

**GUIDELINES FOR
RADON/RADON DECAY PRODUCT TESTING
IN REAL ESTATE TRANSACTIONS
OF RESIDENTIAL DWELLINGS**

PREPARED BY

AMERICAN ASSOCIATION OF RADON SCIENTISTS AND TECHNOLOGISTS

REAL ESTATE TESTING COMMITTEE

BACKGROUND

This document, referred to as the Guide, has come about from the hard work over the past two years of many talented individuals who are professionally involved with radon. The Guide started in a real estate testing committee of the Eastern Pennsylvania Chapter of AARST. The committee's year and a half work was completed and turned over to a special sub-committee of the National AARST Technical Committee in October of 1990. This national committee is presently composed of the following individuals: Bill Brodhead (co-chair), Richard Roth (co-chair), Rich Tucker, Jack Dempsey, Dan Cutler, John Sykes, Ian Thompson, Bill Belanger.

This is the final version approved by this special committee.

To date there have been many inquiries for the most recent version of this Guide from state agencies in order to help them set state policies. It is anticipated that this will be the first such guidelines to address real estate testing directly and thus be influential in the direction that testing regulations take in this critical area.

It should be noted that AARST is presently preparing two other Guideline/Standards. A mitigation model code which is being prepared by Eastern Pennsylvania Chapter of AARST and a Radon/Radon Decay Product Instrumentation Test and Calibration Standard which is being drafted by John Sykes. The Instrumentation standard will fill the gap left in this document in regards to using, maintaining and calibrating active radon/radon decay product detectors.

Send all comments to Bill Brodhead
215-346-8004 or Fax 215-346-8575

**FINAL
DRAFT**

Version 17
September 1991

**GUIDELINES FOR RADON/RADON DECAY PRODUCT TESTING
IN REAL ESTATE TRANSACTIONS OF RESIDENTIAL DWELLINGS**

TABLE OF CONTENTS

INTRODUCTION	2
PURPOSE	2
SCOPE	2
1.0 TESTING GUIDELINES	3
1.1 Guidelines, State Regulations and Federal Protocols	3
1.2 Existing laws	3
1.3 Radon Survey by Certified Test Technician	3
1.4 Acceptable Detectors	3
1.5 Minimum Number of Measurements	3
1.6 Measurement Placement	3
1.7 Detector Non-Interference	4
1.8 Prior Closed-House Conditions	4
1.9 Closed-House Conditions	4
1.10 Obtaining Closed House Conditions	4
1.11 Explaining Test Conditions	4
1.12 Non-Interference Agreement	5
1.13 Radon Survey in Progress Form	5
1.14 Safety	5
1.15 Test Company Verification Minimum Requirements	5
1.16 New Construction Test Conditions	5
1.17 Long Term Testing	5
1.18 Post Mitigation Testing	6
2.0 QUALITY ASSURANCE	6
2.1 Quality Assurance and Operating Procedures	6
2.2 Manufacturers' Specifications	6
2.3 Detector Calibration Requirements	6
2.4 Laboratory Inter-Comparison Program	6
2.5 Inter-Comparison Errors	7
2.6 Passive Detector Blanks	7
2.7 Detector Duplicates	7
2.8 Daily Active Detector Checks	7
2.9 Active Detector QA Record Keeping	7
3.0 REPORTING TEST RESULTS	8
3.1 Test Report and Timeliness	8
3.2 Reporting Measurement Results	8
3.3 Mitigation Systems Status	8
3.4 Structural Openings	8
3.5 Reporting Test Variations	8
3.6 Test Limitations	8
3.7 Retesting Recommendations	9
3.8 Maintaining Records	9
DEFINITIONS	9

**GUIDELINES FOR RADON/RADON DECAY PRODUCT TESTING
IN REAL ESTATE TRANSACTIONS OF RESIDENTIAL DWELLINGS**

Appendix A.	Example of Radon Survey Agreement Form	14
Appendix B.	Example of Radon Survey Agreement Form	15
Appendix C.	Examples of Non-Interference Controls	16
Appendix D.	Example of Radon Survey Notification Form .	18

INTRODUCTION

The American Association of Radon Scientists and Technologists (AARST) is a national, non-profit professional and trade association devoted to benefiting the public health and to formulating measurement and remediation guidelines that assist its members in maintaining a high level of integrity, among other objectives.

Scientific studies since the 1950's have shown a direct relationship between elevated radon and radon decay product concentrations and an increased probability of the incidence of lung cancer. In view of the potential increased risk from lung cancer associated with elevated radon and radon decay products, we, as a professional association, recommend that every occupied dwelling be tested for radon or radon decay products as outlined in the EPA pamphlet, "A Citizen's Guide To Radon".

We further recommend that each time a residential dwelling is transferred to a new owner, because the dwelling is typically used differently by the new owner, it be tested for radon according to this Guide. The procedures of the "Citizen's Guide" are, however, inadequate for the complicating and demanding factors involved in typical short term radon testing during a real estate transaction. This Guide was deemed necessary to improve measurement reproducibility and to more easily detect and minimize the problem of test interference. This Guide goes beyond the "Citizen's Guide" in requiring testing of all the lowest livable areas of the dwelling because of the serious problem of varying radon levels due to short term testing in different seasons as well as the problem of the new owner unknowingly using areas of the dwelling that may not have been previously recommended to be tested.

We further recommend that because of the complicated nature of real estate transaction testing that it only be done by a professional radon test technician who is EPA proficient and/or state certified and that the test, as a minimum, be conducted according to the guidelines set forth in this Guide.

We also recommend that a short term test or tests be performed by a test technician after the installation of a radon mitigation system. If the results of this radon survey or any short term radon survey are below the EPA action level, a long term test or several short term tests in different seasons of the year should be conducted to verify that the levels have been adequately reduced.

PURPOSE

This Guide provides voluntary guidelines for AARST members and other radon measurement professionals. This guide shall be used when conducting radon and radon progeny measurements in residential dwellings involved in a real estate transaction. This Guide sets forth procedures and actions which will ensure that the potential for, or condition of, elevated radon levels will be accurately measured with a high level of quality assurance and in a manner that is ethical and professional.

SCOPE

This Guide applies to measurements of indoor radon and radon decay products made in conjunction with real estate transactions of residential dwellings as defined within this Guide.

GUIDELINES FOR RADON/RADON DECAY PRODUCT TESTING IN REAL ESTATE TRANSACTIONS OF RESIDENTIAL DWELLINGS

Compliance with this Guide requires that all applicable provisions be completely followed. Test companies are free to exceed the guidelines of this Guide if they or their clients so choose.

This is a living document that is not intended to limit innovative techniques or research, inhibit or prevent consumer choices or prevent positive changes in the industry. It will, therefore, be reviewed for content, applicability, and new developments on a periodic basis.

The appendices that follow this Guide are listed strictly as examples and are not a part of this Guide. The use of the information or examples in the appendices is not required to comply with this Guide.

1.0 TESTING GUIDELINES

1.1 Guidelines, State Regulations, and Federal Protocols

The guidelines of this Guide shall be followed unless superseded by the EPA Measurement Protocols or any federal or state regulations or certification requirements in the state in which the radon survey is being performed. In such cases, the federal or state requirements shall be followed for measurements performed in that state. If there are any local, state, or federal laws or regulations and the minimum requirements of this Guide exceeds them, then the Guide's minimum requirements shall be followed.

1.2 Existing Laws

All applicable existing laws, including but not limited to statutes, ordinances and regulations, shall be complied with by testing companies, testing technicians and all others in all locations in which the survey is being conducted. The test company shall not offer or perform any act or service contrary to law.

1.3 Radon Survey by Certified Test Technician

A radon survey in a state that has a certification program shall only be conducted by a state certified test company. In all cases, during a radon survey, primary measurement placement and retrieval of a detector shall only be performed by a test technician.

1.4 Acceptable Detectors

The primary measurements of a radon survey may only be performed with a detector with which the test company has successfully passed the most recent EPA RMPP round for that type of detector and/or has met any government recognized certification requirements of the state in which the detector is used. A testing company may employ the same type or a combination of different types of detectors exposed concurrently.

1.5 Minimum Number of Measurements

In order to comprehensively determine a dwelling's potential to have elevated radon levels, a radon survey shall have a minimum of one primary measurement in each lowest livable structural area of the dwelling. An example of the required test areas would be a split level style of dwelling with a basement, a slab on grade room, and a room over a crawl space. Each of these three separate areas would require one primary measurement. The test technician may make any number of additional or diagnostic measurements to obtain additional information.

**GUIDELINES FOR RADON/RADON DECAY PRODUCT TESTING
IN REAL ESTATE TRANSACTIONS OF RESIDENTIAL DWELLINGS**

1.6 Measurement Placement

The measurement placement shall conform to the current EPA measurement protocols for screening and follow-up measurements.

1.7 Detector Non-Interference

The testing device shall not be moved, covered or have its performance altered during the radon survey by anyone. Examples of performance alteration would be covering the detector, moving it to another location during the test period, or opening windows during a short term test.

1.8 Prior Closed-House Conditions

Closed-house conditions shall be maintained for twelve hours prior to the start of the radon survey, if the test period is four days or fewer in duration. The test company shall inquire with the responsible individual to determine if closed-house conditions have been maintained for the twelve hours prior to the start of the test.

1.9 Closed-House Conditions

Closed-house conditions require that all the windows shall be kept closed and external doors shall be closed except for normal momentary entering and exiting. Structural openings due to disrepair or structural defects that allow a significant amount of ventilation shall be repaired to correct their condition before a radon survey or prior closed house conditions are initiated. All windows and exterior doors shall be inspected by the test technician at the placement and retrieval of the detector.

Heating, air conditioning, and heat recovery ventilators can be operated normally. Operation of dryers, range hoods, and bathroom fans should be kept to a minimum. The responsible individual, however, should be informed that overuse of an appliance that exhausts air may effect the final readings.

Whole house fans shall not be operated. Portable window fans shall be removed from the window or sealed in place. Window air conditioning units shall only be operated in a recirculating mode. If the dwelling contains an air handling system, the air handling system shall not be set for continuous operation unless the air handling equipment is specifically used for radon control and labeled as such.

Fireplaces or combustion appliances shall not be operated unless they are the primary sources of heat for the dwelling. Ceiling fans, portable dehumidifiers, portable humidifiers, portable air filters and portable room air conditioners, shall not be operated in the same room as the detector.

1.10 Obtaining Closed House Conditions

The test technician shall take due and proper care in obtaining closed-house conditions during short term testing in order to increase measurement reproducibility. If the test technician discovers or visually observes that closed-house conditions were not maintained then the radon survey shall not be initiated until twelve hours of prior closed-house conditions have been maintained or, after closed house conditions have been obtained, the radon test period will be extended to more than four days with an appropriate detector. Appendix C gives examples of non-interference controls.

**GUIDELINES FOR RADON/RADON DECAY PRODUCT TESTING
IN REAL ESTATE TRANSACTIONS OF RESIDENTIAL DWELLINGS**

1.11 Explaining Test Conditions

The test company shall make reasonable efforts to determine who is the responsible individual for the dwelling during the test period. Before any primary measurements are begun the responsible individual shall be informed or attempted to be informed about the requirements of and the need for closed-house conditions as well as all other dwelling related conditions of the test.

1.12 Non-Interference Agreement

The responsible individual shall be requested to sign a non-interference agreement that indicates a knowledge of the testing conditions of this Guide and a willingness to co-operate in maintaining the required test conditions. If such an agreement cannot or will not be signed by the responsible individual, the test company shall indicate in the Report why the signature was not obtained. Appendix A and B are examples of Non-Interference Agreements.

1.13 Radon Survey in Progress Form

In order to help inform occupants about the test and the conditions of the test, a "radon survey in progress" notification form, with the conditions of the test stated on the notification, shall be posted, in a conspicuous location, at the dwelling upon initiation of a short term test. Appendix D is an example of a "radon survey in progress" notification form.

1.14 Safety

The test technician should not enter any area or perform any test that would damage property or risk his own or another's safety. If it is known that closed-house conditions will be detrimental to the health of the occupants, then the radon survey shall not be done.

1.15 Test Company Verification Minimum Requirements

A test company's minimum requirements for verifying test conditions shall be fulfilled by the following: informing the responsible individual of the test conditions, obtaining or attempting to obtain a signed non-interference agreement, conducting a visual inspection of the dwelling at the placement and retrieval of the detector, and posting a radon survey in progress notification form. This Guide does not require the test technician to be responsible for inspecting for closed-house conditions 12 hours before the start of the test or between placement and retrieval of the detectors.

1.16 New Construction Test Conditions

Newly constructed dwellings shall be tested in accordance with the guideline. The following items, if such items are part of the completed dwelling, shall be installed and completed before the radon survey is initiated: all insulation, all exterior doors, all windows, all fireplaces and fireplace dampers, all ceiling coverings, all interior trim and coverings for the exterior walls, all exterior siding, weatherproofing and caulking. If the test company knows construction work, which will affect the test results, is to be done inside the dwelling during the test period, then the test company shall re-schedule the test for another time.

1.17 Long Term Testing

If the radon survey is to be a long term measurement, closed-house conditions need not

**GUIDELINES FOR RADON/RADON DECAY PRODUCT TESTING
IN REAL ESTATE TRANSACTIONS OF RESIDENTIAL DWELLINGS**

be maintained. The test company should, however, recommend to the owner or occupant of the dwelling that at least half the test period should be during the season that the dwelling will most likely be operated with closed-house conditions and that reasonable closed-house conditions should be maintained during the test period so that the results of the test are more accurate indicators of the yearly average.

1.18 Post Mitigation Testing

A radon survey made immediately after completing a radon mitigation system shall not be initiated for a minimum of 24 hours after the system is completed and operating if the test period is four days or less. Closed-house conditions shall be maintained for the 24 hours preceding the start of this test. Test periods that are greater than four days, however, can be started immediately after completing the radon mitigation system and the closing up of the dwelling. Each lowest livable structural area of the dwelling shall be tested as specified in 1.5 and 1.6.

2.0 QUALITY ASSURANCE

2.1 Quality Assurance and Operating Procedures

The test company shall have and abide by a written Quality Assurance Plan (QAP) and written Standard Operating Procedures (SOP). The QAP and SOP shall be prepared in accordance with the EPA Measurement Protocols as well as any relevant EPA, AARST, ANSI or ASTM standards or detector manufacturers' instructions.

2.2 Manufacturers' Specifications

All detectors used for primary measurements shall be operated according to manufacturers' specifications.

2.3 Detector Calibration Requirements

A calibration preceded by a pre-calibration, if pertinent, shall be done for all active detectors and a minimum of four of each type of passive detectors used for primary measurements at least once each calendar year. These procedures may be performed by the test company, or by a qualified third party such as a calibration laboratory or the equipment manufacturer.

2.4 Laboratory Inter-Comparison Program

Each type of active detector or a minimum of four of each type of passive detector used by the test company for primary measurements shall be entered into and pass a laboratory inter-comparison program such as the EPA RMP Program or an equivalent AARST, Federal or State approved program. Participation in the program shall be in accordance with the applicable protocols for said program. The frequency of participation shall be in accordance with the protocols for the program, which should be at least once every two years.

2.5 Inter-Comparison Errors

If the inter-comparison produces an "ARE" for any active detector or a "MARE" for a group of similar passive detectors that is greater than 25%, then the test company shall discontinue using the detector(s) or equipment used to read the detectors until the problem

**GUIDELINES FOR RADON/RADON DECAY PRODUCT TESTING
IN REAL ESTATE TRANSACTIONS OF RESIDENTIAL DWELLINGS**

is corrected and the detector accuracy is confirmed by another inter-comparison.

2.6 Passive Detector Blanks

QAPs for testing companies that utilize passive detectors shall include a minimum of approximately 5% of each type of passive detector deployed or 25 each month, whichever is smaller, set aside as blanks. These blanks shall be treated identically to similar field detectors except they should be kept sealed during the exposure period of the field detectors and analyzed along with the field detectors using similar exposure times. If one or more of the blanks produces a measurement result that is significantly greater than the Lower Level of Detection (LLD) or other standard specified by the manufacturer for that detector, then three additional blanks, if possible from the same batch, shall be similarly exposed and analyzed. If any of these blanks also produce measurement results greater than the LLD, commercial use of this detector type shall be discontinued until correction is made and verified.

2.7 Detector Duplicates

Testing companies shall carry out duplicate measurements with a minimum of approximately 10% of each type of detector deployed for primary measurements or 50 each month, whichever is smaller. Different types of radon detectors that measure the same units can be used for duplicates. It is considered a good practice to occasionally compare the performance of a detector with a different type of detector that measures the same units. If possible, the detector analysis should be done without the analysts knowledge that it is a duplicate measurement. These duplicates should be distributed throughout the radon surveys conducted during the month. If the Relative Mean Deviation (RMD) of any of these duplicate measurements at radon concentrations greater than 4 pCi/l is greater than 10%, then either the next radon exposure of the detector shall have four identical detectors placed side by side or the next three measurements using the same detector shall be done with duplicates. If either the four replicate measurements or any of the three individual followup duplicates produces a RMD greater than 10%, then use of this detector shall be discontinued until the precision of the detector is verified to be within the above guideline.

2.8 Daily Active Detector Checks

All active detectors shall have a function test once each day the equipment is used, prior to it being used. All equipment used to read passive detectors shall be tested with a check source or a constancy source once each day that the equipment is used, prior to it being used.

Active detectors may substitute the requirement of duplicate measurements specified in section 2.7 with a check source test used prior to the detector being used. Quality control charts shall be maintained to document the detector response to the check source and the results of the function tests. If at any time the instrument response to the check source or function tests varies by more than the control chart limits or the manufacturers' specifications, then the detector shall be adjusted, repaired, or calibrated as required.

2.9 Active Detector QA Record Keeping

Each active detector shall have its identification code and its latest calibration date written on the outside of the detector. All QA, calibration and check source data shall be recorded and maintained by the test company for at least five years.

**GUIDELINES FOR RADON/RADON DECAY PRODUCT TESTING
IN REAL ESTATE TRANSACTIONS OF RESIDENTIAL DWELLINGS**

3.0 REPORTING TEST RESULTS

3.1 Test Report Timeliness

The Report shall be in writing and either mailed first class, faxed or hand delivered to the client within five business days after the results are obtained by the test company. All reporting statements required by this Guide shall be included in the Report. The client should be informed of any reporting of results to persons other than the client.

3.2 Reporting Measurement Results

The Report shall contain all individual primary measurement results, the exposure period and the detector locations. The Report shall contain a description of the type of detector used, its manufacturer, model or type and the detector identification numbers. No average of any measurements made throughout the dwelling shall be reported. Any diagnostic measurements shall be reported as such.

The measurements shall be reported in units that are appropriate to the measurement method. Any test report that converts measurement results to the unit of another product shall, as a minimum, disclose the limitations and the possibility for variations of such converting. A statement similar but not limited to the following shall be used:

Conversions from WL to pCi/L or pCi/L to WL are made by estimating the percentage of potential radon decay products that are left suspended in the air being tested. This estimated converted value may or may not be close to the actual value.

3.3 Mitigation System Status

The test company shall include a statement in the test report if a mitigation system was observed in a dwelling during the placement or retrieval of the detector(s) and indicate in the report whether the system appeared to be operating. The test company may wish to include a statement in the Report that the test company offers no findings as to the proper operation of the system.

3.4 Structural Openings

Any readily visible structural openings shall be described in the Report.

3.5 Reporting Test Variations

Any observed or discovered deficiency from the required test conditions during the test period, that the test company discovers, shall be included in the Report. The Report shall indicate or describe if the test company discovers, at the time of placement or retrieval of the detector, that the test area is not at a normal occupied temperature.

3.6 Test Limitations

The Report should describe the general limitations of the test such as the following statement:

There is an uncertainty with any measurement result due to: statistical variations and other factors; daily and seasonal variations in radon concentrations due to changes in the weather and operation of the dwelling; severe storm occurring during a short term test period; interference with the necessary test conditions that may or may not

**GUIDELINES FOR RADON/RADON DECAY PRODUCT TESTING
IN REAL ESTATE TRANSACTIONS OF RESIDENTIAL DWELLINGS**

influence the results.

3.8 Retesting Recommendations

All test results shall include a statement which recommends that the dwelling be retested for each of the following situations that occur to the dwelling whether or not the dwelling has been mitigated:

- a) Occupancy by a new owner
- b) Six months since a short term test or three years since a long term test
- c) A new addition is added
- d) An alteration is made that could change the ventilation pattern
- e) Major cracks or penetrations occur in the foundation walls or slab
- f) Significant nearby construction blasting or earthquakes occur
- g) Changes are made or happen to an installed mitigation system

3.9 Maintaining Records

Radon and radon decay product measurements are a radiation exposure measurement. Because of the nature of the health effect of radon and radon decay products, measurement data should be maintained permanently.

DEFINITIONS

Terms used in this Guide are defined as follows:

Action Level - The level of radon or radon decay products in a dwelling above which the EPA recommends taking corrective action to reduce the radon level and below which the EPA recommends that the occupants should decide if they should take corrective action to further reduce their exposure.

Active Detector - A radon or radon decay product detector or instrument used for reading detectors, which includes electronics or a pump.

ANSI - American National Standards Institute

ARE - The absolute value of the relative error. The EPA defines ARE with the following formula:

$$\text{ARE} = | (\text{MV} - \text{AV}) / \text{AV} |$$

where:

MV = Measured Value, and
AV = Actual Value.

ASTM - American Society of Testing and Manufacturing

Attic Ventilator - An exhaust fan installed in the roof or gable of a dwelling that is used to ventilate the attic space.

Average - The number obtained by dividing the sum of a set of quantities by the number of quantities in the set.

Becquerels Per Cubic Meter - It is a radon measurement unit abbreviated as Bq/m³. One pCi/L is equivalent to approximately 37 Bq/m³.

Calibration - A comparison of the response of a given detector with the response of a traceable active detector when both are exposed to the same radiation source under the same conditions; or the determination of the response of a given active detector under well defined conditions when exposed to the output of a traceable source.

**GUIDELINES FOR RADON/RADON DECAY PRODUCT TESTING
IN REAL ESTATE TRANSACTIONS OF RESIDENTIAL DWELLINGS**

Check Source - A radioactive source, not necessarily calibrated, which is used to confirm the continued satisfactory operation of a detector.

Citizen's Guide - EPA Document OPA-86-004, "A Citizen's Guide To Radon", or any revision, amendment or substitution to this document. The Citizen's Guide includes an explanation for homeowners of what radon is, how to test their own house for it, and what action would be appropriate based on the test results.

Client - Person, persons, or businesses who have contracted with a radon test company to perform a radon survey in a dwelling involved in a real estate transaction.

Closed-House Conditions - Those conditions defined in the EPA Measurement Protocols and this Guide for the limiting of building ventilation prior to and during a radon survey.

Combustion Appliance - A unit designed for heating that burns a fuel inside a dwelling that should have the exhaust gases vented to the outside. Examples of this are wood/coal stoves, fireplaces, oil and gas furnaces, boilers and water heaters. A freestanding kerosene stove is not included in this definition.

Constancy Check - An essentially constant signal source of the same type measured by a readout instrument used to produce an observable response by that instrument, for comparison with previous response to the same source under the same circumstances; e.g. a reference electret for electret voltage readers or a film with a known number of tracks to be used with alpha track counting equipment.

Detector - A complete system designed to measure radon/radon decay products in the air. {Such a system may be comprised of one or more of the following components: passive sampler, air moving system, active detector, amplifier, analyzer and read out instrument.} The test company using the detector shall have successfully passed the most recent EPA RMPP round with that type of detector and/or has met any government recognized certification requirements of the state in which the detector is being used.

Diagnostic Measurements - Measurements used to help diagnose radon entry routes, radon flux, and building conditions. A radon survey does not require diagnostic measurements. This Guide does not address how diagnostic measurements are to be made or the equipment requirements.

Duplicate Measurements - Detectors that are exposed for the same time period and are co-located such that they are exposed to the same radon/radon decay product concentrations, the same environmental conditions and, as much as practical, have been handled the same.

Dwelling - A permanent residential structure that is or could be occupied at least 10 hours per week. Excluded are dwellings that are situated above livable spaces over which the occupant of the dwelling has no control. It does not include commercial, industrial, or institutional buildings.

EPA - The United States Environmental Protection Agency.

EPA Measurement Protocols - The following EPA documents: "Interim Indoor Radon and Radon Decay Product Measurement Protocols" (EPA 520/1-86-04, April 1986); "Interim Protocols for Screening and Follow-up Radon and Radon Decay Product Measurements" (EPA 520/1-86-014-1, February 1987); and "Indoor Radon and Radon Decay Product Measurement Protocols" (February 1989) or any revisions, amendments, or replacements to these documents that describe how a radon measurement is to be made. Any reference to EPA Protocols refers to those in effect at the time of testing.

Equilibrium Ratio - The ratio of the potential alpha energy concentration in the air to that which would exist if all short lived radon decay products were in equilibrium with the radon present. A formula for determining the equilibrium ratio is:

$$ER = (WL \times 100) / pCi/L.$$

**GUIDELINES FOR RADON/RADON DECAY PRODUCT TESTING
IN REAL ESTATE TRANSACTIONS OF RESIDENTIAL DWELLINGS**

Follow-up Measurements - Radon measurements that are made to confirm the results from previous measurements or to better estimate the average yearly radon levels by making longer measurements.

Function Test - The checking and adjusting of a detector's functions, as specified by the manufacturer, prior to exposure to a check source or the beginning of a test period. These tests may include, but are not limited to, the following; checking system air flow, checking battery condition, or obtaining background radiation or instrument counts.

Guide - This document or any revision, amendments, or replacements to this document.

Lived-In Area - A habitable space within a dwelling that is used for cooking, dining, eating, sleeping or where an individual or individuals spend four or more hours per day. An example of a lived-in area would be a basement where children play. Lived-in does not include areas used for closets, storage, hallways, utility rooms, or bathrooms.

Long Term Testing - Any radon or radon decay product measurement that is acknowledged as appropriate and acceptable in the EPA Measurement Protocols and has a duration of more than ninety days.

Lowest Livable Area - The lowest level of the dwelling that is a lived-in area or the lowest level that could be converted into a lived-in area without major structural changes such as lowering the floor to create necessary head room.

Make-up Air - Fresh air that is routed directly from the outside to a combustion appliance to supply combustion air that would otherwise be drawn from indoor air.

MARE - The mean absolute value of the relative errors as defined by the EPA. The MARE equals the average of the ARE's.

Mean Deviation - "M.D." The average of the absolute values of the deviation between multiple measurements that are made side by side as determined by the formula where:

$$\text{M.D.} = \frac{\sum |x|}{n}$$

$|x|$ = absolute value of a device's deviation from the average
 \sum = sum of the number that follows
 n = number of devices

Mitigation System - The permanent installation of materials, equipment or an apparatus that is specifically designed to reduce radon or radon decay product levels in a dwelling.

National Standard - An detector, source or other system or device maintained and promulgated as such by the US National Institute of Standards and Technology (NIST).

Non-Interference Agreement - A written agreement that is signed by both a representative of the test company and by the owner or the responsible individual of the dwelling being tested, and which states that the responsible individual that signed the agreement understands and shall maintain the necessary conditions for a proper test to be conducted.

Normal Occupied Temperature - Typically this is between 65 and 85 degrees in the lived in portions of the dwelling. It can however be different in rooms that are occupied irregularly, such as an unfinished basement or a sun room.

Occupant - A person living in a dwelling who may or may not be the owner of the dwelling and is responsible for the dwelling.

Passive Detector - A radon or radon decay product measuring device that contains no energized electronic parts or pumps. Examples of passive detectors are charcoal canisters and vials, electret ion chambers, or alpha track detectors.

pCi/L - A unit of measurement of the concentration of radioactivity in a fluid, usually a gas. One pCi/L corresponds to 0.037 radioactive disintegrations per second in a liter of air. One pCi/L is the equivalent of 37 Bq/m³.

GUIDELINES FOR RADON/RADON DECAY PRODUCT TESTING IN REAL ESTATE TRANSACTIONS OF RESIDENTIAL DWELLINGS

Pre-Calibration - A procedure whereby the detector, detector components or circuits is evaluated and/or adjusted for satisfactory operation. {Typical detector test procedures may include one or more of the following: checking or replacing batteries, evaluating or adjusting the; detector zero, power supply output, high voltage settings, amplifier gain, meter response, internal clock, and system air flow.}

Primary Measurement - Radon or radon decay product measurement that provides an averaged concentration over the exposure period. The detector shall be located as specified in the EPA Measurement Protocols. The detector shall operated in accordance with the recommendations of the detector manufacturer or supplier. The detector exposure time shall not be less than the recommended time as specified in the EPA Measurement Protocols, the Citizen's Guide or any future EPA real estate testing protocols. The detector shall not be exposed for fewer than 48 continuous hours.

Radon - When used in this Guide without modification, the terms "radon" or "radon measurement" refer to the radioactive elements radon (^{222}Rn) and/or its short-lived decay products. If this Guide states "radon gas", the term refers only to ^{222}Rn , a naturally occurring radioactive element, which is a gas and is measured in units of picocuries per liter (pCi/L) or in units of Becquerels per cubic meter (Bq/m³).

Radon Decay Products - Refers to the first four decay products of radon gas: Polonium 218, Lead 214, Bismuth 214, and Polonium 214. Radon decay products are also referred to as radon progeny or radon daughters. The concentration of these products is a combined measurement that is reported in units of working level (WL).

Radon Survey - The process of a test company following the guidelines of this Guide and making one or more primary measurements to sample and analyze the air of a dwelling, either passively or actively so as to measure the radon or radon decay product concentration during the test period in the areas being sampled.

Real Estate Transactions - This refers to the transfer of the title of a dwelling to a new owner or the refinancing of a dwelling by the owner and preparing for such actions.

Relative Mean Deviation - "RMD" The percentage of difference between duplicate measurements that are made side by side as determined by the formula:

$$\text{RMD} = \left| \frac{(M1 - M2)}{M1 + M2} \right| \times 100$$

M1 = 1st measurement result
M2 = 2nd measurement result

Report - A written test report of a radon survey that includes all of the primary measurements and testing information required by this Guide.

Responsible Individual - This refers to the person or persons who is/are responsible for assuring that the test conditions required by this Guide are being followed during a radon survey. This responsible individual does not necessarily have to be the owner of the dwelling.

RMPP - Radon Measurement Proficiency Program sponsored by the EPA to determine the proficiency of testers testing for radon gas and radon decay products.

Severe Storm - The condition outdoors of abnormally high wind speed or rainfall at a dwelling during a test period. An example is when for two hours or more the winds averaged at least 25 miles per hour greater than the normal wind speed and/or there has been over 1/2" of rainfall within 24 hours.

Shall - indicates a requirement that is necessary to fully adhere to the provisions of this Guide.

Short Term Testing - Any radon or radon decay product measurement that is a primary measurement and has a duration of from two to ninety days.

**GUIDELINES FOR RADON/RADON DECAY PRODUCT TESTING
IN REAL ESTATE TRANSACTIONS OF RESIDENTIAL DWELLINGS**

Should - indicates an advisory recommendation that is to be applied whenever practical.

Structural Area - Each area of a dwelling located directly above a distinct foundation type. Examples of distinct foundation types are: basement; crawl space; or slab on grade.

Structural Openings - These are visible openings from the livable and lived-in portions of the dwelling to the outside that allow a significant exchange of air between the inside and the outside. Examples are large air spaces around pipes that penetrate above grade, windows that are broken or will not fully close, large gaps around cellar doors, and crawl space foundation vents.

Test Period - This includes the continuous sampling time of the radon or radon decay product detector. If the detector sampling period is four days or fewer in duration, then the test period must be immediately preceded by 12 hours of closed-house conditions. The detector exposure period shall be in increments of 24 hours, plus or minus 2 hours for each day of exposure length. This means that a three day test can be exposed from 66 to 78 hours. The exceptions to this are: an exposure period cannot be fewer than 48 hours; an exposure period cannot be less than the minimum exposure time recommended in the EPA Measurement Protocols, future EPA real estate testing protocols, the Citizen's Guide, or regulations of the state in which the test is being carried out; an exposure period shall be in accordance with the manufacturer or supplier recommendations.

Test Company - A company, their representative or a test technician who provides a radon survey for a dwelling involved in a real estate transaction.

Test Technician - The person responsible for placing and retrieving the radon or radon decay product detector. This person may be either the owner, employee or sub-contractor of the test company. This technician shall abide by all the requirements of the state in which the test is being conducted. The technician shall be under the supervision of the test company. The technician shall have, as a minimum, attended a state or federally approved radon testing course that fulfills any necessary educational requirements for state certification in the state in which the test is being performed, or shall have been continually employed for one year as a test technician under the supervision of a state certified company.

Traceable - The ability to show that a particular detector or radiation source has either been calibrated using a National Standard or has been calibrated using a transfer instrument in a chain or echelon of calibrations ultimately leading to a comparison with a National Standard.

Transfer Instrument - Instrument or device exhibiting high precision which has been calibrated against a National Standard.

Whole House Fan - A large exhaust fan used to ventilate the whole dwelling. Typically the fan is installed in the ceiling or attic of the dwelling and draws air from the ceiling of the highest floor of the dwelling.

Working Level (WL) - A measurement unit of the energy that is released by the successive disintegrations of the four short term decay products that follow radon gas in a measured volume of air over a specified amount of time. $1 \text{ WL} = 1.3 \times 10^{-5} \text{ MeV}$. If the equilibrium ratio is 50% then 1 WL will prevail at a radon concentration of approximately 200 pCi/l.

APPENDIX A

EXAMPLE OF A NON-INTERFERENCE RADON SURVEY AGREEMENT FOR RESIDENTIAL DWELLINGS

REQUIRED CONDITIONS OF THE RADON SURVEY

Radon and radon decay product concentrations in a dwelling fluctuate. The following test recommendations were developed by the EPA to provide standardized conditions under which a short term radon survey is to be performed in order to reduce the variation in radon levels in a dwelling. These conditions will tend to maximize the radon measurement in order to determine if a dwelling has the "potential" to have an elevated radon level. If the result is elevated, the EPA recommends further testing to better determine the yearly average concentration.

The radon technician has my permission to install and retrieve radon testing devices at the property listed below. AGREE ___ DISAGREE ___

I/WE will not move, cover or try to alter or affect the performance of the test devices. AGREE ___ DISAGREE ___

I/WE will not touch, and/or remove any non-interference controls that may be used. AGREE ___ DISAGREE ___

I/WE will not operate equipment, excluding heat recovery ventilators, that brings fresh air directly into the dwelling. AGREE ___ DISAGREE ___

I/WE will not use any whole house ventilating fans, wood stoves or fireplaces unless they are primary heaters. AGREE ___ DISAGREE ___

I/WE will keep all windows closed and external doors closed except for normal momentary entering and exiting. AGREE ___ DISAGREE ___

I/WE agree that the normal occupied operating temperature be maintained at the test location. AGREE ___ DISAGREE ___

I/WE will notify the testing co. during or at the test conclusion if any conditions of the agreement are violated. AGREE ___ DISAGREE ___

I/WE agree that the above conditions have been or will be maintained by all persons at the test location during the testing period and if the measurement period is four days or less verify and agree that these conditions have been or will be maintained for the 12 hours before the detector is exposed. AGREE ___ DISAGREE ___

Property Address: _____

Detector Type & Locations Test Technician: _____

1st: _____ Responsible Individual: _____

2nd: _____ Real Estate Agent: _____

3rd: _____ Signing Date: _____

Installed Date/Time: _____ Retrieval Date/Time: _____

Comments:

APPENDIX B

EXAMPLE OF A NON-INTERFERENCE RADON SURVEY AGREEMENT FOR RESIDENTIAL DWELLINGS

REQUIRED CONDITIONS OF THE RADON SURVEY

Radon and radon decay product concentrations in a dwelling fluctuate from hour to hour, from day to day and from season to season. The following test recommendations were developed by the EPA to provide standardized conditions under which a short term radon survey is to be performed in order to reduce the variation in radon levels in a dwelling. These conditions will tend to maximize the radon measurement in order to determine if a dwelling has the "potential" to have an elevated radon level. If the result is elevated, the EPA recommends further testing to better determine the yearly average concentration.

If the test conditions below are not adhered to, the test results may be deemed invalid.

The following conditions must be read, understood and followed:

All windows must be kept closed. All doors must be kept closed except for normal, momentary entering and exiting.

The radon detector cannot be moved, covered or altered in any way. Heating, air conditioning, dryers, range hoods, bathroom fans and attic ventilators can be operated normally. If any heating, air conditioning or ventilating equipment has a built in outdoor air supply that is manually controlled, it shall be turned off or the inlet closed. Fireplaces or wood stoves shall not be operated, unless they are a primary heat source. Whole house fans shall not be operated. Window fans shall be removed or sealed shut.

These test conditions shall be maintained for 12 hours prior to the start of the radon detector being exposed, unless the test is longer than four days in duration.

If there are any questions, or the test conditions are not met, please contact the test company at (Co. Phone Number)

I/We the responsible individual or building custodian understand and will inform all occupants of this dwelling of the above conditions of the test. I/we agree to maintain these conditions during the test period.

Property Address: _____

Test Technician: _____

Responsible Individual: _____

Installed Date/Time: _____ Retrieval Date/Time: _____

Detector Locations: _____

Detector Locations: _____

Detector Locations: _____

Date: _____ Comments: _____

APPENDIX C

NON-INTERFERENCE CONTROLS

INTRODUCTION

The following are examples of non-interference controls which may or may not be used to help deter or determine that interference has occurred during a radon survey. These examples do not provide complete assurance that a radon survey has or has not been interfered with.

This appendix is provided for reference purposes only and are not required by the Guide to verify closed-house conditions unless these examples are directly specified in the Guide.

EDUCATION

Before the radon survey is begun, educate all responsible individuals of the dwelling to be tested about the necessary test conditions of the radon survey, and the need to adhere to these conditions to ensure the validity of the test results. The responsible individuals includes the owner and occupants of the dwelling and may also include the real estate brokers or any individuals responsible for the dwelling during the test.

Install a radon survey in progress notification form which describes the necessary conditions of the test in a prominent location. If the dwelling is vacant, post the notification on or near all exterior doors that are normally used for entrance into or out of the dwelling.

AGREEMENTS

Request the owner or responsible individual for the dwelling, to read and sign a non-interference agreement.

WINDOWS & DOOR SEALS

Windows, especially those in the same room as the detector, can be marked with seals placed between the window sash and the jambs to identify any movement. Some seals should be visible to help deter anyone from attempting to open the window during the test period. The window can also have invisible seals installed to reduce the chance of someone removing all the seals and later replacing the removed seals when the window is closed. Some of the possible seal materials include clear double stick tape, white paper seals, and removable non-staining adhesive caulk. The seals can be more tamper proof by using color coded tape or coloring the tape at the test site, initialing or coding white paper seals or slicing the seals to make it difficult to remove or open the window without tearing the seals.

Exterior doors that are not the primary entrance into the dwelling can be sealed in a similar manner as the windows or with seals on the door hinges.

DETECTORS

A continuous radon or radon decay product detector can be used that gives interval measurements. An unusual variation in concentrations might indicate that the dwelling was ventilated or the performance of the equipment was altered or that severe weather conditions took place during the exposure period.

To determine if a detector is moved during a test period, the detectors can be installed in a noted position or on top of a paper with a coded grid or light sensitive paper. The paper would first be installed with double stick tape to secure it in place. The detector would then be placed in a noted location on the grid so that any movement of the detector could be determined at the time of retrieval. The movement of the detector can then be documented by drawing a circle around the detector in its changed position.

The radon entry location into the detector could have a loop of double stick tape installed in such a manner that it does not obstruct the entry of radon into the detector but reduces the possibility of the entry location being covered.

The detector could be placed in or on a motion detector that does not interfere with the performance of the detector but detects any movement.

APPENDIX C cont.

NON-INTERFERENCE CONTROLS

The detector could be placed to overhang the edge of its stand so that any attempt to cover it up would be difficult.

If the detector stand is portable, the stand could be taped to the floor in a manner that would indicate any attempt to move the stand.

VENTILATION EQUIPMENT

Switches which control ventilation equipment can be held in place with a double stick tape or white initialed tape. This may include the fresh air supply control for a window air conditioner or the manual fan switch for a forced air system.

GRAB SAMPLES

Grab samples taken of radon and/or radon decay products at the beginning and/or end of the test period can be compared to the average test results from the whole exposure period. If there is a significant difference in the readings, it might indicate the building had been ventilated either before or during the exposure period. Grab samples can be used to locate the measurement device in the highest radon location that still falls within the placement locations of the Guide.

MEASUREMENTS of RADON and RADON DECAY PRODUCTS

If both radon and radon decay product measurements are made at the same time at the beginning and/or at the end of a measurement period or during the measurement period, the equilibrium ratio between the readings can be obtained. If there is significant variation in the readings or the equilibrium ratio is unusual, it may indicate that excessive ventilation has taken place. Unusual equilibrium ratios can also indicate that one or more of the detectors is out of calibration.

TEMPERATURE MEASUREMENTS

Temperature readings of the outdoor and the indoor testing area taken at the beginning and end or during the measurement period might indicate excessive ventilation took place if the indoor temperature is significantly closer to the outdoor temperature as compared to the normal occupied temperature of the dwelling.

MEASUREMENT COMPARISONS

The measured radon levels taken in the basement can be compared with the levels of the upper floors to determine if they fall within a comparative range that would be expected for the type of house construction, air handling equipment and usage, weather conditions and occupant operation of the dwelling.

APPENDIX D

EXAMPLE OF RADON SURVEY IN PROGRESS NOTIFICATION FORM

RADON SURVEY IN PROGRESS

DO NOT REMOVE THIS NOTIFICATION

The following conditions must be maintained:

- 1) Do not open any windows. Do not open any doors except for normal momentary entering and exiting.
- 2) Do not touch, cover, move or alter the performance of any radon detectors or non-interference controls.
- 3) Do not operate any whole house fan(s). Do not use any fireplace(s) or wood stove(s), unless they are the primary heat source.
- 4) Operate heating and air conditioning normally. Turn off and keep off any equipment that supplies fresh air to the dwelling unless it is vented supply air to a combustion appliance.

NOTE:

The dryer, range hood, bathroom fan or attic ventilating fan, can be operated. This equipment should only be operated normally because any exhaust fan or any combustion appliance may increase the negative pressure in the dwelling, which can raise or lower the radon concentration. Windows must be kept closed because they can create negative pressure in the lower portions of the dwelling due to the warm air escaping or the direction of the wind, which can raise or lower the radon levels.

Test Period From: _____ To: _____

Responsible Individual: _____

Date: _____

9/21/91

Dear AARST Board of Directors;

It has been a year that a special sub-committee of the AARST Technical committee has been working on a final draft of the Real Estate Testing Guidelines. We finally have completed it with a lot of work from the committee. We all feel very good about this guideline and are anxious to see it distributed as quickly as possible. The EPA is quickly drawing up their real estate testing guideline and we feel it is imperative that we get this out so that we can influence that document.

Please review this document and have a signed vote back to me no later than Friday, October 4th. If there are grammar changes that you find, please include them with your vote. If you feel there are important changes that should be made in the document, please forward those to me as soon as possible so that I might distribute them for a vote for a change in the document.

Please circle your choice and return ASAP.

- A) I Approve of Guide 17
- B) I do not Approve of this Guide
- C) I Approve of Guide 17 with the following recommended changes:

Board of Director Signature: _____

DATE: _____