	< 0.3
1351	< 0.3	450	< 0.3	1042	< 0.3	B1	1.1
1451	< 0.3	241	< 0.3	940	< 0.3	B2	1.5
1349	< 0.3	245	< 0.3	951	< 0.3	B4	< 0.3
1141	0.5	140	< 0.3	744	< 0.3	B3	< 0.3
1250	< 0.3	442	< 0.3	641	< 0.3	849	< 0.3
1243	0.5	342	< 0.3	549	< 0.3	845	< 0.3
1140	< 0.3	343	< 0.3	640	< 0.3	849	< 0.3
1141	< 0.3	148	< 0.3	743	0.5		
				641	< 0.3		

Results reported above are based on short-term tests and should not be interpreted as annual exposures to the occupants. This is due to environmental and geological as well as changes in the operation of the dwelling.

The U.S. Environmental Protection Agency Recommends that all homes with average indoor radon concentrations of 4 pCi/1 (Pico curies per Liter of air) or higher should be mitigated to reduce the radon levels to below 4 pCi/1. If your results are greater than this level, a determination should be made as to whether to engage in follow-up testing or seek remediation advice.

Ambassador Construction Consultants and personnel do not accept responsibility for the financial or health consequences of the subsequent action taken by the client of their consultants based on these results, nor are we responsible for the results of improper handling of detectors during the exposure period.

Below is the "Multifamily Radon Testing Report". The report was written with the protocol MAMF-2012 ANSI/AAEAR Protocol for conduction radon and radon decay product measurements in multifamily guidelines.

- 8.0 Documentation will be kept in Ambassador Construction Consultants LLC file for a period of six years.
- 8.1 Test Site: 2014 Sample Dr. Sample Ohio
- Contacts Donald Duck,
- 8.2.1 Testing service information
- 8.2.2 Marko Vovk from Ambassador Construction Consultants LLC performed all the radon testing in the above said multifamily building. Marko Vovk is licensed in the State of Ohio for radon testing and multifamily radon testing under the licensed number RT259.
- 8.2.3 The laboratory that performed the tests was Air Chek located at 1936 Butler Bridge RD, Mills River, NC 28759. Air Chek is certified in Ohio to perform multifamily radon testing. The Air Chek phone number is 1-828-684-0883, and 1-828-684-8498. The web page is www.radon.com.
- 8.2.4 The State of Ohio radon contact is Chuck McCracken the supervisor for the radon program at chuckMcCracken@odh.ohio.gov. The address is Bureau of Radiation Protection, Ohio Department of Health, 246 N, High Street, 7th floor 35 bldg. Columbus, Ohio 43215. The phone number is 1-614-466-5136
- 8.2.5 Summary of measurement results:
- No recommendation is needed at this time
 - All radon levels are were low and acceptable.
 - No further testing is needed at this time.
 - All testing, reporting and others were done in accordance with the latest versions of EPA's Home Buyer's and Sellers's Guide to Radon, EPA Citizens Guide to Radon. These can be downloaded at www.houseinvestigations.com or at EPA. Furthermore, all testing was done in accordance to the Multifamily Ohio and EPA guidelines.
 - All tested units with tenants present or not present were provided a copy of the EPA Home buyer's and Sellers Guide to radon dated January 2009. Both above can be downloaded at www.epa.gov/iaq.
- 8.5 This report contains all valid measurements.
- 8.5.1 We did not use continues monitors and therefore hourly reading were not taken.
- 8.5.2 We did not average test results. All test results were reported individually.
- 8.5.3 All test results on this report are in picocuries per liter (pCi/L)
- 8.5.4 All quality control measurements have been providing on this report.
- 8.5.5 All prior test data that has been acquired from residents or other testing companies has been incorporated into this report. Below are several first floor tests that were done on July 25, 2013 by Marko Vovk from Ambassador Construction Consultants LLC. After these tests were done, it was determined by management that additional testing was needed to fulfill their multifamily radon testing requirements. This additional testing was the multifamily tests that were done on 10-28-13 which this report reflects. Below is the radon result from the first level that was completed on July 25, 2013.
- 8.6 Detector and location information.

8.6.1 Documentation of all detectors was done by photograph and by diagram drawings. Photographs can be provided if deemed.

Diagram I for testing locations

Below are the room #'s and location of the radon tests.

Tests were done at identical locations.

ROOMS

1440 1543 1542 1543 1351 1451 1349 1141 1250 1243 1140 1141 1046 1047 940 951 744
641 549 640 743 641 540 450 241 245 140 442 342 343 148 140 849 845 849 B1 B2 B3 B4
CBL1 CBL2 CBL3 CBL4 Board Room Meeting Room Janitorial Room SP1 SP2 SP3

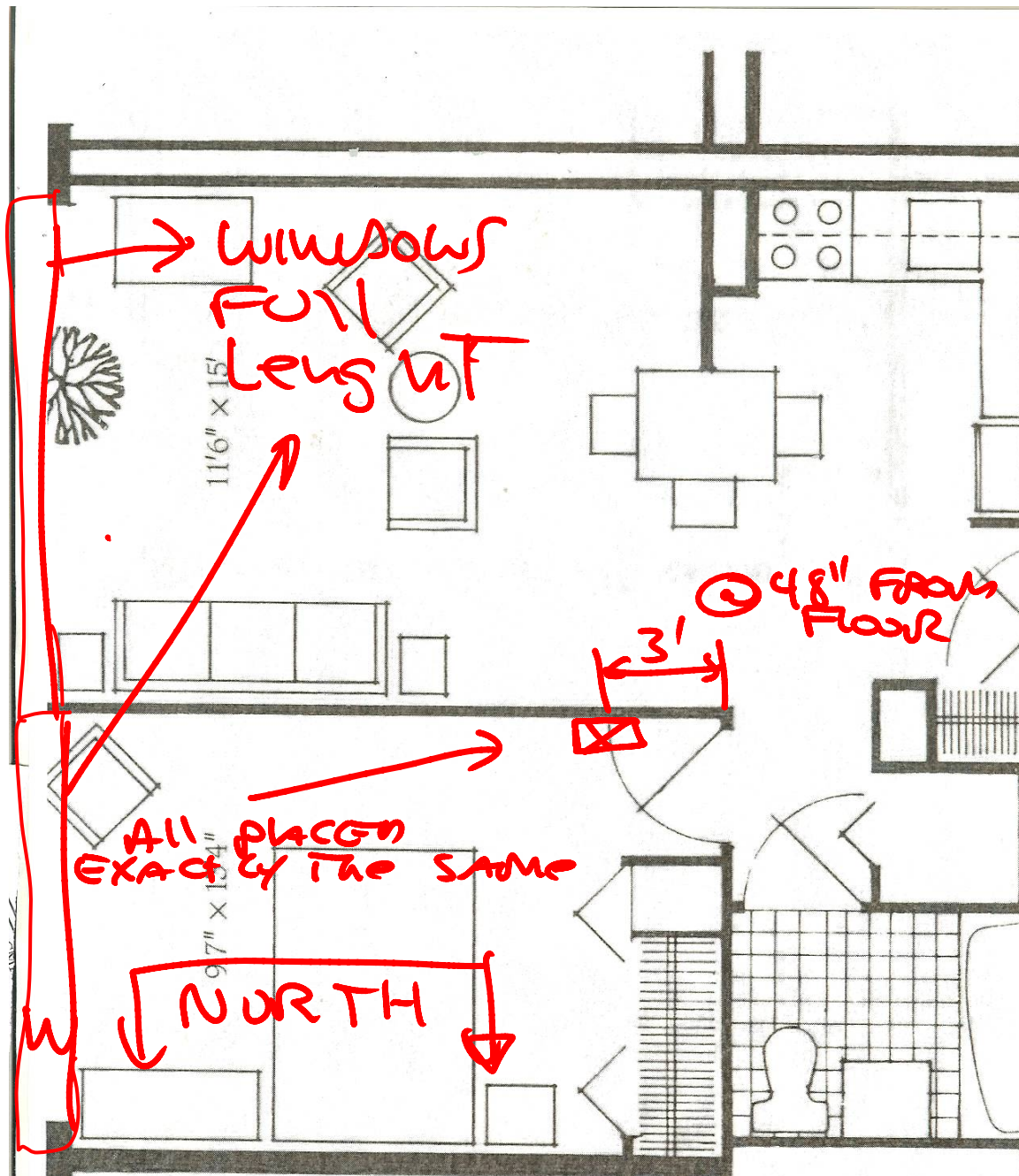


Diagram II for testing locations

Below are the room #'s and location of the radon tests.

Tests were done at identical locations. Red circles show room numbers that were tested on this diagram.

ROOMS

1440 1543 1542 1543 1351 1451 1349 1141 1250 1243 1140 1141 1046 1042 940 951 744
 641 549 640 743 641 540 450 241 245 140 442 342 343 148 140 849 845 849 B1 B2 B3 B4
 CBL1 CBL2 CBL3 CBL4 Board Room Meeting Room Janitorial Room SP1 SP2 SP3

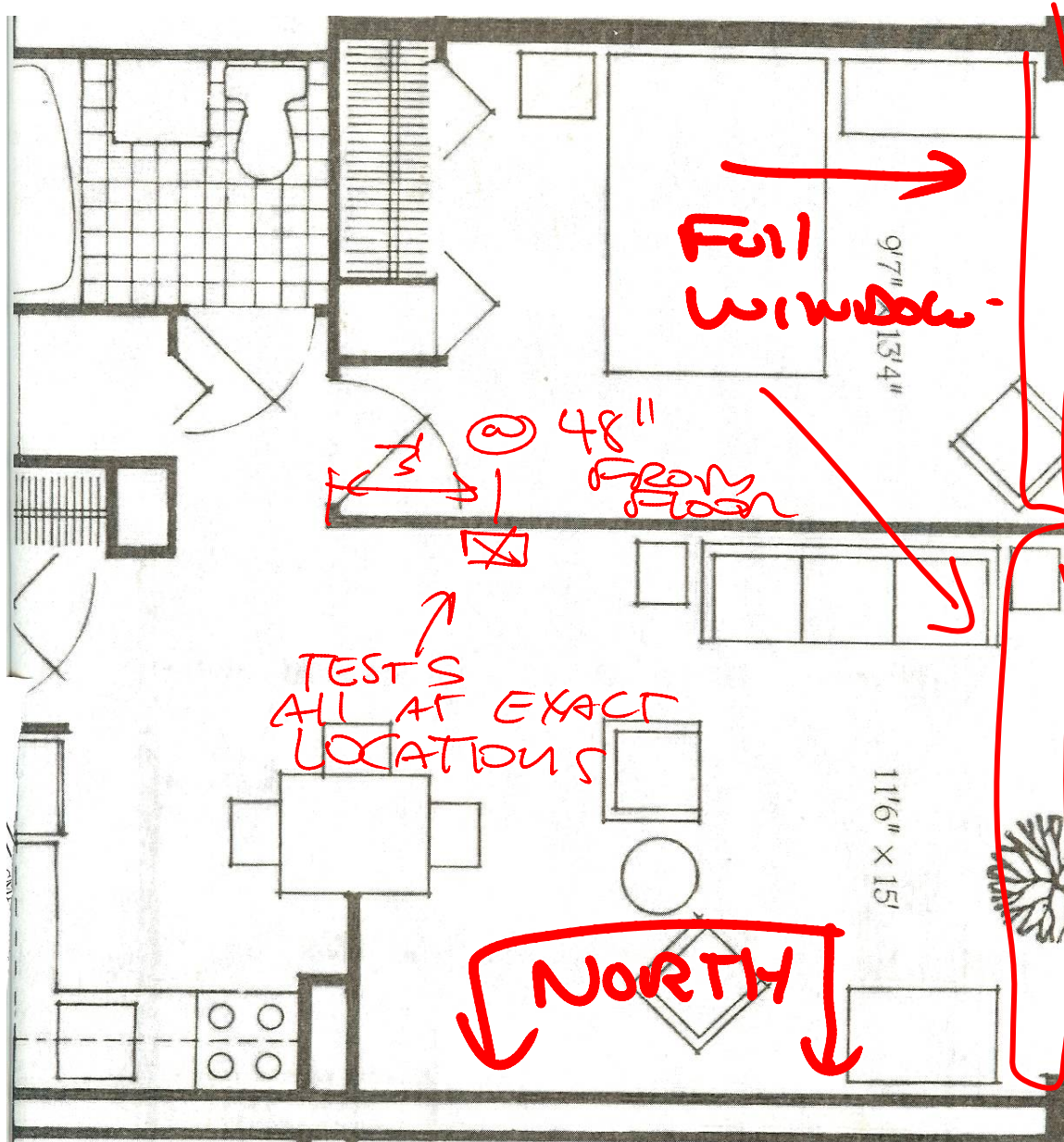


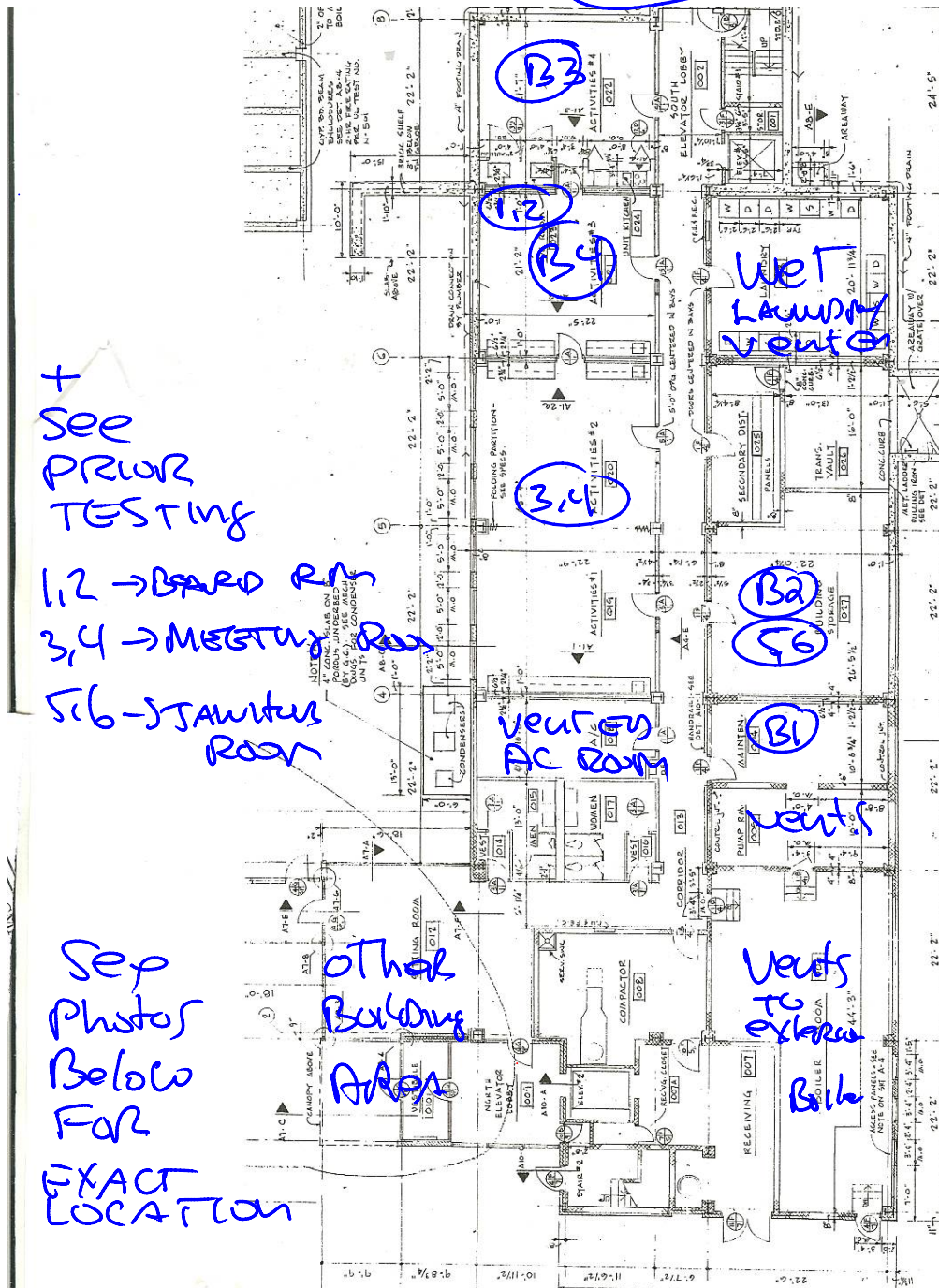
Diagram III for testing location.

This is the floor plan for the first level.

Below are the room #'s and location of the radon tests. Tests were done at identical locations. Red circles show room numbers that were tested on this diagram.

ROOMS

1440 1543 1542 1543 1351 1451 1349 1141 1250 1243 1140 1141 1046 1042 940 951 744
 641 549 640 743 641 540 450 241 245 140 442 342 343 148 140 849 845 849 B1 B2 B3 B4
 CBL1 CBL2 CBL3 CBL4 Board Room Meeting Room Janitorial Room SP1 SP2 SP3



NOTE:

- The following were the control blanks : CBL1 CBL2 CBL3 CBL4
- The following were the control spikes: SP1 SP2 SP3
- The duplicate controls are listed above and below charts.



B2 Location

- Center wall 3 feet from the entrance door on right, 48 inches from the ground.



B1 Location

- Door is closed and did not open.
- This room was 100% full of clutter. This was the only location that we could test.
- North wall 8 feet from the entrance door, right side, 60 inches from the ground.



B3 Location

- Center room on top shelf, 10 feet from the east wall, 11 feet from the west wall, 52 inches from the ground.



B4 Location

- Center wall, two feet from wall, three feet from the main entrance door right side, 50 inches from the ground.

8.6.1.1 All locations that needed to be tested were tested.

8.6.1.2 No detectors were lost during testing

8.6.1.2.1 All exact start times and stop times were recorded. We did round up or down for laboratory purposes and to meet the laboratory QA/QC/SOP requirements.

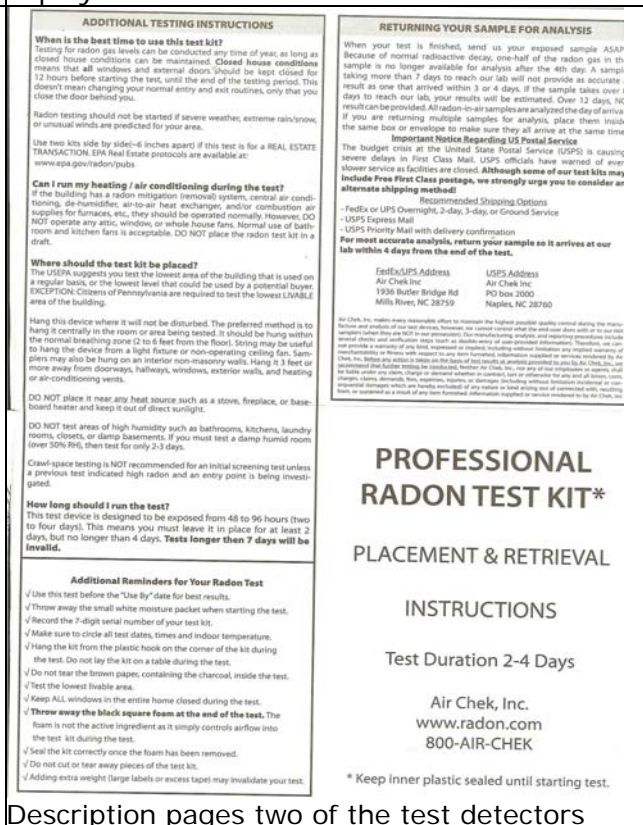
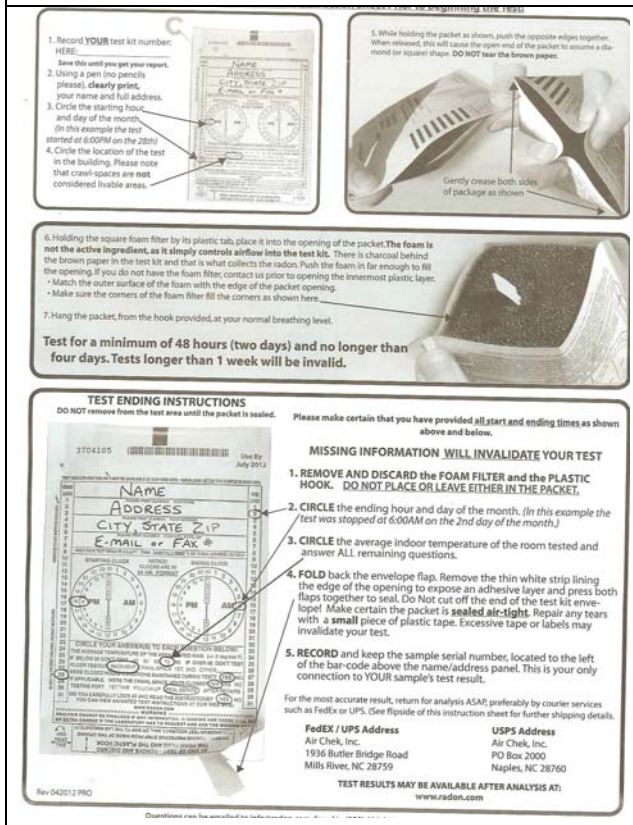
8.6.2 The test device that was used for this project is shown below. The first image is the front of the detector. The second image is the back of the detector.



Front detector (Actual size is much bigger)
All detectors have serial numbers.



Back of detectors (Actual size is much bigger)
All detectors come sealed in two plastic containers.
Plastic is only removed when test is being deployed.



Description page one of the test detectors used.	used.
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8.6.3 We performed quality control during our testing. Below are the duplicates and blank tests results. (See supporting documentation at end of report for definitions.)

- **Green** are QA/QC Spike¹ tests (Serial numbers 4726100, 4726101, and 4726104)
SPIKE CALCULATION ATTACHED
- **Yellow** are Duplicate tests (Rooms 154, 114, 641, and 140)
DUPLICATED CALCULATIONS ATTACHED
- **Orange** are QA/QC Blank tests (Serial numbers 4726147, 4726141, 4726145, 4726139)
- **Blue** are extra tests from lot in case we had to retest several areas. These extra units were not used and fees were not charged to the client.
- NOTE: All quality control, testing, and calculations meet the OHIO STATE GUIDELINES, RULES, REGULATIONS, LAWS, and Marko Vovk's SOP/QA program.

Below are the laboratory results.

Kit	Start Date	Start Time	End Date	End Time	Temp	Room	Floor	Result	Variance	Analysis Date	Moisture
Number								RADON			Moisture
4726100	SPIKE							3			
4726101	SPIKE							3			
4726102		10:00 am	2013-10-30	2:00 pm	76	1440	3	< 0.3	0.3	2013-11-01	4.8
4726103		9:00 am	2013-10-30	2:00 pm	73	1543	3	< 0.3	0.3	2013-11-01	4.1
4726104	SPIKE							3			
4726105		9:00 am	2013-10-30	2:00 pm	73	1542	3	< 0.3	0.2	2013-11-01	4.9
4726106		2:00 pm	2013-10-30	4:00 pm	76	CBL1	1	< 0.3	0.4	2013-11-01	3.4
4726107		9:00 am	2013-10-30	2:00 pm	73	1543	3	0.5	0.3	2013-11-01	4.9
4726108		10:00 am	2013-10-30	2:00 pm	68	1351	3	< 0.3	0.3	2013-11-01	4.9
4726109		10:00 am	2013-10-30	2:00 pm	72	1451	3	< 0.3	0.3	2013-11-01	4.9

47261	2013-10	10:00 am	2013-10-30	2:00 pm	7	1349	3	< 0.3	0.2	2013-11-01	5.6
47261	2013-10-28	11:00 am	2013-10-30	2:00 pm	6	1141	3	0.5	0.2	2013-11-01	4.9
47261	2013-10-28	10:00 am	2013-10-30	2:00 pm	6	1250	3	< 0.3	0.2	2013-11-01	4.9
47261	2013-10-28	11:00 am	2013-10-30	2:00 pm	7	1243	3	0.5	0.3	2013-11-01	4.9
47261	2013-10-28	11:00 am	2013-10-30	2:00 pm	6	1140	3	< 0.3	0.2	2013-11-01	5.6
47261	2013-10-28	11:00 am	2013-10-30	2:00 pm	7	1141	3	< 0.3	0.2	2013-11-01	4.8
47261	2013-10-28	11:00 am	2013-10-30	2:00 pm	7	1046	3	< 0.3	0.2	2013-11-01	4.8
47261	2013-10-28	11:00 am	2013-10-30	2:00 pm	6	1042	3	< 0.3	0.2	2013-11-01	5.6
47261	2013-10-28	11:00 am	2013-10-30	2:00 pm	7	940	3	< 0.3	0.2	2013-11-01	5.6
47261	2013-10-28	11:00 am	2013-10-30	2:00 pm	7	951	3	< 0.3	0.2	2013-11-01	5.6
47261	2013-10-28	12:00 pm	2013-10-30	2:00 pm	7	744	3	< 0.3	0.3	2013-11-01	4.2
47261	2013-10-28	12:00 pm	2013-10-30	3:00 pm	7	641	3	< 0.3	0.3	2013-11-01	5.6
47261	2013-10-28	12:00 pm	2013-10-30	3:00 pm	6	549	3	< 0.3	0.2	2013-11-01	5.5
47261	2013-10-28	12:00 pm	2013-10-30	2:00 pm	7	640	3	< 0.3	0.3	2013-11-01	4.9
47261	2013-10-28	12:00 pm	2013-10-30	2:00 pm	7	743	3	0.5	0.2	2013-11-01	3.4
47261	2013-10-28	12:00 pm	2013-10-30	3:00 pm	7	641	3	< 0.3	0.2	2013-11-01	6.9
47261	2013-10-28	12:00 pm	2013-10-30	3:00 pm	6	540	3	< 0.3	0.3	2013-11-01	4.8
47261	2013-10-28	1:00 pm	2013-10-30	3:00 pm	7	450	3	< 0.3	0.3	2013-11-01	4.2
47261	2013-10-28	1:00 pm	2013-10-30	3:00 pm	6	241	2	< 0.3	0.3	2013-11-01	4.9

47261 29	2013- 10-28	1:0 0 pm	2013- 10-30	3:0 0 pm	7 3	245	2	< 0.3	0.3	2013- 11-01	4.9
47261 30	2013- 10-28	1:0 0 pm	2013- 10-30	3:0 0 pm	7 1	140	1	< 0.3	0.2	2013- 11-01	4.9
47261 31	2013- 10-28	12: 00 pm	2013- 10-30	3:0 0 pm	6 8	442	3	< 0.3	0.3	2013- 11-01	5.6
47261 32	2013- 10-28	1:0 0 pm	2013- 10-30	3:0 0 pm	6 9	342	3	< 0.3	0.3	2013- 11-01	4.9
47261 33	2013- 10-28	1:0 0 pm	2013- 10-30	3:0 0 pm	7 5	343	3	< 0.3	0.3	2013- 11-01	4.2
47261 34	2013- 10-28	1:0 0 pm	2013- 10-30	3:0 0 pm	7 1	148	1	< 0.3	0.2	2013- 11-01	4.9
47261 35	2013- 10-28	1:0 0 pm	2013- 10-30	3:0 0 pm	7 1	140	1	< 0.3	0.2	2013- 11-01	4.9
47261 36	2013- 10-28	1:0 0 pm	2013- 10-30	3:0 0 pm	6 9	B1	0	1.1	0.3	2013- 11-01	5.7
47261 37	2013- 10-28	2:0 0 pm	2013- 10-30	4:0 0 pm	7 0	CBL3	1	< 0.3	0.3	2013- 11-01	3.5
47261 38	2013- 10-28	1:0 0 pm	2013- 10-30	3:0 0 pm	6 5	B2	1	1.5	0.2	2013- 11-01	5.6
47261 39							3				
47261 40	2013- 10-28	2:0 0 pm	2013- 10-30	4:0 0 pm	6 7	B4	1	< 0.3	0.3	2013- 11-01	4.2
47261 41							3				
47261 42	2013- 10-28	1:0 0 pm	2013- 10-30	3:0 0 pm	6 4	B3	1	< 0.3	0.2	2013- 11-01	5.6
47261 43	2013- 10-28	2:0 0 pm	2013- 10-30	4:0 0 pm	7 6	849	3	< 0.3	0.3	2013- 11-01	4.9
47261 44	2013- 10-28	2:0 0 pm	2013- 10-30	4:0 0 pm	7 0	CBL2	1	< 0.3	0.3	2013- 11-01	3.5
47261 45											
47261 46	2013- 10-28	12: 00 pm	2013- 10-30	2:0 0 pm	6 7	845	3	< 0.3	0.2	2013- 11-01	5.6
47261 47							3				
47261 48	2013- 10-28	2:0 0 pm	2013- 10-30	4:0 0 pm	6 9	849	3	< 0.3	0.2	2013- 11-01	4.9
47261	2013-	2:0	2013-	4:0	7	CBL4	1	< 0.3	0.3	2013-	4.2



If you like to make all above larger, simply cut, paste, and enlarge.
Below is a blow up sample.

343 VACANT (NEED)

**OCUPANT / TENANT / HOME OWNER
PLEASE SIGN BOTH COPIES (Below)**

**AMBASSADOR CONSTRUCTION CONSULTANTS LLC
MARKO VOVK RADON TESTING**
1501 SPRING GARDEN AVE, LAKEWOOD OHIO 44107
Clevelandmold@aol.com email www.houseinvestigations.com website
For radon videos on youtube simply Goggle ClevelandMarko

Residential Testing Program
(Get 2 signed copies, 1 to keep and 1 for the client)

RADON INSPECTION DECLARATION OF VOLUNTARY COMPLIANCE

As the responsible party for the residence listed below, I hereby acknowledge receipt of the EPA's "Home Buyer's and Seller's Guide to Radon". I further understand that potential purchasers and/or lenders will be making important decisions pending the outcome of this test. Given this information I hereby certify that:

- (1) I agree to keep this house closed (except for normal entry and exit) for at least 12 hours prior to the start of the test.
- (2) I agree to keep all doors and windows shut during the entire test period except for normal entry and exit.
- (3) I will not knowingly alter the test environment in any way including, but not limited to, raising or lowering the thermostat(s) or changing HVAC fan controls, or moving the test device(s).
- (4) I will not touch, tamper with, remove, cover, or change the location of the test device(s).
- (5) I will report any circumstances that occur during the test that may influence the final results such as unusual or severe weather, power outages, etc.
- (6) If I have any questions about the test I will contact the testing firm immediately. <Telephone>

TEST ADDRESS: 343 VACANT

Occupant or Responsible Party ☒ VACANT

Test Address 343 Date 10/23/13

City W Technician Marko Vovk (216-924-8378) Clevelandmold@aol.com

State OH Zip 44107 License #: RT259 Date 10/23/13

Example of a vacant unit. No signatures at vacant units. Roughly, 40% of the units were vacant. All vacant units were properly heated and conditioned. All windows closed before, during and after the test.



All tests with exception of the first level had tests locations all the same exact location. We did have to move some wall pictures with tenant permission. All radon tests were taped to the wall, all location were measured and documented, and all locations were photographed. We can provide the digital photos at some future date if deemed.

8.7.3 Mitigation System Status. This section was not applicable.

8.7.3 Temporary Conditions.

- The building was under some renovation.

- Many tested units were vacant. All tested vacant units were heated and windows were closed. No protocol violations were observed in vacant units.
- All bathroom exhaust fans were off, before, during and after radon test.
- No unusual weather or severe storms accrued during the radon testing.

8.8 Statement of limitations

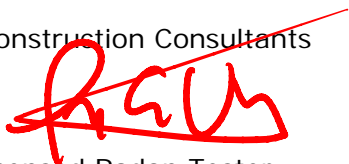
- There is an uncertainty with any measurement result due to statistical variations and other factors such as daily and seasonal variations in radon concentrations. Variations may be due to changes in the weather, operation for the dwelling or building, or possible interference with the necessary test conditions.

(We refer radon mitigation and long term testing to Radon Survey System Inc. at 330-963-6633). Ambassador Construction Consultants and personnel does not accept responsibility for the financial or health consequences of the subsequent action taken by the client of their consultants based on these results, nor are we responsible for the results of improper handling of detectors during the exposure period.

Please go to our web site www.houseinvestigations.com for additional radon information (We refer Radon Mitigation and long term testing to Radon Survey System Inc. at 330-963-6633).

Thank you
Ambassador Construction Consultants
216-924-8378

Marko E. Vovk
T-000259-0 Licensed Radon Tester



End of Multifamily Radon REPORT

Supporting Documents Below

EXPOSURE IN BOWSER-MORNER RADON CHAMBER

CLIENT Ambassador Construction Consultants Job Number 163996

NOMINAL Conditions: Radon Conc 25.1 pCi/L Rel. Hum 33.9 % Temp. 70.0 F

Date Start: 11/1/13 Date Stop: 11/4/13

Time Start: 1030 Time Stop: 1030

Device No.'s: (5) Char. Bags - Device No.'s: _____

47a6100, 47a6101, 47a6104

34 C-94

Note: All times are in 24-hour (military) notation, Eastern Standard Time (EST)
Background = 7 µR/h Elevation = 820 ft

Bowser-Morner Radon Chamber 3 Spikes for QC Chain of Custody.

KADON TESTS

Floor	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
	140 ✓	244*	343 ✓	448 ✓	540 ✓	643 ✓	743 ✓	843 ✓	945 ✓	1042 ✓	1140 ✓	1249 ✓	1345 ✓	1443 ✓	1542 ✓
	151*	245 ✓	346*	450 ✓	548 ✓	640 ✓	744 ✓	846 ✓	946 ✓	1044 ✓	1141 ✓	1243 ✓	1351 ✓	1451 ✓	1546 ✓
	148 ✓	241 ✓	342 ✓	442 ✓	546 ✓	647 ✓	749 ✓	845 ✓	951 ✓	1046 ✓	1142 ✓	1250 ✓	1349 ✓	1440 ✓	1543 ✓

*151 moving out as of 10/31 resident not living there
*movers using
*will be turning in the keys Tues/Wed
*moving out as of 10/31 resident not living there

no AP-1 2:00 PM

Fred → 216 589-3558

List of units identified for radon testing. All units and occupants were contacted several weeks prior to radon testing by building management. The checked units with V note vacant units tested. The checked units with circles note units with tenants. These are field notes from 10-28-13

RADON TEST IN PROGRESS

Closed House Conditions Must Be Maintained

ALL Windows **MUST** Remain Closed. External Doors **MUST** Remain Closed Except for Entry or Exit.

Heating and Air Systems Should Be Operated Normally In The Auto Mode During The Radon Test.

Contact the Number Below for Additional Information



Marko Vovk

Cleveland, Ohio
216-924-8378

CAUTION!

RADON TEST IN PROGRESS

CLOSED BUILDING CONDITIONS MUST BE MAINTAINED:

ALL WINDOW AND DOORS **MUST BE CLOSED EXCEPT FOR BRIEF DOOR OPENING FOR ENTRY AND EXIT.**

HEATING AND AIR CONDITIONING SYSTEMS SHOULD BE OPERATED IN THE AUTO MODE DURING CLOSED BUILDING CONDITIONS.

PLEASE CALL NUMBER BELOW FOR ADDITIONAL INFORMATION CONCERNING TESTING OF THIS BUILDING

Ambassador Construction Consultants LLC

Marko Vovk # RT259

216-924-8378

Door sign unused. All rooms tested received door signs.

Radon sign used. These were all taped to the wall and posted next to all radon tests. Additional signs were left on kitchen countertops.

SPIKE DATA IS IN AMBASSADOR FILE

**OCUPANT / TENANT / HOME OWNER
PLEASE SIGN BOTH COPIES (Below)**

**AMBASSADOR CONSTRUCTION CONSULTANTS LLC
MARKO VOVK RADON TESTING**
1501 SPRING GARDEN AVE, LAKEWOOD OHIO 44107
Clevelandmold@aol.com email www.houseinvestigations.com website
For radon videos on youtube simply Goggle ClevelandMarko

Residential Testing Program
(Get 2 signed copies, 1 to keep and 1 for the client)

RADON INSPECTION DECLARATION OF VOLUNTARY COMPLIANCE

As the responsible party for the residence listed below, I hereby acknowledge receipt of the EPA's "Home Buyer's and Seller's Guide to Radon". I further understand that potential purchasers and/or lenders will be making important decisions pending the outcome of this test. Given this information I hereby certify that:

- (1) I agree to keep this house closed (except for normal entry and exit) for at least 12 hours prior to the start of the test.
- (2) I agree to keep all doors and windows shut during the entire test period except for normal entry and exit.
- (3) I will not knowingly alter the test environment in any way including, but not limited to, raising or lowering the thermostat(s) or changing HVAC fan controls, or moving the test device(s).
- (4) I will not touch, tamper with, remove, cover, or change the location of the test device(s).
- (5) I will report any circumstances that occur during the test that may influence the final results such as unusual or severe weather, power outages, etc.
- (6) If I have any questions about the test I will contact the testing firm immediately. <Telephone>

TEST ADDRESS

Occupant or Responsible Party **X**

Test Address _____ Date _____
City _____ Technician Marko Vovk (216-924-8378) Clevelandmold@aol.com
State _____ Zip _____ License #: RT259 Date _____

All tenants that were home signed. All units that were empty, this sign was posted and taped next to the radon test.

Chain of Custody

Building Name:

Testing Contractor:

Marko Vovk 1501 Spring Garden Ave Lakewood Ohio 44107 216-924-8378

Contact Name :

Serial # Kit Number	See Photo Room Number	See Photo Room Location	See Photo Room Location	Start Date	Start Time	STOP End Date	STOP End Time	99 = QA Floor	COM MENT	Place	PU
4726102	1440	Living Room	Drywall wall	2013-10-28	10:00 am	2013-10-30	2:00 pm	14	NA	VOVK	VOVK
4726103	1543	Living Room	Drywall wall	2013-10-28	9:00 am	2013-10-30	2:00 pm	15	NA	VOVK	VOVK
4726105	1542	Living Room	Drywall wall	2013-10-28	9:00 am	2013-10-30	2:00 pm	15	NA	VOVK	VOVK
4726106	CBL1	BLANK	Drywall wall	2013-10-28	2:00 pm	2013-10-30	4:00 pm	99	NA	VOVK	VOVK
4726107	1543	DUPLICATE	Drywall wall	2013-10-28	9:00 am	2013-10-30	2:00 pm	15	NA	VOVK	VOVK
4726108	1351	Living Room	Drywall wall	2013-10-28	10:00 am	2013-10-30	2:00 pm	13	NA	VOVK	VOVK
4726109	1451	Living Room	Drywall wall	2013-10-28	10:00 am	2013-10-30	2:00 pm	14	NA	VOVK	VOVK

4726110	1349	Living Room	Drywall wall	2013-10-28	10:00 am	2013-10-30	2:00 pm	13	NA	VOVK	VOVK
4726111	1141	DUPLICATE	Drywall wall	2013-10-28	11:00 am	2013-10-30	2:00 pm	11	NA	VOVK	VOVK
4726112	1250	Living Room	Drywall wall	2013-10-28	10:00 am	2013-10-30	2:00 pm	12	NA	VOVK	VOVK
4726113	1243	Living Room	Drywall wall	2013-10-28	11:00 am	2013-10-30	2:00 pm	12	NA	VOVK	VOVK
4726114	1140	Living Room	Drywall wall	2013-10-28	11:00 am	2013-10-30	2:00 pm	11	NA	VOVK	VOVK
4726115	1141	Living Room	Drywall wall	2013-10-28	11:00 am	2013-10-30	2:00 pm	11	NA	VOVK	VOVK
4726116	1046	Living Room	Drywall wall	2013-10-28	11:00 am	2013-10-30	2:00 pm	10	NA	VOVK	VOVK
4726117	1042	Living Room	Drywall wall	2013-10-28	11:00 am	2013-10-30	2:00 pm	10	NA	VOVK	VOVK
4726118	940	Living Room	Drywall wall	2013-10-28	11:00 am	2013-10-30	2:00 pm	9	NA	VOVK	VOVK
4726119	951	Living Room	Drywall wall	2013-10-28	11:00 am	2013-10-30	2:00 pm	9	NA	VOVK	VOVK
4726120	744	Living Room	Drywall wall	2013-10-28	12:00 pm	2013-10-30	2:00 pm	7	NA	VOVK	VOVK
4726121	641	Living Room	Drywall wall	2013-10-28	12:00 pm	2013-10-30	3:00 pm	6	NA	VOVK	VOVK
4726122	549	Living Room	Drywall wall	2013-10-28	12:00 pm	2013-10-30	3:00 pm	5	NA	VOVK	VOVK
4726123	640	Living Room	Drywall wall	2013-10-28	12:00 pm	2013-10-30	2:00 pm	6	NA	VOVK	VOVK
4726124	743	Living Room	Drywall wall	2013-10-28	12:00 pm	2013-10-30	2:00 pm	7	NA	VOVK	VOVK
4726125	641	DUPLICATE	Drywall wall	2013-10-28	12:00 pm	2013-10-30	3:00 pm	6	NA	VOVK	VOVK
4726126	540	Living Room	Drywall wall	2013-10-28	12:00 pm	2013-10-30	3:00 pm	5	NA	VOVK	VOVK
4726127	450	Living Room	Drywall wall	2013-10-28	1:00 pm	2013-10-30	3:00 pm	4	NA	VOVK	VOVK
4726128	241	Living Room	Drywall wall	2013-10-28	1:00 pm	2013-10-30	3:00 pm	2	NA	VOVK	VOVK
4726129	245	Living Room	Drywall wall	2013-10-28	1:00 pm	2013-10-30	3:00 pm	2	NA	VOVK	VOVK
4726130	140	DUPLICATE	Drywall wall	2013-10-28	1:00 pm	2013-10-30	3:00 pm	1	NA	VOVK	VOVK
4726131	442	Living Room	Drywall wall	2013-10-28	12:00 pm	2013-10-30	3:00 pm	4	NA	VOVK	VOVK
4726132	342	Living Room	Drywall wall	2013-10-28	1:00 pm	2013-10-30	3:00 pm	3	NA	VOVK	VOVK
4726133	343	Living Room	Drywall wall	2013-10-28	1:00 pm	2013-10-30	3:00 pm	3	NA	VOVK	VOVK
4726134	148	Living Room	Drywall wall	2013-10-28	1:00 pm	2013-10-30	3:00 pm	1	NA	VOVK	VOVK
4726135	140	Living Room	Drywall wall	2013-10-28	1:00 pm	2013-10-30	3:00 pm	1	NA	VOVK	VOVK
4726136	B1	Room	Drywall wall	2013-10-28	1:00 pm	2013-10-30	3:00 pm	0	NA	VOVK	VOVK
4726137	CBL3	BLANK	BLANK	2013-10-28	2:00 pm	2013-10-30	4:00 pm	99	NA	VOVK	VOVK
4726138	B2	Room	Hang Shelf	2013-10-28	1:00 pm	2013-10-30	3:00 pm	1	NA	VOVK	VOVK
4726140	B4	Room	Hang Shelf	2013-10-28	2:00 pm	2013-10-30	4:00 pm	1	NA	VOVK	VOVK
4726142	B3	Room	Drywall wall	2013-10-28	1:00 pm	2013-10-30	3:00 pm	1	NA	VOVK	VOVK
4726143	849	Living Room	Drywall wall	2013-10-28	2:00 pm	2013-10-30	4:00 pm	8	NA	VOVK	VOVK
4726144	CBL2	BLANK	BLANK	2013-10-28	2:00 pm	2013-10-30	4:00 pm	99	NA	VOVK	VOVK
4726146	845	Living Room	Drywall wall	2013-10-28	12:00 pm	2013-10-30	2:00 pm	8	NA	VOVK	VOVK
4726148	849	Living Room	Drywall wall	2013-10-28	2:00 pm	2013-10-30	4:00 pm	8	NA	VOVK	VOVK
4726149	CBL4	BLANK	BLANK	2013-10-28	2:00 pm	2013-10-30	4:00 pm	99	NA	VOVK	VOVK

ASSESSING RESULTS FOR DUPLICATES AND SPIKES

D.1 Assessing Results of Duplicate Quality Control Samples (Precision Measurements)

Measuring radioactive substances, such as radon gas, can be made more difficult due to encounters with random Obstacles. Obstacles met when measuring radon gas with activated charcoal include, but are not limited to, variations of radon at the test location, differences in the test kits, care taken during test kit deployment, and background radiation levels at the laboratory. Therefore, side-by-side radon samples are expected to produce slightly different results. It is critical to understand, document, and monitor your precision error. This knowledge and documentation will allow you to characterize your precision error to clients. Furthermore, the continual monitoring of precision provides a check on every aspect of the measurement system. In order to determine when the differences in side-by-side (duplicate) measurements are larger than expected, EPA recommends calculating and analyzing the relative percent difference (RPD) between the duplicates. The RPD is calculated as the difference between the two samples divided by the average of the two samples. In order to be able to fully assess precision, a minimum of 20 duplicate pairs must be completed.

Figure D-1: Calculating Relative Percent Difference (RPD)

Calculation for Determining (RPD)

$$RPD = |D1-D2| / ((D1+D2) / 2) \times 100\%$$

Where RPD = Relative Percent Difference

D1 = measured value of the first duplicate D2 = measured value of the second duplicate

RADON LEVEL IN BLUE

47261	2013-03	10-28	9:0 am	2013-10-30	2:0 pm	7	3	1543	3	< 0.3
47261	2013-07	10-28	9:0 am	2013-10-30	2:0 pm	7	3	1543	3	0.5

Relative percent difference calculations can expect larger percent errors for duplicates with less radon than errors for Duplicates exposed to higher radon levels. In order to keep the two ranges in proper perspective, two sets of control Charts have been developed. Since very low radon levels magnify the RPD between samples, **it is inappropriate to Calculate the differences for duplicates with averages below 2.0 pCi/L.** Therefore, one control chart will be maintained to display and analyze duplicates where the average is between 2.0 and 3.9 pCi/L and a second control chart will be used to assess duplicates averaging 4.0 pCi/L or higher.

47261	11	2013-10-28	11:00 am	2013-10-30	2:00 pm	69	1141	3	0.5
47261	15	2013-10-28	11:00 am	2013-10-30	2:00 pm	70	1141	3	< 0.3

Relative percent difference calculations can expect larger percent errors for duplicates with less radon than errors for Duplicates exposed to higher radon levels. In order to keep the two ranges in proper perspective, two sets of control Charts have been developed. Since very low radon levels magnify the RPD between samples, **it is inappropriate to Calculate the differences for duplicates with averages below 2.0 pCi/L.** Therefore, one control chart will be maintained to display and analyze duplicates where the average is between 2.0 and 3.9 pCi/L and a second control chart will be used to assess duplicates averaging 4.0 pCi/L or higher.

4726121	28	2013-10-28	12:00 pm	2013-10-30	3:00 pm	71	641	3	< 0.3
4726125	28	2013-10-28	12:00 pm	2013-10-30	3:00 pm	71	641	3	< 0.3

Relative percent difference calculations can expect larger percent errors for duplicates with less radon than errors for Duplicates exposed to higher radon levels. In order to keep the two ranges in proper perspective, two sets of control Charts have been developed. Since very low radon levels magnify the RPD between samples, **it is inappropriate to**

Calculate the differences for duplicates with averages below 2.0 pCi/L. Therefore, one control chart will be maintained to display and analyze duplicates where the average is between 2.0 and 3.9 pCi/L and a second control chart will be used to assess duplicates averaging 4.0 pCi/L or higher.

4726130	2013-10-28	1:00 pm	2013-10-30	3:00 pm	71	140	1	< 0.3
4726135	2013-10-28	1:00 pm	2013-10-30	3:00 pm	71	140	1	< 0.3

Relative percent difference calculations can expect larger percent errors for duplicates with less radon than errors for Duplicates exposed to higher radon levels. In order to keep the two ranges in proper perspective, two sets of control Charts have been developed. Since very low radon levels magnify the RPD between samples, it is inappropriate to Calculate the differences for duplicates with averages below 2.0 pCi/L. Therefore, one control chart will be maintained to display and analyze duplicates where the average is between 2.0 and 3.9 pCi/L and a second control chart will be used to assess duplicates averaging 4.0 pCi/L or higher.

ALL DUPLICATD BELOW 2.0 pCi/L NO FURTHER ACTION NEEDED.

D.2 Assessing Results of Spikes (Monitoring Bias)

To assess the results of spiked measurements over time, the results are plotted on a means control chart. One of the key Elements in spike control charts are to assess the laboratory accuracy over a period. As the quality assurance Program gathers more and more data, control charts will begin to have a higher degree of reliability because more data Will be taken into account. The results of known exposure measurements, or spikes, are plotted on a spike control chart

(Exhibit D-5). The centerline is set at zero, and the warning and control limits are set at +/- 16% and +/- 24% Respectively.

Calculating the Individual Relative Error (IRE)

IRE = (MV – TV) / TV x 100% Where: IRE = Individual Relative Error for each Measurement MV = measured value for the spike TV = radon chamber target value TV= 25.1

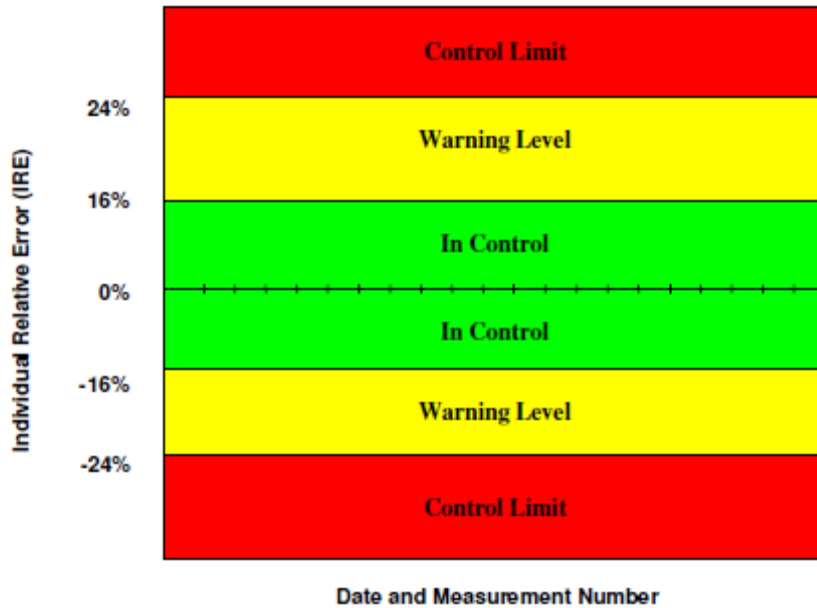
Kit Number	Start Date	Start Time	End Date	End Time	Temperature	Result	Variance	%Moisture
4726100	2013-11-01	11:00 am	2013-11-04	11:00 am	70	30.4	0.8	3.4
4726101	2013-11-01	11:00 am	2013-11-04	11:00 am	70	24.1	0.7	3.4
4726104	2013-11-01	11:00 am	2013-11-04	11:00 am	70	27.3	0.8	3.5

$$\text{RPD 4726100} = 30.4 - 25.1 / 25.1 \times 100 = 21\%$$

$$\text{RPD 4726101} = 34.1 - 25.1 / 25.1 \times 100 = 3.5\%$$

$$\text{RPD 4726104} = 27.3 - 25.1 / 25.1 \times 100 = 8.7\%$$

Figure D-5
Example Control Chart for Plotting Spike Results (≥ 4.0 pCi/L)



The QA Officer plots the results from the spikes on the appropriate control chart, as results are available, and checks the results as soon as they are plotted. Ideally, the plotting of spike results should show an even distribution of spikes above and below the zero percent (0%) centerline. Radon kits that have been in storage for extended periods may lose Efficiency, resulting in a much greater number of results falling outside the warning level. When results of spikes fall Outside of the warning level, **Marko Vovk** will contact Air Chek immediately.

NO SPIKES IN CONTOL LIMIT. NO FURTHER ACTION NEEDED.

alpha particles that strike the sensor and generate submicroscopic damage called alpha tracks. The damaged portions of the plastic can be made visible by etching in a caustic solution, because the damaged areas are more soluble in caustic than the undamaged plastic. The etched areas can be seen using a microscope. The tracks are typically counted using computer recognition and automated scanning. The number of tracks per unit area is proportional to the integrated average radon concentration in pCi-days/liter. AT's are most commonly used for medium- to long-term tests up to one year in length.

Continuous Monitors

CR and CW – Continuous Radon Monitors and Radon Decay Product Monitors

Continuous monitors use various types of sensors. Some collect air for analysis with a small pump while others allow air to passively diffuse into a sensor chamber. All have electrical circuitry capable of producing and recording integrated radon concentrations for periodic intervals of one hour or less.

Continuous radon monitors measure radon gas. Continuous radon decay product monitors measure radon decay product concentrations and require a pump to sample air containing radon decay products onto a filter assembly.

If a device cannot integrate or record readings each hour or less or is not set to record readings each hour or less, then it is functioning as an integrating device.

Other Devices:

Devices that may be developed that use various other sensors and technologies for integrating data over time. All devices used for measuring radon in buildings shall meet state requirements and be approved by NEHA-NRPP or NRSB. All devices shall be used in strict accordance with manufacturer's instructions.

DEVICE QUALITY CONTROL

Terminology associated with *quality control (QC)* is briefly explained below.

Quality Assurance (QA) and related standard operating procedures are an inherent requirement of any measurement program or project. In lieu of other consensus protocols that may be developed, see EPA Guidance on Quality Assurance (402-R-95-012, October 1997) for details on quality assurance. Additional specific requirements for each device can be found in EPA's "Indoor Radon and Radon Decay Product Measurement Device Protocols." Written

Quality Assurance Plans are required of radon measurement professionals and labs who are state licensed or certified by NEHA-NRPP or NRSB.

Duplicate (Collocated) Measurements

Duplicates are pairs of detectors or monitors deployed in the same location, side-by-side for the same measurement period. The purpose of duplicates is to evaluate precision or agreement between detectors. (Note: Duplicates do not evaluate accuracy; for accuracy, see spiked measurements below.) Duplicates may help identify problems that may introduce error into the test results. Duplicates are typically deployed at a rate of 10% of the measurement locations. When establishing a testing service's overall quality control plan up to fifty duplicates per month are recommended. However, additional duplicate measurement may be required for specific testing programs such as discussed herein for Multifamily buildings.

Field duplicates should provide the same or similar radon results. Duplicate pairs of measurements greater than or equal to 4 pCi/L (148 Bq/m³) should produce a Relative Percent Difference (RPD) greater than 36% no more than 1% of the time. Greater than 1% duplicates above 4 pCi/L (148 Bq/m³) with an RPD greater than 36% indicates the measurement system is "out of control," and all measurements are questionable.

See Appendix C "Definition of Terms" for information on calculating the RPD.

If one duplicate is equal to or greater than 4 pCi/L (148 Bq/m³) and the other below, the higher result may not be twice or more than the other. Such measurements must be repeated.

Blank Measurements

Blanks are integrating or equilibrating detectors that are not intentionally exposed for sampling (i.e. not left open to permit radon to enter the detector during the deployment period). Blanks help evaluate any detector response from sources other than radon exposure at a testing location such as in the manufacturing process or during shipping, storage, analysis and handling.

Blanks are typically deployed at a rate of 5% of the measurement locations. When establishing a testing service's overall quality control plan, up to 25 blanks per month are recommended.

However, additional blank detectors may be required for a specific testing program such as herein discussed for Multifamily buildings. See Section III, subsection 5.0.

Consult with the manufacturer/laboratory to insure detector-specific procedures approved by the manufacturer/laboratory are used when conducting blank measurements. For many detectors, blanks are unwrapped and immediately re-

wrapped (or momentarily opened and closed) to give the appearance that they have been used in testing. The blanks are then shipped with the exposed detectors so that the laboratory cannot distinguish them.

- *Laboratory blanks* are those returned to the laboratory immediately in order to evaluate laboratory quality yet also serve to evaluate if any unexpected exposures resulted during shipping or handling.
- *Office blanks* are those that remain in office locations where detectors are stored or handled in order to additionally evaluate any unexpected exposures that might result in those locations. Detectors should be stored and handled in a known low-radon environment.
- *Field blanks* are those that accompany the onsite sampling detectors in order to evaluate any unexpected exposures that might result onsite or from handling procedures.

Since blanks are not exposed, their measurement value should be below the lower limit of detection (LLD—the radon concentration below which the measurement system cannot accurately measure). Depending on the device, if one or more results are greater than the LLD, this may indicate defective detectors, poor quality control or improper procedures. If a problem is identified, the detector supplier should be contacted to evaluate and institute corrective procedures.

Spiked Measurements

Spikes are detectors that have been exposed in a NEHA-NRPP or NRSB approved chamber to a known concentration of radon (i.e. “spiked” with radon). Using spiked measurements can help evaluate the accuracy of a laboratory analysis and/or how accurately detectors supplied by a laboratory measure radon.

Detectors from the same batch as those slated for the sampling program are spiked and returned to the laboratory for analysis as near the sampling period as possible. Many detectors are time sensitive and require return to the laboratory for analysis immediately after spiking. In general, spikes are included at a rate of no less than 3 per 100 sampling locations. When establishing a testing service’s overall quality control plan, up to six spikes per month and a minimum of three per year are standard operating procedure. However, a specific testing program such as discussed herein for Multifamily buildings may require additional spiked detectors.

The results from spikes are compared to the known value provided by the reference facility where they are spiked using the formula for Relative Percent Error (RPE). The RPE is plotted on a control chart. If the result of a spike differs greatly from the spike’s known concentration, it may

indicate that the detectors are defective or the laboratory procedures are faulty. EPA 402-R-95-012, *Guidance on Quality Assurance* provides guidance on how to set warning and control limits. In general, the expectation is that the values of RPE fall between +10% and -10%, but the entire range of +20% to -20% is considered “in control.” Outside of +/-20% but inside +/-30% is the warning level and outside of +/-30% is the control limit.

See Appendix C “Definition of Terms” for information on calculating Relative Percent Error.

Quality Control for Continuous Monitors

Continuous radon monitors require calibration and background checks within the timeframe recommended and at facilities approved by certification requirements, state licensure requirements or the manufacturer’s recommendation, whichever is more stringent. Annual calibrations are commonly a minimum requirement. Cross-checks should be conducted at least every six months. Duplicates using a continuous monitor are to be deployed in 10% of the measurement locations. The agreement of duplicate results are calculated using the RPD as noted above and plotted on control charts. An informal intercomparison with a co-located device that reads in the same units (i.e. pCi/L) can also aid in checking quality.