

Public Review: MALB/MAMF 09-2020

Work on harmonization of text between these two standards resulted in significant improvements and similar scope, due to so many mix-use buildings.

The holistic review resulted in many technical improvements and conversion to sentence styles that aid assessments for compliance with the standard.

In addition to technical review, the consensus body will be looking for comments that support or disagree with merging these two standards.

COMMENT DEADLINE: November 9th, 2020

REQUESTED PROCESS AND FORM FOR FORMAL PUBLIC REVIEW COMMENTS

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- 1) Do not submit marked-up or highlighted copies of the entire document.*
- 2) If a new provision is proposed, text of the proposed provision must be submitted in writing. If modification of a provision is proposed, the proposed text must be submitted utilizing the strikeout/underline format.*
- 3) For substantiating statements: Be brief. Provide abstract of lengthy substantiation. (If appropriate, full text may be enclosed for project committee reference.)*

REQUESTED FORMAT

Title of Public Review Draft: **MALB/MAMF 09-2020**

- **Name:** _____ **Affiliation:** _____
- **Clause or Subclause:** _____
- **Comment/Recommendation:** _____
- **Substantiating Statements:** _____
- ☐ Check here if your comment is supportive in nature and does not require substantive changes in the current proposal in order to resolve your comment.

Repeat the five bullet items above for each comment.

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Introduction For Reviewers

Proposed revisions to MALB and MAMF

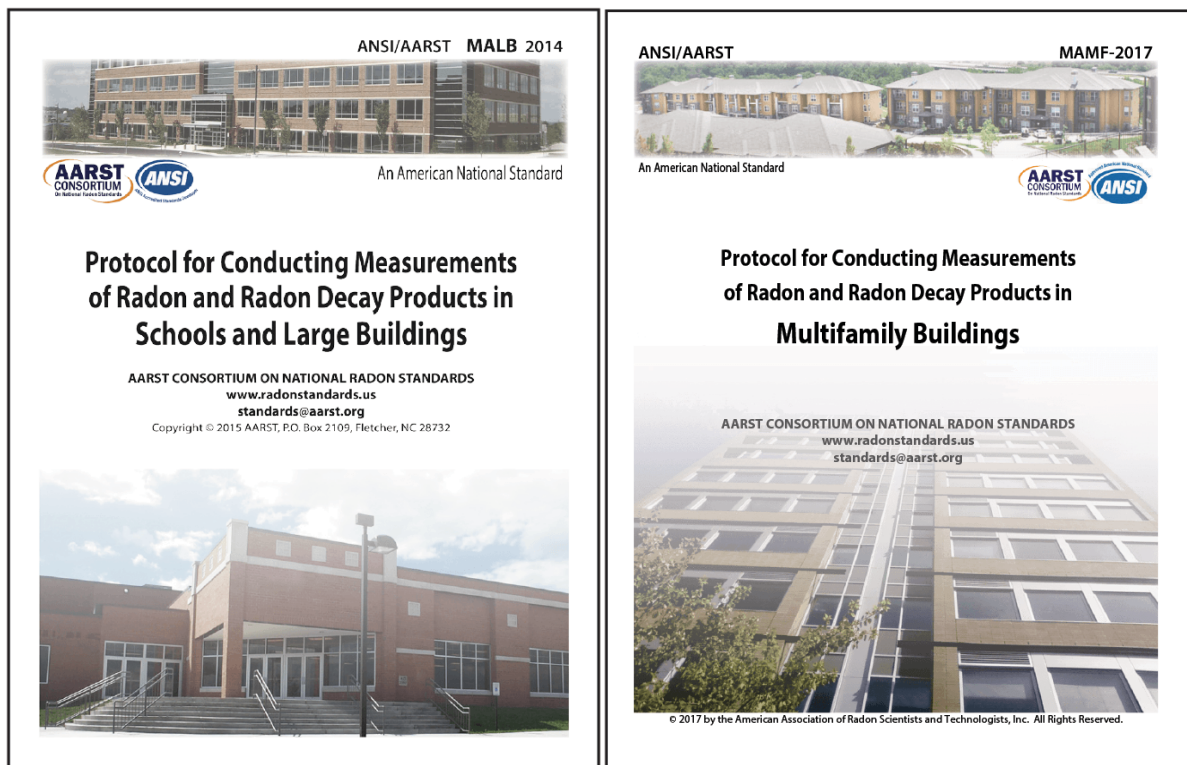


Work on harmonization of text between these two standards resulted in significant improvements and similar scope, due to so many mix-use buildings.

The holistic review of both standards resulted in many technical improvements and conversion to sentence styles that aid assessments for compliance with the standard.

In addition to technical review, the consensus body will be looking for comments that support or disagree with merging these two standards.

Currently published versions of these standards are available for review at www.standards.aarst.org.



Introductory Content

Designation of the standard: MAMF

As used for catalogue identification, “MAMF” stands for Measurement of Air in Multifamily buildings.

Designation of the standard: MALB

As used for catalogue identification, “MALB” stands for Measurement of Air in Large Buildings

Normative References

ANSI/AARST MS-QA “*Radon Measurement Systems Quality Assurance*”

In regards to conducting *radon decay product (RDP)* measurements, ANSI/AARST MAH “*Protocol for Conducting Measurements of Radon and Radon Decay Products in Homes*”

The Consensus Process

The consensus process developed for the AARST Consortium on National Radon Standards and as accredited to meet essential requirements for American National Standards by the American National Standards Institute (ANSI) has been applied throughout the process of approving this document.

Continuous Maintenance

This standard is under continuous maintenance by the AARST Consortium on National Radon Standards for which the Executive Stakeholder Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard.

User Tools: User tools are posted online (www.standards.aarst.org/public-review) as they become available (such as templates for field notices, inspection forms, interpretations and approved addenda updates across time).

AARST Consortium on National Radon Standards

Website: www.standards.aarst.org Email: standards@aarst.org

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MALB/MAMF

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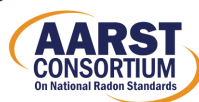
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A Reporting Building Operating Conditions	
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MEAS STANDING COMMITTEE (CONSENSUS BODY MEMBERS)

Protocol for Conducting Measurements of Radon and Radon Decay Products in Multifamily Buildings, Schools and Large Buildings



1.0 SCOPE AND PURPOSE

1.1 Scope

This standard of practice specifies procedures and minimum requirements when measuring *radon* concentrations in shared structures, or portions of shared structures, used for residential, non-residential or mixed use purposes¹ to determine if *radon mitigation* is necessary to protect current and future occupants. These protocols address low-rise and high-rise structures and procedures for testing whole buildings but also for testing only one or several individual rooms or dwellings within a shared building.

1.1.1 *Multifamily and other residential occupancies*

The protocols in this standard of practice address residential occupancies that include:

- a) buildings having more than one attached dwelling or other occupied unit under the same ownership or designated maintenance or management authority;
- b) buildings or structures, or a portion thereof that are used, for example, as apartment houses, dormitories, military congregate residences, fraternities and sororities, non-transient boarding houses, hotels, convents, monasteries, motels, and live/work units; and
- c) multifamily structures that can include those with shared ownership or maintenance such as co-op units, townhouses, condominiums or vacation timeshare properties.

1.1.2 *Schools, commercial buildings and other non-residential occupancies*

The protocols in this standard of practice also address non-residential occupancies that include:

- a) Educational occupancies including for religious and educational purposes through the 12th grade and day care facilities (Group E);
- b) Business occupancies including for offices, training and educational facilities to include universities, professional services or service-type transactions (Group B);
- c) Assembly occupancies including for civic, social or religious functions (Group A);
- d) Factory occupancies including for fabrication or manufacturing, repair or processing (Group F);
- e) High-hazard occupancies (Group H);
- f) Institutional occupancies including those where people are cared for or live in a supervised environment such as under restraint or security, detained in a penal institution, or for medical, surgical, psychiatric, nursing and custodial care or for child care facility purposes (Group I); and
- g) Mercantile occupancies including for the display and sale of merchandise, goods, wares or merchandise incidental to such purposes and accessible to the public (Group M).

1.2 Applicability

The terms "shall" and "required" indicate provisions herein that are mandatory for compliance with this standard. The terms "note", "informative", "should" and "recommended" indicate provisions that are considered to be helpful or good practice but that do not contain a mandatory requirement.

¹ As point of reference, see the International Building Code (IBC) as published by the International Code Council.

2.0 BEFORE YOU TEST

2.1 Which Buildings Should be Tested?

Informative Advisory

Any building on any parcel of land can have a *radon* problem. Testing is the only way to know.

Radon concentrations cannot be predicted based on national, state or local *radon* survey maps or neighborhood *radon* measurements.

2.2 When to Test?

2.2.1 *Where occupied both day and night*

Radon testing is permitted at any time of the year for residential dwellings or living units and non-residential locations that are *significantly occupied* both day and night.

Informative Advisory—Measurements more likely to provide an accurate reflection of occupant exposure to *radon* hazards are measurements conducted under conditions that most closely align to the normal building operating condition that prevails during the greatest amount of time each year.

2.2.2 *Where not occupied both day and night*

For buildings or portions of buildings that are non-residential and not *significantly occupied* both day and night, the measurements shall be conducted at a time that is representative of *normal occupied building operating conditions*, as defined in [Section 2.7.2](#).

Exception: It shall be permitted to test at any time of the year when the purpose of the testing demands timeliness, such as a business transaction or health concern demands.

2.3 Test Devices

2.3.1 *Approved test devices required*

All test devices used for determining if *mitigation* is warranted shall be devices that are listed by one of the following authorities for having proven to meet minimum quality requirements:

- a) the National Radon Proficiency Program (NRPP) or the National Radon Safety Board (NRSB); or
- b) as required by local jurisdictions that have a program for evaluating and approving devices.

2.3.2 *Device instructions and appropriateness*

Radon measurement devices shall be used in compliance with both this standard and instructions provided by the manufacturer that relate to device-specific needs.

~~Note—Section B in the attached Companion Guidance provides descriptions of test devices.~~

2.3.3 *Test device types (defined)*

When the following terms are used to describe *radon test devices*, the following definitions shall apply:

- a) The term “*Passive Device*” refers to those that collect a time-weighted average and do not provide hourly readings.
- b) The term “*Continuous Monitor*” refers to monitors that are capable of automatically recording a retrievable time series of numeric measurements of *radon* concentration averaged over time intervals of 1 hour or less and can be recalibrated periodically. If a device is not capable of these functions or is not set to record readings each hour, it is functioning as a *passive device* and is not considered a continuous monitor under this protocol.

2.3.4 Radon Decay Products (RDP)

The use of *radon decay product (RDP)* measurement devices shall comply with ANSI/AARST MAH *Protocol for Conducting Measurements of Radon and Radon Decay Products in Homes*.

2.4 Who Should Conduct the Testing?

To be considered qualified for conducting measurements in multifamily, schools and large buildings, the person(s) or team, regardless of business organizational structure, shall operate under a *quality assurance* program with a *QA plan* that includes individuals who are qualified for their apportioned task and operations conducted under the responsible charge of a *qualified measurement professional*.

2.4.1 Qualified measurement professionals

For testing multifamily, schools and large buildings, a “*Qualified Measurement Professional*” is defined as: “An individual that has demonstrated a minimum degree of appropriate technical knowledge and skills both sufficient to place, retrieve and analyze (as applicable) *radon* detectors and to design, plan, and implement quality procedures when conducting *radon* measurements in multifamily, schools and large buildings:

- a) as established in certification requirements of the National Radon Proficiency Program (NRPP) or the National Radon Safety Board (NRSB); and
- b) as required by local statute, state licensure or certification programs that evaluate individuals for *radon* specific technical knowledge and skills.”

2.4.2 Testing project oversight

A *qualified measurement professional* shall be physically present during all onsite activities for placement and retrieval of *radon* detectors and shall be immediately available to direct, instruct, oversee and control activities of any other individuals placing and retrieving detectors.

Individuals who are not *qualified measurement professionals* are permitted to assist in the placement and retrieval of detectors provided that their participation is approved by the *qualified measurement professional* and permitted by statute, state licensure or certification program. Participant names and qualifications or preparations shall be retained in QC records and made available to the *client* upon request.

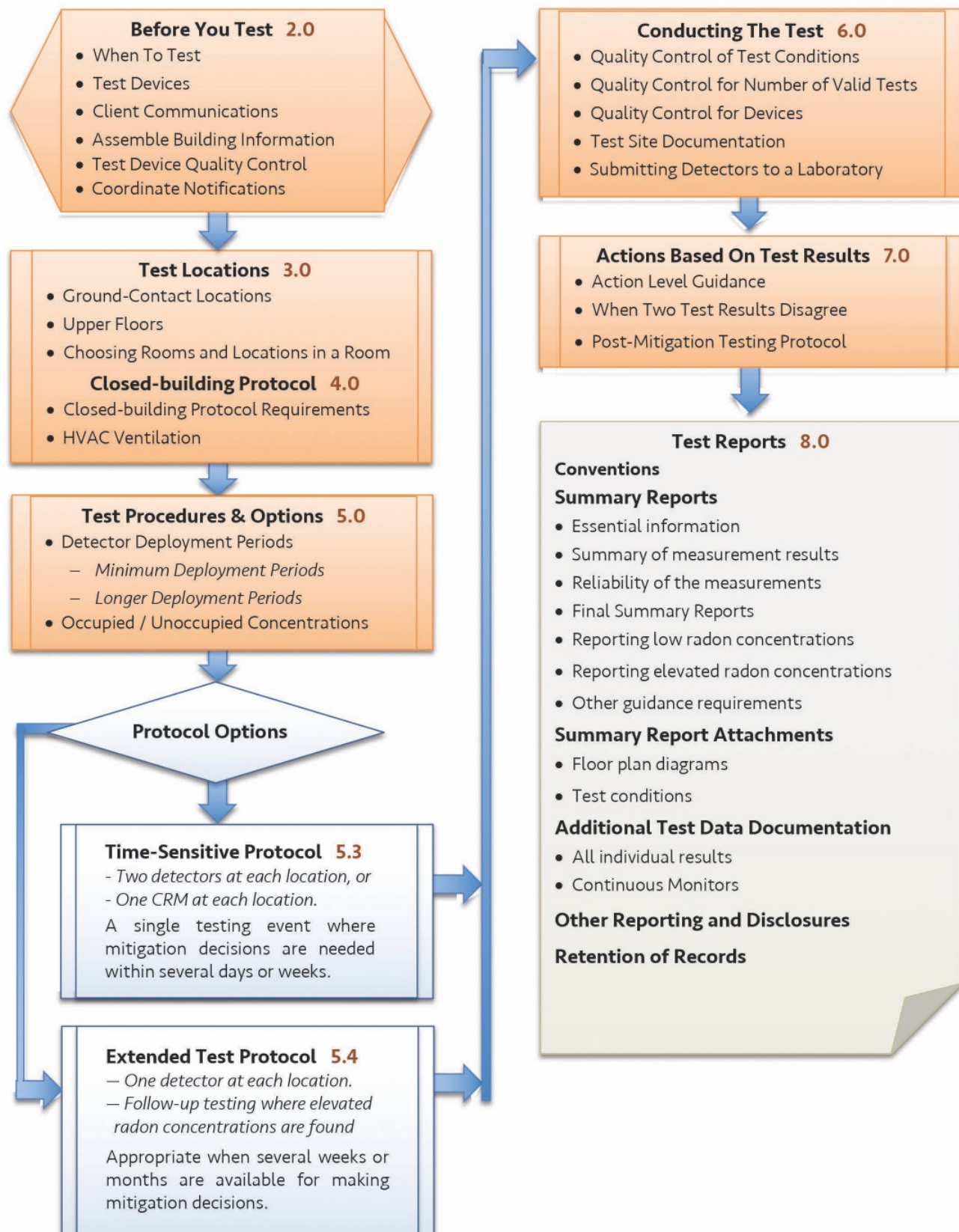
If noncertified individuals assist in detector placement and retrieval, the *qualified measurement professional* shall be responsible to either:

- a) Create and present a written work plan specific to apportioned tasks and obtain evidence that the work plan is understood by all participants; or
- b) Verify that individuals have demonstrated, within the last 2 years, appropriate training and skills specific to detector placement and retrieval, such as completion of an approved NRPP or NRSB training class, or state licensure or certification program, where applicable.

~~Note—Section D in the attached Companion Guidance provides guidance for work plan training.~~

2.5 Summary of Testing Procedures

Flowchart of procedures embodied in this standard



2.6 Client Communications

2.6.1 *Designing a plan for testing*

Prior to designing a testing plan, the person(s) responsible for quality procedures shall obtain or attempt to obtain information about the building(s) to identify test locations that comply with this standard.

2.6.2 *Client advisories prior to testing*

During initial interactions or in proposals, the *client* shall be informed in writing regarding;

- a) Test plan options that comply with this standard;
- b) Required quality control for closed-building conditions;
- c) The *normal occupied building operating condition* that prevails during the greatest amount of time each year for similar local buildings, in accordance with **Normative Appendix A**; and
- d) Requirements for a valid measurement at all test locations in each building and the possibility of delays and additional expense when test locations are not readily accessible or where requirements for *closed-building conditions* are not observed.

2.6.3 *Client authorizations*

Prior to testing, the *client* shall be requested in writing to provide confirmation regarding:

- a) who is authorized by the *client* to receive test data and any limits the *client* requests or requires on disclosing test data or results, and
- b) at which junctures during the process that the *client* requests or requires data to be provided.

Note—**Exhibit 1** provides an example form for seeking to obtain client authorizations.

2.6.4 *Client commitments*

Prior to testing, the person(s) responsible for quality procedures shall obtain or attempt to obtain a signed statement from the *client*, or client's authorized agent, and *facilitating staff* members regarding:

- a) Commitments to aid quality control of closed-building conditions.
- b) A commitment from the onsite supervisor(s) to:
 1. distribute notices prior to testing for both occupants and other staff members, and
 2. provide timely access to all test locations.
- c) A commitment from the HVAC or building operations supervisor(s) to ensure that building conditions required to achieve reliable *radon* tests are met. This commitment shall include:
 1. providing information about HVAC systems when requested, and
 2. affirmation prior to testing that HVAC system(s) have been reviewed and adjusted, as needed, where systems include automated or manual controls or dampers for:
 - a. *variable outdoor air ventilation*, and
 - b. *variable air volume distribution (VAV)* systems

Note 1—**Exhibits 2, 3, 4 and 5** provide example forms for meeting these requirements.

Note 2— **Exhibit 6** describes HVAC systems of concern that may be encountered.

2.7 Assemble Building Information

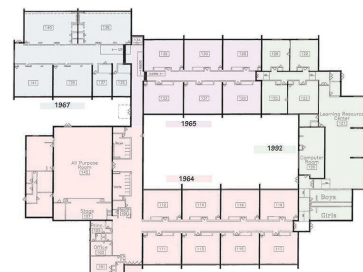
2.7.1 Records

A method to record and track activities for each test location shall be established prior to testing, such as creation or procurement of floor plan diagrams for recording and tracking details.

For tested areas, records shall be updated during test procedures:

- to match current addresses,
- the current use of non-residential rooms, and
- building foundation types such as slab-on-grade, basement and crawl space foundations in the building being tested.

Note—**Exhibit 7** provides an example of a floor plan diagram.



2.7.2 Building operating conditions

Planning and conducting measurements require identification of the *normal occupied building operating condition* that prevails during the greatest amount of time each year. The predominant building operating condition reported and used for testing procedures shall be based on climate examples in accordance with **Normative Appendix A**.

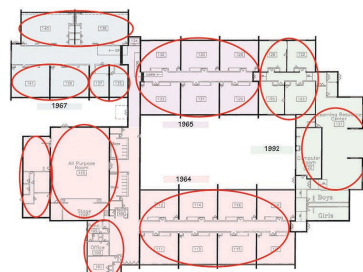
Planning and conducting measurements additionally require identification of conditions that temporarily inhibit clear characterization of *radon* hazards. These are conditions that do not exhibit regularity for at least intermittent periods during a test regarding:

- activity of heating or cooling system blowers, where applicable to the *HVAC* system, and
- negative air pressure in the lowest portions of the building relative to outside air.

2.7.3 Unique sectors

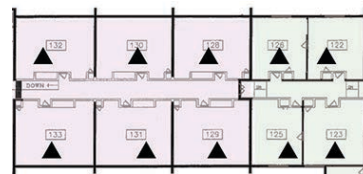
Each area served by a unique *HVAC* system shall be classified as a *unique sector*. When planning, or no later than when conducting measurements, actions are required to account for temporary conditions that can adversely affect reliability of the test result(s) where *HVAC* systems are designed with:

- Variable outdoor air ventilation*;
- Variable air volume (VAV)*;
- Return-air* ducts laid in soil; and
- HVAC setback* for non-residential locations.



2.7.4 Test devices needed

The number of test devices for each test procedure shall include all planned test locations relative to the test procedure as specified in this standard and those additionally required for *quality control*.



2.8 Test Device Quality Control

Any person or team conducting *radon* or *radon decay product* measurements shall establish, maintain and follow a *quality assurance* plan that complies with ANSI/AARST MS-QA “*Radon Measurement Systems Quality Assurance*.” Among other things, MS-QA requires a system to record and monitor the results of *quality control* check measurements and training qualifications of staff.

2.8.1 Reporting QA checks

All *quality control (QC)* check measurements for *duplicates, comparison checks, spikes and blanks* associated with a testing project shall be included in report documentation, as required in **Section 8.4**.

2.8.2 Onsite—Duplicate and comparison checks

For each detector configuration, *duplicate* measurements, or *comparison checks* associated with *continuous radon monitors (CRM)*, shall be:

- a) not less than 10% of all locations tested during each initial and *follow-up test procedure*, and
- b) distributed as widely as possible across all buildings being tested during the same testing event.

2.8.3 Blanks required

The local office(s) directly implementing the testing project(s) shall conduct *blank quality control check* measurements for *charcoal adsorption detectors (CAD)*, *alpha track detectors (ATD)*, and *electret ion chamber detectors (EIC)* in compliance with requirements of both a) and b) of this **Section 2.8.3**.

a) Project Start-up

For local office(s) directly implementing a testing project or projects that require 50 test locations or more during the same 60-day period, *blanks* shall be conducted in accordance with **Table 2.8.3**.

Table 2.8.3 Project start-up	
For CAD, ATD and EIC detectors, no less than nine <i>blanks</i> that meet the following requirements are to be conducted prior to or in conjunction with initiating test deployments:	
1.	Three <i>lab-transit blanks</i> (to look for unexpected exposures during shipping or handling) shall be returned to the laboratory immediately, or in conjunction with, beginning detector deployment.
2.	Three <i>office blanks</i> (to reveal any unexpected exposures during storage) shall remain where detectors are stored and be returned to the laboratory per normal procedure for the field detectors.
3.	Three <i>field blanks</i> (to reveal unexpected exposures onsite or from handling procedures) shall be deployed in the field and returned to the laboratory per normal procedure for the field detectors.
Standard practice of conducting not less than 5% blanks for all testing locations shall resume when the number of test locations exceeds 180 in accordance with Section 2.8.3 b .	

b) General Requirements (*Blanks*)

Project startup and throughout the testing project shall be subject to the following requirements:

1. The total number of *blank* measurements conducted and analyzed for each different detector configuration shall be not less than 5% of all testing locations where the detector configuration is deployed.
2. A portion of the required 5% *blanks* shall be *field blanks* with additional *blanks* dedicated to other evaluations, if and where deemed necessary, such as environments where test device inventories are stored (i.e., *office blanks*) and anomalies that might occur as a result of shipping (i.e., *lab-transit blanks*).
3. *Blank* measurement results associated with other *quality control* activities at the local office(s) implementing the testing project are acceptable to include for meeting testing project reporting requirements in **Section 8.4**.
4. For CAD and ATD detectors where storage locations have not been evaluated and monitored, *blank* measurements shall be conducted prior to deployment for detectors that have been

stored for more than 30-day durations. Alternatively, where storage locations are monitored under an ongoing program, monitoring records shall be made available upon request that verify inventories are stored in an environmentally controlled location that prevents unintended exposure to *radon*, high relative humidity and extreme temperatures beyond manufacturer's recommendations.

2.8.4 *Spiked measurements required*

For CAD, ATD and EIC measurement methods, requirements a) and b) of this **Section 2.8.4** are required to provide evidence of continued accurate measurement system operation by comparing reported *spike* analyses results to a recognized reference authority for radon concentration.

- a) The number of *spiked measurements* conducted and analyzed for each detector configuration associated with the testing project(s) shall be not less than 3% of EIC detectors and not less than 3% from each *lot* of CAD and ATD detectors placed into local inventories.

Exception: For each detector configuration associated with the testing project(s), the maximum required is six *spikes* per month for both EIC detectors and from each *lot* of CAD and ATD detectors with no less than three *spikes* conducted each year; and

- b) Spiked measurement results from EIC detectors and from each *lot* of CAD and ATD detectors associated with the testing project that are also associated with other quality control activities shall be acceptable to include for meeting test project reporting requirements in **Section 8.4**.

2.9 Coordinate Notifications

Informative Advisory—Failure to comply with required test conditions is most likely to occur when building staff and occupants are not properly informed about the necessary test conditions.

2.9.1 *Prior notification of facilitating staff*

Once a testing activity is confirmed, the property management team shall be instructed in writing to distribute *notices of radon testing* that inform and appropriately instruct individual *facilitating staff* members, such as authorized building supervisors, maintenance staff, teachers or office managers.

Notifications for *facilitating staff* shall comply with requirements in a) and b) of this **Section 2.9.1**.

- a) Instructions shall be provided for distributing notices for both tested and non-tested units, and for posting of publicly viewable notices. The occupant notices provided shall include:
 - 1. Scheduled dates and times for test device placement and retrieval;
 - 2. Essential closed-building requirements portrayed in **Table 4-A** and that these conditions are required no later than 12 hours prior to the test and throughout the test period;
 - 3. Information on how to obtain federal or state health guidance; and
 - 4. Local contact information for inquiries, such as the authorized building supervisor.

Note—**Exhibits 3** and **4** provide examples of occupant notifications.

- b) In addition to coordination of access, instructions shall be provided for duties required of *facilitating staff*, such as closing windows and adjustments to HVAC units or controls.

Note—**Exhibit 5** provides an example of written instructions for building operations staff.

2.9.2 *Prior notification of occupants*

The property management team shall be instructed and informed in writing to post *notices of radon testing*, as applicable, and distribute notices of *radon* testing no less than 24 hours prior to testing to all occupants in all buildings being tested.

3.0 TEST LOCATIONS

3.1 Ground-Contact Locations

A measurement shall be conducted in all dwellings and all nonresidential rooms that are *occupied*, or *intended to be occupied*, that:

- a) have floors or walls in contact with the ground, and
- b) are closest to ground over untested *ground-contact* locations, to include the lowest level of the building over a *crawl space*, utility tunnel, parking garage or other non-habitable space that is in contact with ground.

3.1.1 *Ground-contact dwellings*

For each *ground-contact* dwelling or living unit, a measurement shall be conducted in the lowest level that serves or could serve as a living area, sleeping quarters, office, playroom or otherwise be *occupied* for residential use at some time in the future.

3.1.2 Non-residential ground-contact locations

For non-residential *ground-contact* locations, a measurement shall be conducted in all *ground-contact* rooms, offices, classrooms and other general use areas that are *occupied* or *intended to be occupied*.

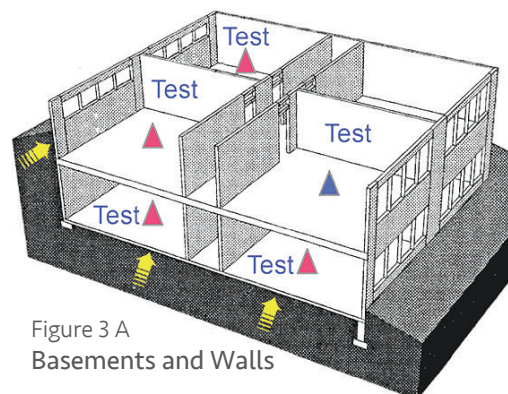


Figure 3 A
Basements and Walls

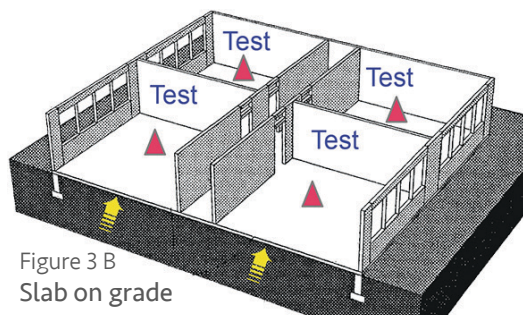


Figure 3 B
Slab on grade

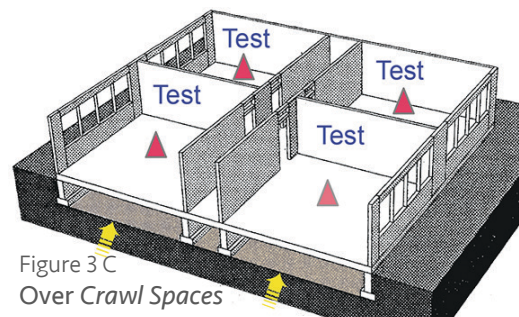


Figure 3 C
Over Crawl Spaces

3.2 Upper Floors

On each upper floor, a measurement shall be conducted in at least one and not less than 10% of all dwellings and nonresidential rooms that are *occupied* or *intended to be occupied*. These measurements shall be in addition to tests performed in *ground-contact* locations and rooms or dwellings that adjoin immediately above untested *ground-contact* locations.

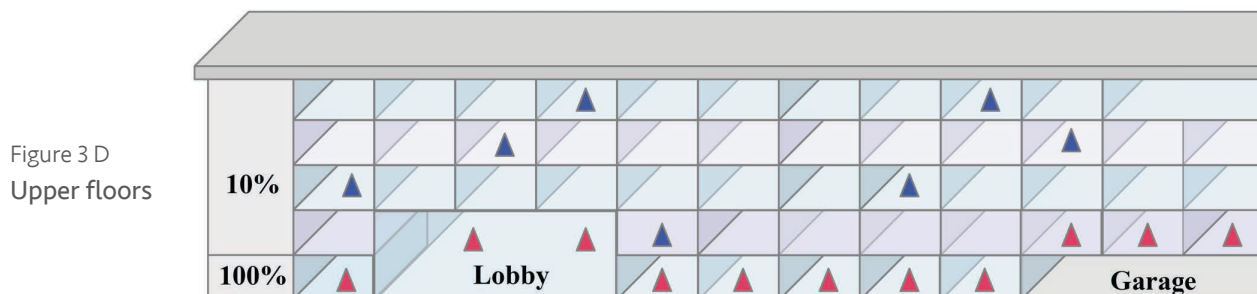


Figure 3 D
Upper floors

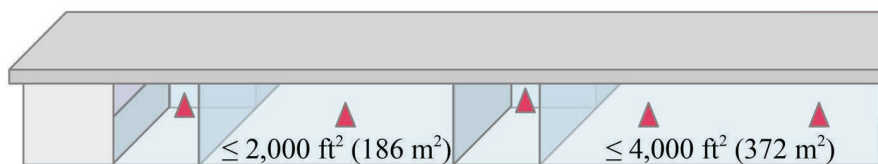
3.3 Locations Not to Test

Unless for investigative purposes, test locations shall not include hallways, closets and bathroom or shower areas unless they are open to other rooms that are *occupied* for other purposes.

Note—Table 3.8 provides additional requirements regarding rooms that are not to be tested.

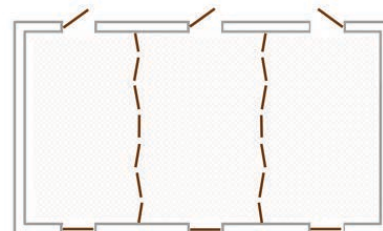
3.4 Large Rooms or Open Areas

For large rooms and open areas, one detector shall be placed for every 2,000 square feet (186 m²).



3.4.1 Open-Plan or Pod Design

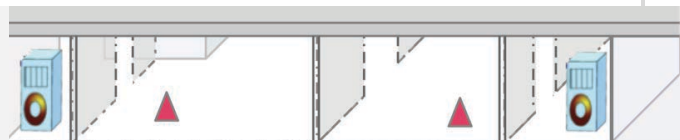
Where an open-plan or pod design area has moveable walls that can physically separate an area into individual rooms, the movable wall shall be configured to divide the area into individual rooms and each resulting room shall be measured separately. Where moveable walls are absent or inoperable, the area shall be measured as one room.



3.5 Multi-zone HVAC Systems

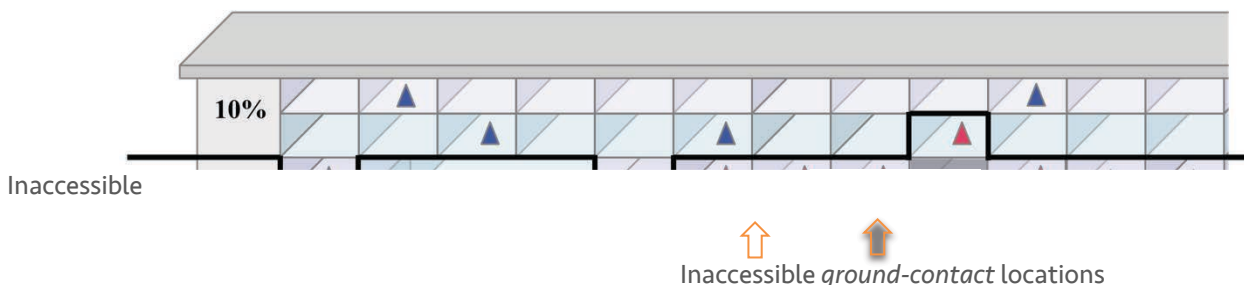
Informative Advisory—Multi-zone HVAC systems, as described in Exhibit 6, Group 2 are sometimes found for larger open rooms or dwellings. Whenever encountered, it is recommended to place enough additional detectors to adequately characterize and record differences between areas or rooms that are served by the different HVAC systems.

Figure 3 G
Multi-zone HVAC



3.6 Inaccessible Ground-Contact Locations

When restricted access is imposed by independent owners of *ground-contact locations*, the lowest accessible level of the building that is closest to ground shall be tested in accordance with Section 3.1 *Ground-contact Locations*.



3.7 Choosing A Room

Note—It is best to choose test locations where people are more likely to spend time, such as a finished or occupied room when this choice exists. When this choice does not exist, preferred choices are areas not currently used or finished but that could serve as a work area, playroom or an additional bedroom at some time in the future.

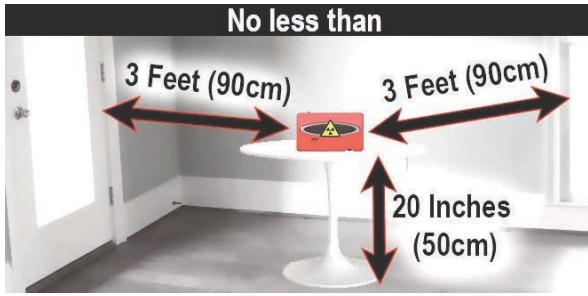
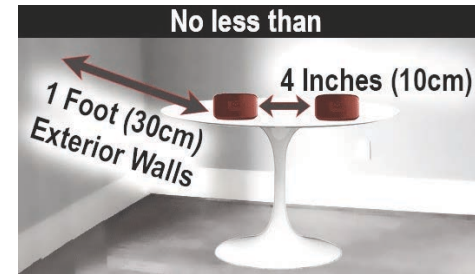
3.8 Choosing A Location Within A Room

Detectors shall be placed in accordance with Table 3.8.

Note—As overall guidance, test in the general breathing zone.

Table 3.8

Requirements for Test Locations Within a Room

Detectors shall be located not less than:	3 feet (90 cm) from exterior doors and windows or other potential openings to the outdoors.	
	20 inches (50 cm) above the floor.	
	1 foot (30 cm) from the exterior wall of the building.	
	1 foot (30 cm) below the ceiling.	
	4 inches (10 cm) from other test detectors and objects or surfaces that are above or to the side of the detector.	
Exception: Less than 4 inches (10 cm) is permitted for detectors that are not affected by close proximity to other objects. Confirm manufacturer or laboratory requirements or recommendations prior to exercising this exception.		
Side-by-side detectors	Detectors are to be not more than 8 inches (20 cm) from each other whenever seeking to use the average test result of two side-by-side detectors for <i>mitigation</i> decisions.	
Where not easily disturbed	<i>Informative Advisory</i> —Select a position within the room where the detector(s) will not likely be disturbed, moved or have their performance altered during the measurement period.	
Detectors shall not be located:	— inside closets, cabinets, drawers, sumps, <i>crawl spaces</i> or nooks in the building foundation.	
	— near heat sources, such as on appliances, radiators, fireplaces or in direct sunlight.	
	— near drafts caused by fans or heating and air conditioning vents or within enclosed areas of high air velocity such as mechanical/furnace closets.	
	— within enclosed areas that accumulate high humidity, such as bathrooms, laundry rooms and kitchens that are isolated by partitions and doors from adjoining less humid areas. Exception: Where regularly occupied by workers for essential tasks, such as for cafeteria food preparation. Testing in such locations requires detector types that are virtually unaffected by high humidity which is to be confirmed by the manufacturer or laboratory prior to exercising this exception.	
	<i>Informative Advisory</i> —Avoid placing detectors on or near objects that may produce radiation such as natural stone, rock collections, granite counter tops, hearths and slate pool tables.	

4.0 TEST CONDITIONS REQUIRED

4.1 Closed-building protocol requirements

Closed-building conditions, as they are for occupied conditions in winter heating seasons or summer cooling seasons, in accordance with **Tables 4-A, 4-B, 4-C and Section 4.2** are required to be:

- a) initiated 12 hours prior to the test for tests lasting less than 4 days, and
- b) maintained throughout the test period for tests lasting up to 90 days.

Table 4-A ESSENTIAL CLOSED-BUILDING PROTOCOL REQUIREMENTS	
Windows	Keep closed on all levels of the building including areas not being tested
Exterior doors (except for momentary entry and exit)	
Heating and cooling systems	Set to normal occupied operating conditions with normal temperatures between 65° and 80° F (18° - 27° C)
Systems that temporarily ventilate with outdoor air for seasonal comfort or energy savings	Set to the lowest seasonal ventilation
Bathroom fans	Operate normally
Exhausts Systems (that temporarily draw air from the building such as from laundries, workshops, community kitchens or for local control of fumes)	Avoid excessive operation
Fireplaces (that burn solid, liquid or gas fuels unless a primary/normal source of heat for the building)	Do not operate

4.2 HVAC Ventilation

4.2.1 Outside air for combustion appliances

Openings to outside air designed to provide air needed for combustion appliances shall not be closed.

4.2.2 Ventilation with outside air

Where HVAC operation or design includes temporarily increasing outdoor air ventilation for seasonal comfort or energy savings, outside air inlet dampers shall be configured to provide only the minimum volume of outdoor air that is needed at all times of the year when the building or *unique sector* is *significantly occupied*.

Note—Further descriptions are provided in **Exhibit 6** for **Group 3** HVAC systems.

4.2.3 Temperature control via air volume

For variable air volume (VAV) systems that temper room temperatures using thermostats to vary the volume of heated or cooled air coming into rooms, thermostats shall be set to a *normal occupied temperature* in all portions of the building being tested that are served by the system.

Note—Further descriptions are provided in **Exhibit 6** for **Group 4** HVAC systems.

4.3 Upper Floor Rooms and Dwellings

Note—**Sections 6.1.3** adds specific required conditions when not testing adjoining rooms or dwellings.

Table 4-B ADDITIONAL REQUIREMENTS FOR NEW CONSTRUCTION, RENOVATIONS AND REPAIRS	
All openings to the exterior (due to incomplete construction, structural defect or disrepair)	These openings to the exterior shall be closed or sealed at least 12 hours prior to initiating the test
Heating/cooling systems active and set to a <i>normal occupiable temperature</i>	These items shall be completed or installed at least 12 hours prior to initiating the test
All windows and exterior doors installed with hardware and seals	
All insulation and exterior siding	
All wall and ceiling coverings to be completed including interior drywall or paneling but does not include decorative finishing of walls, floors or ceilings	
All fireplaces and fireplace dampers installed	

Table 4-C ADDITIONAL CLARIFICATION ON CLOSED BUILDING PROTOCOL REQUIREMENTS FOR SPECIFIC COMPONENTS	
Windows and Doors on all levels of the building including areas not being tested	
Broken windows or doors	Seal closed
Interior partition or stairway doors	No special requirements
Exterior doors into non-residential rooms	Keep closed (except for momentary entry and exit of individuals who customarily enter the building)
Garage doors and doors leading into a garage	Keep closed (except for momentary entry and exit).
Small Appliances	
Ceiling fans and portable fans	Do not blow fans directly towards testing devices
Window fans	Remove or seal shut and do not operate
Humidifiers and dehumidifiers	Operate normally
Crawl Spaces	
Passive <i>crawl space</i> vents	Set vents to the condition that prevails during the greatest amount of time each year
<i>Crawl space</i> humidity control systems	Operate normally
Mechanical Systems	
Passive vents for combustion air makeup	Leave open
Combustion appliance fans	Operate normally
Fans installed in attics to ventilate only attic air	
Window air conditioners	Operate in recirculation mode only
Evaporative cooling systems	Do not operate and do not cover

5.0 TESTING PROCEDURES AND OPTIONS

5.1 Test Deployment Periods

5.1.1 Test phase

All measurement locations in each building shall be tested on the same days for:

- a) all locations required in **Section 3** within each building; and
- b) all locations identified within each building for *follow-up test procedures*.

5.1.2 Minimum deployment periods

While deployment periods should optimally collect at least 48 hours of valid sampling time, tests shall be conducted continuously for durations that are:

- a) not less than 46 hours under closed-building conditions that comply with **Section 4**; and
- b) not less than the minimum exposure time recommended by the manufacturer of the device.

Note—For tests extended an additional day or more, it is best to terminate the test at a similar time of day as when the test was started to more evenly account for day-to-night fluctuations of *radon* entry.

5.1.3 Non-residential deployment periods

Where the building or portion of the building is not *significantly occupied* 24 hours a day, such as a school or office building, testing shall only be conducted, in accordance with **Section 5.1.2**, during portions of a week when the building is *significantly occupied*.

Exception—Where *HVAC systems* are not operated differently during nights, weekends and holidays compared to when occupied by the majority of workers or students.

5.1.4 Longer test periods

When longer test periods are chosen with intent to more closely evaluate the annual average *radon* concentration before deciding if *mitigation* is warranted, the test period shall include heating season conditions that are not less than the percentage of year when heating systems are active.

Exception: Where heating season conditions are not the *normal occupied building operating condition* as defined in **Normative Appendix A**.

5.2 Evaluation of Occupied Versus Unoccupied Concentrations

For non-residential buildings or portions of a building that are not *significantly occupied* day and night most the year, an evaluation of *occupied* versus unoccupied *radon* concentrations is recommended and shall be permitted as an additional line of evidence relative to mitigation decisions. When conducting such evaluation, the test devices, procedures and reporting shall comply with **Normative Appendix B**.

5.2.1 When to conduct the evaluation

An evaluation of occupied versus unoccupied *radon* concentrations is permitted during initial testing, *follow-up testing*, post-mitigation testing, or in a series of sequential tests. An evaluation that simulates various building operating conditions is also permitted in accordance with **Normative Appendix B-2**

5.2.2 Where to conduct the evaluation

Informative advisories: During initial testing, the evaluation is recommended for each *unique sector* at locations where airflow from *HVAC systems* is most representative of occupied rooms within the *unique sector*. For *follow-up testing*, the evaluation is recommended for at least the location of the highest *radon* concentration found during previous measurements within each *unique sector*.

5.3 The Time-Sensitive Testing Option

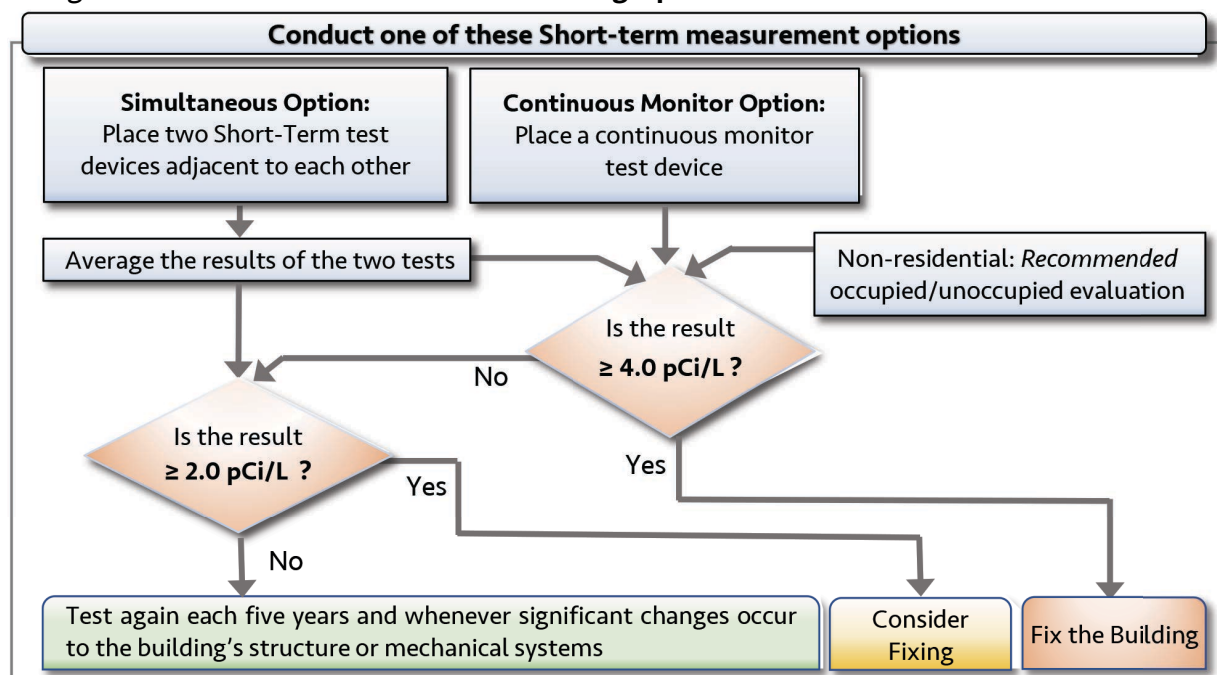
Note—This protocol builds upon protocols developed by EPA, relative to EPA's "*Home Buyer's and Seller's Guide to Radon*."

Table 5.3 Time-Sensitive Testing Option—Required Procedure and Summary	
Step 1 Options	Simultaneous Testing Option Tests at each test location are conducted using two <i>short-term test devices</i> at the same time, 4 to 8 inches (10-20 cm) apart.
	Continuous Monitor Option Tests at each test location are conducted using a monitor that records retrievable hourly measurements.
	Evaluations of occupied versus unoccupied <i>radon</i> concentrations are additionally recommended for non-residential locations.
Step 2	Decisions to Fix the Building <i>Mitigation</i> decisions are to be based on the average result from a <i>continuous monitor</i> or the average of two test results conducted at the same time in the same location. ^{1, 2} Fix the building if test results meet or exceed the <i>action level</i> , e.g., 4 pCi/L. Consider fixing the building if results are greater than half the <i>action level</i> , e.g., between 2 and 4 pCi/L.

¹ Where evaluations of occupied versus unoccupied concentrations have been conducted in accordance with Section 5.2, report recommendations shall account for *radon* exposures indicated by the evaluation.

² Section 7.2 provides requirements for when the test result from two *short-term test devices* disagree in terms of making a *mitigation* decision.

Figure 5.3 Time-Sensitive Testing Option Flowchart



5.4 The Extended Testing Option

Note—This protocol builds upon those developed by EPA, relative to EPA's "A Citizen's Guide to Radon."

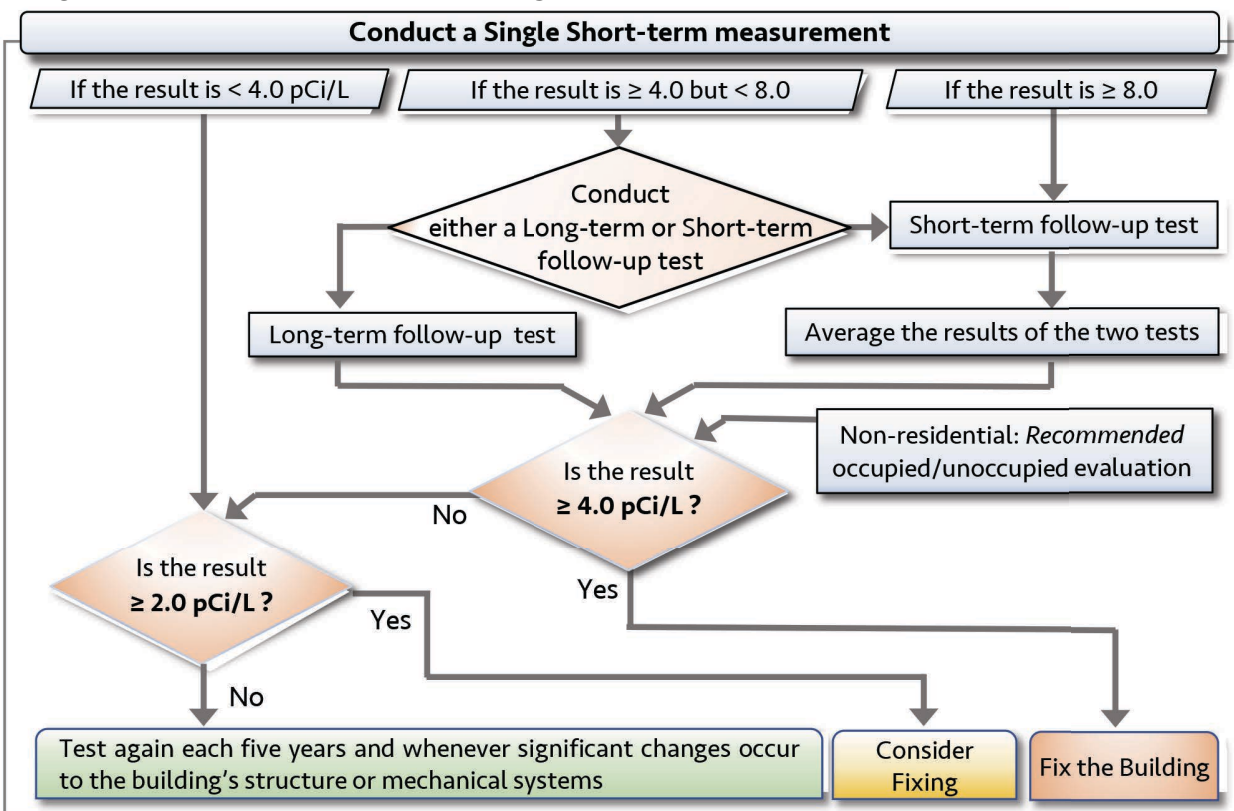
Table 5.4 Extended Testing Option—Required Procedure and Summary	
Step 1	Initial Test Testing at each location is conducted using a single <i>short-term device</i> .
	Evaluations of occupied versus unoccupied <i>radon</i> concentrations are additionally recommended for non-residential locations.
Step 2	Follow-up Test Options Retest locations that meet or exceed the <i>action level</i> , e.g., 4 pCi/L. <i>Follow-up</i> testing requirements allow the following options: ²
	a) A second test with a <i>short-term device</i> is conducted. Where a first test is twice the <i>action level</i> or greater, this confirmation test should be conducted without delay; or
	b) Where a first test is less than twice the <i>action level</i> , testing can be conducted with a <i>long-term test device</i> for an extended period if the situation allows a closer evaluation of annual average to <i>radon</i> concentrations; or
	c) Evaluation of occupied versus unoccupied <i>radon</i> concentrations for non-residential locations.
Step 3	Decisions to Fix the Building
	<p><i>Mitigation</i> decisions are to be based on the average of the two test results from <i>short-term devices</i> or the results from <i>long-term testing</i> ^{1, 3}</p> <p style="text-align: center;">Fix the building</p> <p style="text-align: center;">if test results meet or exceed the <i>action level</i>, e.g., 4 pCi/L.</p> <p style="text-align: center;">Consider fixing the building if results are greater than half the <i>action level</i>, e.g., between 2 and 4 pCi/L.</p>
<p>¹ Where evaluations of occupied versus unoccupied concentrations have been conducted in accordance with Section 5.2, report recommendations shall account for <i>radon</i> exposures indicated by the evaluation.</p> <p>² Note—While decisions to <i>mitigate</i> at any time are not prohibited, the second test aids confidence that decisions are not being made based on a faulty test device or unexpected conditions.</p> <p>³ Note—Section 7.2 provides requirements for when the test result from two <i>short-term test devices</i> disagree in terms of making a <i>mitigation</i> decision.</p>	

5.4.1 Client Advisory required

If choosing to use the *Extended testing* option in **Table 5.4** under a *time-sensitive* situation, the *client* shall be informed in writing prior to conducting tests that:

- Test results from Steps 1 and 2 of the *Extended testing* protocol are to be used for *mitigation* decisions, and
- Time-sensitive* situations will often not permit long test periods to more closely evaluate annual exposures to *radon*.

Figure 5.4

Extended Testing Option Flowchart**5.4.2 Long-term test option**

Mitigation decisions are permitted to be based solely upon testing that is conducted with a *long-term test device* at each test location where the test period meets requirements in [Section 5.1.3](#) to account for seasonal conditions and either:

- the test location is a residential dwelling or living space, or
- the test location is non-residential with *HVAC systems* that are not operated differently during nights and weekends compared to when occupied by the majority of workers or students.

Note—Test periods employed for this purpose in the U.S. are commonly those greater than 90 days. Tests that are longer than 2-7 days can reduce the influence of short-lived temporary conditions on test results. However, regardless of test duration, any correlation between the test result and the annual average *radon* concentration depends upon building conditions during the test.

5.5 New Construction

For buildings constructed with *radon-resistant* features, initial testing shall be conducted normally, such as required in accordance with either [Section 5.3 Time-Sensitive Testing Option](#) or [Section 5.4 Extended Testing Option](#).

However, *radon-resistant* features that do not include a fan shall be regarded as *mitigation* efforts that require seasonal verification of effectiveness, in accordance with *clearance testing* requirements in [Section 7.3.2 b](#).

5.6 Testing A Single Room or Dwelling

Note—[Sections 6.1.3](#) adds additional required conditions when testing only individual rooms or dwellings.

6.0 CONDUCTING THE TEST

6.1 Quality Control of Required Test Conditions

Informative advisory—Avoid testing during weather that is unusually severe for local weather if the test period is less than 4 days. When this occurs during a test, retesting may be appropriate.

6.1.1 *Where closed-building conditions cannot be maintained*

Tests shall not be conducted if closed building conditions, as required in **Section 4**, cannot be maintained across the test period for tests lasting up to 90 days.

6.1.2 *Where closed-building conditions did not occur prior to the test*

Where closed-building conditions were not maintained for twelve hours prior to deployment, as required in **Section 4**, the *radon* testing shall be conducted with one of the following options:

- a) The testing is postponed until at least 12 hours of closed-building conditions have been maintained prior to initiating the test; or
- b) The test period is extended to 4 days or more after closed-building conditions are initiated; or
- c) The test period is extended, if testing with a continuous monitor. For this option, device features or other methods shall be employed to obtain an average test result that represents no less than 46 hours of contiguous data collected after 12 hours of closed building conditions were maintained.

6.1.3 *Individual dwellings or rooms*

When testing only one or several dwellings or rooms that are part of a shared building, such as when testing upper floors identified in **Section 3.2** or an individual apartment, classroom or office, minimum requirements include closed-building conditions in accordance with **Section 4** for dwellings and non-residential enclosed rooms:

- a) immediately adjoining above and below the test location(s), and
- b) on all floors directly below test location(s) that are 3 stories or less above grade.

6.1.4 *Failed closed conditions*

Where compliance with closed-building conditions in **Section 4** did not occur for non-residential rooms, dwellings or untested *ground-contact* spaces, retest procedures shall include retesting those rooms or dwellings and any tested rooms or dwellings:

- a) that immediately adjoin the side, above and below such locations, and
- b) that share the same heating or cooling air ducts.

6.1.5 *Where closed conditions pose a health hazard*

If observing that closed-building conditions present a health hazard, the test shall not be conducted under conditions that place an occupant in harm's way.

Note—Hot weather is an example where closed building conditions can pose a health hazard in buildings that have no cooling systems. Safe conditions can violate requirements of this standard such as use of outdoor air ventilation, window fans or evaporative cooling systems.

6.1.6 *Fulfilling minimum requirements*

To fulfill minimum requirements for verifying test conditions, all the following steps, that are covered in greater detail elsewhere in this standard, are required:

- a) Inform the person responsible for building operation of the required test conditions;
- b) Ensure that notifications of a "Radon Test in Progress" are posted in conspicuous locations.

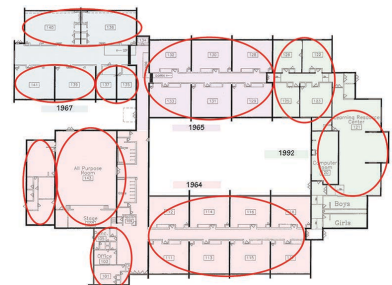
Note—**Exhibits 4** and **8** provide examples of public notices, door hangers and device placards;

- c) Obtain or attempt to obtain a signed statement from the onsite supervisor or other *facilitating staff* member(s) regarding a commitment to aid in the quality control of closed-building conditions; and
- d) **Conduct visual inspections.**
Visual inspections to evaluate observed conditions and document deviations from protocol or temporary conditions that might affect the reliability of the test result shall be conducted:
 - 1. Upon detector placement to help ensure all closed-building conditions and other protocol requirements are met, and
 - 2. Upon retrieval of detectors to help verify that closed-building conditions and other protocol requirements are still being maintained.
- e) **Surveillance not required**
The measurement professional is not required to inspect for closed-building conditions during the 12-hour period before the start of the test or between placement and retrieval of the detectors.

6.1.7 Visual Inspections

Where observations suggest reliability of the testing may be compromised, the observations shall be transmitted in a timely manner to person(s) responsible for quality control and recorded in testing records. To that end, the scope of visual inspections required in **Section 6.1.5 d** shall include requirements a), b), c) and d) of this **Section 6.1.7**.

- a) Testing records shall include any observed deviations from basic closed-building requirements in **Section 4.1**; **Tables 4-A, 4-B and 4-C**; and **Section 6.1.3**. Testing records shall also include where efforts to influence the outcome of the test are observed, to include tampering with devices or otherwise influencing test conditions.
- b) Where, in accordance with **Section 4.2**, *unique sectors* of the building have been identified or found to be served by HVAC operation or designs that temporarily vary ventilation, requirements include:
 - 1. *Variable outdoor air ventilation*
Testing records shall include a description of any observed outdoor air intakes that do not appear to be configured to provide the minimum volume of outdoor air ventilation needed at all times of the year when a building or *unique sector* is *significantly occupied*.
 - 2. *Variable air volume (VAV)*
Testing records shall include a description of any observed thermostats or controls for *variable air distribution (VAV)* systems that are not set to a *normal occupied temperature* in portions of the building served by the system(s).
- c) *Return-air* ducts laid in soil
Testing records shall include if *return-air* ducts are observed under slabs or otherwise surrounded by soil where this relates to:
 - 1. Compliance with reporting requirements in **Section 8.2.3 b Temporary conditions**, or
 - 2. Decisions on whether or not an evaluation of occupied versus unoccupied concentrations, in accordance with **Section 5.2**, may be warranted.



d) *HVAC setback* for non-residential locations

Testing records shall include if non-residential rooms are observed to be operating with *HVAC setback* temperatures when not *significantly occupied* that are outside of normal occupied temperatures of 65° and 80° F (18° - 27° C) where this relates to:

1. Compliance with provisions in **Section 5.1.3 Non-residential deployment periods**, or
2. Decisions on whether or not an evaluation of occupied versus unoccupied concentrations, in accordance with **Section 5.2**, may be warranted.

6.2 Quality Control for Number of Valid Tests

For dwellings or non-residential rooms where access problems, test conditions, or other reasons or situations prevented achieving a valid test result, *follow-up procedures* shall include testing all locations that were intended to be tested but did not result in valid measurements.

Exceptions:

- a) Where it is decided to proceed with *mitigation*; or
- b) Where all other test locations in the building are less than 2.0 pCi/L (75 Bq/m³) and the number of missing valid tests in *ground-contact* locations of the building do not exceed the allowance in **Table 6.2**.

Table 6.2

<i>Ground-contact</i> Test Locations:	4-7	8-11	12-15	16-19	20 or more
Allowance:	1	2	3	4	5

Informative advisory—Characterization of *radon* hazards for each occupant within a shared building requires achieving a valid *radon* measurement in each location required in **Section 3**.^{2 3}

Some latitude is provided based on a probability analysis of test results from 597 random buildings where all test results were less than 2.0 pCi/L (75 Bq/m³). In this situation, the analysis indicated roughly 90-95% confidence that untested locations allowed in **Table 5.6** will be below 4.0 pCi/L (150 Bq/m³).⁴

6.3 Quality Control for Devices

Quality control check measurements deployed and retrieved shall include:

- a) *Duplicate* measurements or *comparison checks* for all device types at not less than 10% of all locations being tested in accordance with **Section 2.8.2**; and
- b) *Field Blank* measurements for CAD, ATD and EIC detectors, in accordance with **Section 2.8.3**.

² Using the Monte Carlo method to evaluate the reliability of screening multifamily housing for radon. David Wilson, Research Staff, Oak Ridge National Laboratory. AARST Radon Reporter, March 2020

³ Evaluation of Percentage-Base Radon Testing Requirements for Federally-Funded Multi-Family Housing Projects. Antonio Neri MD, MPH, Centers for Disease Control and Prevention. Journal of Occupational Health and Hygiene, January 2019 <https://www.ncbi.nlm.nih.gov/pubmed/30620246>

⁴ Evaluating and Assessing Radon Testing in Housing with Multifamily Financing (EARTH). See attached supplemental information at the end of these proposed revisions.

6.4 Test Site Documentation

6.4.1 Update testing records

Floor plan diagrams or other records for tracking test locations shall be updated to achieve a record of:

- a) Test locations, addresses, rooms and mechanical systems or conditions observed that were inadvertently omitted or different than found during initial efforts to assemble building information;
- b) The nature of non-residential occupancies, such as locations occupied for educational, retail, food, beverage or office purposes. This includes noting if *significantly occupied* hours of the day, portions of the week or months of the year are different than typically expected for such establishment; and
- c) Building foundation types such as slab-on-grade, basement and crawl space foundations in the building being tested.

6.4.2 Test device logs

No later than in conjunction with retrieval of devices and detectors, site testing logs shall be completed to include:

- a) Essential tracking details
 - 1. Test location identification or address with any location specific notes,
 - 2. Detector identification/serial numbers,
 - 3. The start and stop dates and times of the measurement period; and
- b) Test reliability
 - 1. A record of conditions that are known or suspected to impact the reliability of the test at any location, and
 - 2. Annotation for each *quality control* check measurement to indicate its purpose.

6.5 Submitting Detectors to a Laboratory

Detectors shall be forwarded to the laboratory as soon as possible in accordance with laboratory requirements to ensure quality of analysis procedures. Information provided to the laboratory shall include:

- a) The address of the property tested to include street address, city, state and zip code.
- b) Detector identification/serial numbers, and
- c) The start and stop dates and times of the measurement period.

7.0 ACTIONS BASED ON TEST RESULTS

7.1 Action Level Guidance

Countries worldwide have adopted *action levels* for *radon* exposures. The *action level* observed should comply with the guidance of the country, state or local jurisdiction of authority where the test is being conducted.

U.S. Action Level. The following *action level* descriptions reflect guidance from the United States Environmental Protection Agency (EPA):

- **4 pCi/L or greater** ($\geq 150 \text{ Bq/m}^3$)

Fix the building. The higher the *radon* concentration, the more quickly action should be taken to reduce the concentrations.

- **Below 4 pCi/L** ($< 150 \text{ Bq/m}^3$)

Consider fixing the building if test results indicate that *radon* concentrations are greater than half the *action level*, such as between 2 and 4 pCi/L (75 and 150 Bq/m³).

With observance that hazards from *radon* are virtually the same for *radon* concentrations that are near *action level* thresholds, it is noteworthy that the World Health Organization recommends limiting *long-term* exposures to less than 2.7 pCi/L (100 Bq/m³).

When measurement devices indicate concentrations lower than about 2.0 pCi/L (75 Bq/m³), test data should normally be interpreted as being lower than the test device can accurately measure.

7.2 When Two Test Results Disagree

7.2.1 Acceptable

When two test devices were deployed to test the same testing location, the average of the two test results shall be reported as the value used for determining needs for *mitigation* if:

- a) both test results are above the *action level*, or
- b) both test results are below the *action level*.

7.2.2 Where test results disagree on exceeding the action level

When one test result is above the *action level* and the other test result is below the *action level*:

- a) **Acceptable**

If the higher result is less than twice the lower result, the average of the test results shall be reported as the value used to determine if this location needs *mitigation*; and

- b) **Not acceptable**

If the higher test result is more than twice the lower test result:

1. For two *collocated* (side-by-side) tests conducted at the same time, a repeated *collocated* test for this location is required to obtain a valid measurement; and
2. For two *short-term* detectors deployed at different times in the same location, obtaining confirmation on whether or not *mitigation* is warranted requires additional testing unless it is decided to proceed with *mitigation*.

This degree of uncertainty requires a precautionary stance to include that the higher test result shall be regarded as correct for making *mitigation* decisions unless further testing indicates otherwise.

Test results to be regarded as a more accurate reflection of occupant exposure to *radon* hazards shall be those that most closely align to the predominant *normal occupied building operating condition* for the location tested, as defined in [Section 2.7.2](#).

When conducting confirmation testing:

- a. the testing shall be conducted under building conditions that are representative of the predominant *normal occupied building operating condition*, as defined in [Section 2.7.2](#).
- b. testing shall be initiated within 1 year subsequent to initial testing unless the evaluation is relative to older, historic test results; and
- c. the evaluations shall be permitted based on data from *short-term* or *long-term test devices* or data from evaluations of occupied versus unoccupied *radon* concentrations.

7.3 Post-Mitigation Testing Protocol

The following procedures are required for determining if additional *mitigation* efforts are warranted.

7.3.1 General procedures—Post-mitigation testing

One or more *short-term test devices* shall be deployed at each test location to evaluate the effectiveness of the *mitigation* efforts. These measurements shall be conducted no sooner than 24 hours after activation of a *mitigation system* fan or completion of other *mitigation* efforts. In addition, closed-building conditions, in accordance with [Section 4](#), shall be maintained 12 hours prior to and throughout the test period. Testing shall be either:

- a) postponed until both conditions are met, or
- b) extended if testing with a *continuous monitor* where device features or other methods shall be used to obtain an average reading that represents no less than 46 hours of contiguous data collected after both conditions are met.

7.3.2 Clearance Testing

Clearance testing to verify all portions of a building are below the *action level* shall comply with all requirements in a), b) and c) of this [Section 7.3.2](#).

a) Test locations

1. Test locations shall include all *ground-contact* dwellings and non-residential rooms, in accordance with [Section 3](#), to include not less than 10% of the dwellings and non-residential rooms on each upper floor; and
2. Where any *active soil depressurization (ASD)* system exhausts below the roof, a test shall also be conducted in the room(s) immediately adjoining the outside exhaust location.

b) Seasonal verification

Efforts to reduce *radon* concentrations shall not be reported as complete until retests provide evidence of effectiveness that accounts for seasonal influences. Prior to, or within the first year of occupancy or ownership of property management, *clearance testing* requires the following verifications of seasonal effectiveness:

1. A *post-mitigation clearance test* conducted under conditions that are representative of the predominant *normal occupied building operating condition* for the test location, in accordance with requirements in [Section 2.7.2](#), shall have occurred or be conducted;
2. Where *mitigation* methods are based on passive efforts or mechanical dilution or pressurization of indoor air, two *post-mitigation clearance tests* are required to include:

- a. One *clearance* conducted under conditions that are representative of the predominant *normal occupied building operating condition*, such as heating season conditions, and
 - b. Another *clearance test* conducted under cooling season conditions, or the alternate seasonal condition of longest annual duration; and
3. Where decisions to mitigate relied on an evaluation of occupied versus unoccupied concentrations, as is recommended in **Section 5.2**, *post-mitigation clearance testing* shall include such an evaluation that meets requirements in **Normative Appendix B**.
- c) **Clearance testing—Failed locations**
- Where *clearance testing* reveals a need for additional *mitigation* efforts, testing specific locations after additional mitigation efforts shall be sufficient for meeting *clearance test* requirements if the following requirements are met:
1. Where the *mitigation* method is *active soil depressurization (ASD)* and the mitigated locations are served by individual HVAC systems described in **Exhibit 6** for Group 1 *Basic Heating and Cooling*: Testing shall include all locations where *clearance testing* revealed elevated *radon* concentrations.
 2. Where *mitigation* methods are based on passive *mitigation* efforts: Testing shall include all locations where *clearance testing* revealed elevated *radon* concentrations.
 3. Where *mitigation* methods rely on HVAC mechanical systems to provide dilution or pressurization of indoor air, testing shall include:
 - a. All locations required in **Section 3** within each *unique sector* mitigated, and
 - b. At least one measurement in each adjoining sector served by a different HVAC system.

7.3.3 System Performance Testing

Performance testing mitigation systems by testing only locations where elevated *radon* concentrations have been found shall not be reported as *clearance testing* verification that a building has been fixed. *Performance testing* mitigation systems shall be limited to evaluations of active systems prior to *clearance testing* or related to maintenance of active systems.

8.0 TEST REPORTS

8.1 Conventions

8.1.1 Units and Rounding

When reporting *radon* gas concentrations, the unit of measurement shall be *picocuries per liter (pCi/L)* reported to only one digit after the decimal (e.g., 3.2 pCi/L). Where the average of two measurements produces a second decimal digit that is "5" or greater, the value shall be rounded up. For example, 3.95 pCi/L shall be reported as 4.0 pCi/L.

Exception: Where conventionally appropriate, reports that use *Becquerel per cubic meter (Bq/m³)* as the unit of measurement for *radon* gas concentration activity shall be permitted.

8.1.2 Averaging

Measurement results reported in *summary reports*, on floor-plan diagrams and in other test result narratives shall be reported in accordance with requirements a) and b) of this **Section 8.1.2**.

a) **Collocated (side-by-side) measurements**

Where *collocated* (side-by-side) measurements were conducted, the average of valid results shall be reported in accordance with **Section 7.2**. Measurement devices located more than 8 inches (20 cm) from the outer surface of each other shall be regarded as being in separate locations. Measurements made in separate locations shall not be averaged.

b) **Follow-up measurements**

At each location where short-term detectors are used for *follow-up* testing under the *Extended Testing Protocol* prescribed in **Section 5.3**, the average of initial and *follow-up* test results shall be reported in accordance with **Section 7.2**.

8.2 Summary Reports

All reports shall include a *summary report* that complies with all requirements in this **Section 8.2**.

8.2.1 Essential information

Essential information provided in *summary reports* shall include all requirements in this **Section 8.2.1**.

a) **Measurement company**

The name, address and contact information for the company or entity responsible for the overall quality of content provided in the test report shall be provided;

b) **Site location**

The complete address with zip code of the building(s) measured shall be provided;

c) **Scope of the measurements conducted**

A summary of testing conducted shall be provided to include identification of the testing protocol used for testing, such as ANSI/AARST MAMF, and a description of:

- 1) The intended purpose of the testing procedure,
- 2) The measurement system to include method and test devices or detectors used, and
- 3) The dates when the testing was conducted.

d) **Laboratory**

The name, address and relevant certification or license number(s) of the service or organization(s) used to analyze detectors shall be provided;

e) **Radon Information Sources**

Information shall be provided for obtaining federal or state guidance documents and contacting the *State Radon Office* or equivalent authority where the test is conducted; and

f) **Measurement professional(s)**

The measurement professional(s) responsible for adherence to protocols onsite, during deployment and retrieval activities, and the measurement professional(s) responsible for quality procedures, such as during planning, implementation and reporting, shall be identified, to include:

- 1) their name, address and phone number(s),
- 2) their relevant *radon* measurement certification or license number(s), and
- 3) their legally binding signature (manual, or electronic in conformance with the Electronic Signatures in Global and National Commerce [E-SIGN] Act).

8.2.2 **Summary of measurement results**

Summary reports shall provide a summary of information that is pertinent to further actions or procedures that may be required relative to *mitigation* decisions, to include information required in a), b), c) and d) of this **Section 8.2.2**.

a) **Elevated concentrations**

Summary reports shall describe locations where test results meet or exceed the *action level*.

b) **Upper floors**

When elevated *radon* concentrations are found in upper floor test locations, *summary reports* shall clearly recommend that evaluations for determining the cause be conducted without delay.

c) **Follow-up procedures**

Summary reports shall identify all locations that still need to be tested or retested to comply with requirements in this standard.

d) **Unoccupied non-residential rooms**

Where nonresidential ground-contact locations, that are part of *conditioned space*, were not tested because they were not occupied, *summary reports* shall recommend either testing or that testing be conducted if occupied in the future.

8.2.3 **Reliability of the measurements**

Summary reports shall provide statements regarding reliability and shortcomings of the measurement procedures in accordance with requirements a), b), c), d) and e) of this **Section 8.2.3**.

Detailed elaboration is permitted to be included in *summary report* attachments.

a) **Quality assurance summary statements**

A summary statement regarding QC measurements shall be provided that conveys:

1. Confirmation of compliance with QC measurements requirements; and
2. Descriptions of any QC measurements that were missing or fell outside of control tolerances established in ANSI/AARST MS-QA “*Radon Measurement Systems Quality Assurance*.”

b) **Temporary conditions**

Where temporary building conditions or other factors are observed that are known or suspected to cause a test to not reflect occupant risk from *radon*, *summary reports* shall recommend retesting the affected location(s). Temporary conditions subject to this requirement include:

1. The property, dwelling or portion of the building tested was not operated under occupied operating conditions because it was vacant during the test period;

2. Systems were temporarily ventilating with outdoor air for seasonal comfort or energy savings during the test period, including:
 - a. Closable passive *crawl space* vents that were open during the test but would be closed more than 50% of the year for energy savings, comfort or to prevent frozen pipes,
 - b. Window air conditioners did not have closed outside air dampers during the test period,
 - c. Evaporative cooling systems were operating or not covered during the test period,
 - d. Energy recovery ventilators, heat recovery ventilators or *economizer* ventilation systems were operating under one or both of the following conditions:
 - the system was not set to the lowest outdoor air ventilation rate that occurs during all seasons.
 - not all thermostats in areas served by these systems were set to *normal occupiable temperatures*;
 3. Sub-slab return ducts observed, and minimal air handler activity occurred during the test; and
 4. If weather events occurred that were unusually severe for local weather.
- c) **Deviations from protocol**
- Where deviations from this standard were observed that are known or suspected to cause a test to not reflect occupant risk from *radon*, *summary reports* shall recommend retesting the affected location(s). Deviations from protocol subject to this requirement include, but are not limited to:
1. observed noncompliance with required conditions, such as closed-building conditions 12 hours prior to, or during the test period;
 2. observed deviation from a *normal occupiable indoor temperature*; and
 3. where *noninterference* controls indicate concerns regarding protocol compliance.
- d) **Radon mitigation system status (if applicable)**
- Where a *mitigation* system or efforts to mitigate *radon* are observed, *summary reports* shall include:
1. a statement that a *mitigation system* was observed and whether it appeared to be operating;
 2. a statement regarding the condition of any temporary *radon mitigation* strategies that are not permanent installations; and
 3. a statement on the limits of the inspection. It is permitted to provide a statement in the report that the test company offers no findings as to the proper installation and operation of the *mitigation system*.

8.2.4 Final Summary Reports

Where, in spite of insistent efforts, it is beyond the control of person(s) conducting the test to achieve valid tests in all locations required by this standard, the final *summary report*, and any elaborations in *summary report* attachments, shall provide a description of efforts for each location where conditions could not be overcome to achieve a valid test.

8.2.5 Low Radon Concentrations

Guidance in *summary reports* and otherwise provided where test results are below the action level shall comply with all applicable requirements in a), b) and c) of this **Section 8.2.5**.

a) Specific messages

The final *summary report* shall include equivalent statements for each of the guidance messages shown in Table 8-A where test results are below the *action level*.

8-A

Reporting Low Radon Concentrations

EQUIVALENT STATEMENTS FOR THESE ADVISORIES SHALL BE INCLUDED IN THE REPORT.

"Consider fixing the building if test results indicate radon concentrations greater than half the action level, (e.g., between 2 and 4 pCi/L).

Responsible care requires repeating initial testing procedures for all building(s) at least every 5 years and in conjunction with any sale of a building.

Radon testing should also be conducted when any of the following circumstances occur:

- ✓ a new addition is constructed or alterations for building reconfiguration or rehabilitation occur;
- ✓ a ground contact area not previously tested is occupied, or a building is newly occupied;
- ✓ heating or cooling systems are significantly altered, resulting in changes to air pressures or pressure relationships;
- ✓ ventilation is significantly altered by extensive weatherization, changes to mechanical systems or comparable procedures;
- ✓ significant openings to soil occur due to:
 - groundwater or slab surface water control systems that are altered or added (e.g., sumps, perimeter drain tile, shower/tub retrofits, etc.) or,
 - natural settlement causing major cracks to develop;
- ✓ earthquakes or construction blasting, fracking or formation of sink holes nearby; or
- ✓ a mitigation system is altered, modified or repaired.

Should testing indicate concentrations that meet or exceed the action level, conduct evaluations, corrections and further testing until radon concentrations have been mitigated to below the action level."

b) Seasonal reliability

If not already accounted for, additional testing shall be recommended, no later than within the first year after occupancy or ownership of property management, where:

1. Testing was not conducted under conditions that are representative of the *normal occupied building operating condition* that prevails during the greatest amount of time each year; or
2. Testing was conducted under conditions that inhibit clear characterization of a *radon hazard*.

c) Post-mitigation

Where the low test result is related to verifying *mitigation* effectiveness, the final *summary report* shall include all applicable requirements in b), c), d) and e) of the following **Section 8.2.6**.

8.2.6 Elevated Radon Concentrations

Guidance in *summary reports* and otherwise provided where test results meet or exceed the *action level* shall comply with all applicable requirements in a), b), c), d) and f) of this **Section 8.2.6**.

a) Specific messages

Summary reports shall include equivalent statements for each of the guidance messages shown in Table 8-B where test results meet or exceed the *action level*.

Table 8-B

Reporting Elevated Radon Concentrations

EQUIVALENT STATEMENTS FOR THESE ADVISORIES SHALL BE INCLUDED IN THE SUMMARY REPORT.

“Fix the building. Test results indicate occupants may be exposed to radon concentrations that meet or exceed the action level.

Efforts to reduce radon concentrations are not complete until retests provide evidence of effectiveness. The initial retest should be conducted within 30 days after mitigation efforts and system installations.

- Post-mitigation *clearance testing* to confirm each building is fixed requires testing all buildings that demonstrated elevated radon concentrations:
 - 1) in all ground-contact rooms and dwellings,
 - 2) in not less than 10% of non-residential rooms and dwellings on each upper floor.
- Should testing indicate concentrations that meet or exceed the action level, conduct evaluations, corrections and further testing until radon concentrations have been mitigated to below the action level.”

a) Mitigation Prior to Test Completion

When multiple test locations in close proximity to each other indicate elevated concentrations, recommendations to mitigate are permitted prior to completion of all planned test procedures. When reporting that *mitigation* could be warranted:

1. The recommendations shall include the following or equivalent statement: “Decisions on whether to mitigate are more fully informed once all testing is complete;” and
2. The recommendations shall be disclosed in a manner approved by the *client* in accordance with a *client's* pre-established directives on disclosing test data, as described in **Section 2.6.3**.

b) Clearance Testing

Recommendations shall be consistent with *clearance testing* requirements in **Section 7.3**.

Testing the effectiveness of mitigation efforts only in locations where elevated *radon* concentrations have been found shall be reported as *performance tests* with observance that the testing is not conclusive for fully verifying if the building has been fixed.

c) Seasonal Verification

Recommendations shall convey that efforts to reduce *radon* concentrations are not complete until retests provide evidence of effectiveness that accounts for seasonal influences.

It shall be recommended to conduct additional *clearance testing* within the first year after occupancy, or ownership of property management:

1. Where *post-mitigation clearance testing* has not been conducted under the predominant *normal occupied building operating conditions*, for the building or *unique sector*, and
2. Where *mitigation* methods are based on passive methods or mechanical dilution or pressurization of indoor air and *clearance testing* has not been conducted during two different seasons, in accordance with **Section 7.3.2**.

d) **Radon Sources Other Than Soil Gas**

Where testing indicates a possible *radon* source other than soil gas entry on upper floors or elsewhere in the building, recommendations regarding evaluations and *post-mitigation* testing shall be consistent with **Normative Appendix C**.

e) **Ongoing operation, maintenance and monitoring (OM&M)**

Where *post-mitigation* testing has indicated concentrations that are below the *action level*, *summary reports* shall:

1. recommend retesting every 2 years to verify continued *mitigation* system effectiveness, and
2. include guidance required in **Section 8.2.5** whenever reporting low test results.

8.2.7 Other guidance requirements

Guidance in *summary reports* and otherwise provided shall comply with all requirements of this **Section 8.2.7**.

a) **Opinions and interpretations**

When opinions and interpretations on any topic are included, the basis upon which the opinions and interpretations have been made shall be included in test reports. Opinions and interpretations shall be clearly marked as such in a test report.

b) **Health guidance**

Health and *action level* guidance provided in reports or otherwise furnished shall be consistent with federal guidance or as required by the state or equivalent local jurisdiction of authority where the test is conducted.

Note—**Section 7.1** provides an additional informational resource related to such guidance.

c) **Longer test periods**

Longer test periods, such as those greater than 90 days, shall not be reported as a closer evaluation of annual average *radon* concentrations when, in accordance with **Section 5.1.4**, heating season conditions during the test were less than the percentage of year when heating systems are active.

d) **Occupied versus unoccupied evaluations**

Evaluations of *occupied* versus unoccupied *radon* concentrations shall be permitted in *summary reports* to aid *mitigation* decisions when conducted in accordance with **Section 5.2**.

e) **Extended testing protocol**

Where the *Extended Testing* protocol option was chosen, it shall be recommended that test results achieved from Steps 1 and 2 of the protocol, in accordance with **Section 5.4.1**, are to be used for *mitigation* decisions.

8.3 Summary Report Attachments

Immediately attached to or otherwise accompanying a *summary report*, there shall be supplemental clarity provided in accordance with all requirements of this **Section 8.3**.

8.3.1 Test Results Across the Building

Floor plan diagrams shall be provided with *summary reports* that show the average of each test result from all locations where valid test results were achieved.

Exception: Where residential addresses are not expected to change, narrative identification and vicinity within the building shall be permitted in lieu of floor plan diagrams.

8.3.2 Test Conditions

For current or future evaluations regarding weather and building operating conditions on the reliability of the test to not reflect occupant risk from *radon*, the *summary report* attachments shall include:

- The minimum, maximum and average outdoor temperature that existed 12 hours prior to and during the test period;
- If the degree of precipitation was near to flood or drought conditions and if the ground is covered by snow or ice; and
- The seasonal relationship between test conditions and annual average conditions, in accordance with **Normative Appendix A**. Reporting this relationship shall include:
 - The percentage of time across the year for each differing *occupied operating condition*, and
 - The operating condition(s) that occurred during the test.

Fig. 8.3.2 Example Report Format

Outdoor Temperatures	Averages	Annual		During the Test
		45°		70°
Operating Conditions	Heating Conditions	75%	compared to	25%
	Cooling Conditions	-		-
	Mixed Conditions	25%		75%
Prevailing Operating Condition	Averages	Heating Conditions	compared to	Mixed Conditions
Condition less likely to inhibit characterization of a radon hazard		Air distribution systems active		Air distribution systems intermittent

Informative advisories:

- Fluctuations in *radon* concentrations are usually caused by either:
 - changes in the strength of indoor air pressures that draw soil gas into a building; or
 - changes in the volume of outside air entering a building.
- Clear characterization of a *radon* hazard is more likely to occur when:
 - Outdoor temperatures extend below 65°F (18°C), at least intermittently, which causes natural indoor air pressures that draw *radon* laden soil gas into a building; and
 - Heating or cooling distribution fans are at least intermittently active during a test.
- Measurements more likely to reflect an occupant's exposure to *radon* are measurements conducted under conditions that most closely align to the building operating conditions that prevail during the greatest amount of time each year.

8.3.3 *Elaborations*

Where detailed elaborations are warranted in *summary report* attachments regarding concerns of testing reliability or extenuating circumstances, such elaborations shall be prominently identified.

8.4 **Additional Test-Data Documentation**

Test data, in accordance with **Sections 8.4.1** through **8.4.3**, shall be provided with each test report.

8.4.1 *All individual results*

The test results from all individual valid measurements from each detector or test device, including results from individual *quality control* check detectors or devices, shall be provided along with:

- a) Detector identification/serial numbers;
- b) The start and stop dates and times of the measurement period;
- c) Test location notes, as appropriate; and
- d) Annotation for QC measurement results to indicate their purpose.

8.4.2 *Continuous Monitors*

Additional requirements when using and reporting *continuous radon monitor* test results include:

- a) hourly data shall either be included in the test report or made available to be provided to the client upon request;
- b) the calibration date of each continuous monitor shall be included on the test report; and
- c) removal of or “backing out” portions of hourly data imbedded within the contiguous sampling period reported (such as to account for weather or other conditions) shall invalidate the measurement.

Exceptions:

- 1. The first 4 hours of data are to be discarded or incorporated into the calculated test result reported using system correction factors (EPA 402-R-92-004, EPA 1992);
- 2. The first 12 or more hours are to be discarded in the calculated test result reported where required for meeting closed-building requirements in **Sections 4, 6.1.2** and **7.3.2**;
- 3. The first 24 or more hours are to be discarded in the calculated test result reported where required in **Section 7.3.2** after activation of a *mitigation system* fan or completion of other *mitigation* efforts, for evaluation of post-*mitigation* effectiveness; and
- 4. Where hourly data is intentionally used to evaluate occupied versus unoccupied concentrations, in accordance with **Section 5.2**.

8.4.3 *Test notifications*

Records of *client* notifications and dates distributed shall be included with each report, to include:

- a) Communications regarding *client* advisories, *client* authorizations and *client* commitments, as required in **Section 2.6**; and
- b) Communications regarding the content of occupant notices that the client's *facilitating staff* were to distribute, as required in **Section 2.9.1**.

8.5 Other Reporting and Disclosures

It shall be incumbent upon all measurement professionals responsible for adherence to protocols during onsite activities and quality procedures during planning and reporting to ensure compliance with requirements in a), b), c) and d) of this **Section 8.5**:

- a) All valid test results shall be reported in accordance with local statutes and requirements of the state radon office or other local authority where the testing is conducted;
- b) Test location details submitted voluntarily to a state, federal authority or research project shall include no less than:
 - 1. The address of the property tested to include street address, city, state and zip code,
 - 2. Detector identification/serial numbers,
 - 3. The start and stop dates and times of the measurement period, and
 - 4. The test result.
- c) The client shall be informed in writing that the chain of custody for test devices is available upon request.
- d) The client shall be informed in writing of their responsibility to identify and comply with local statutes regarding obligations that may exist for disclosing test results to occupants and affected third parties.

8.6 Retention of Records

The detector placement log, floor-plan diagrams, supporting documentation with evidence of compliance with this standard and other records related to the testing shall be maintained for at least 6 years after testing.

9.0 DEFINITION OF TERMS

Terms not defined herein shall have their ordinary meaning within the context of their use. Ordinary meaning shall be defined in "*Webster's Eleventh New Collegiate Dictionary*."

- 9.1 **Action Level** A threshold for when *mitigation* of exposure to harmful elements is recommended or required.
- 9.2 **Active Soil Depressurization (ASD)** A radon control system involving fan-powered soil depressurization, including but not limited to sub-slab and sub-membrane depressurization.
- 9.3 **Alpha Track Detector (ATD):** A *radon* detector constructed from a piece of plastic, typically of either allyl diglycol carbonate or cellulose nitrate, inside a chamber usually made of electrically conducting plastic. *Radon* diffuses passively into the chamber, where it subsequently decays. Alpha particles emitted from *radon* and two of its short-lived progeny, ²¹⁸Po and ²¹⁴Po, strike the plastic detector and create damaged volumes or "latent tracks." The plastic is etched in a caustic solution, which produces tracks that are visible with a microscope because the latent tracks are more soluble than the surrounding undamaged material in such a solution.
- 9.4 **Basic Heating and Cooling** A dedicated heating and cooling system that does not supply additional outside air for ventilation. See Exhibit 6, Group 1.
- 9.5 **Batch** The set of material that is considered to be homogenous regarding characteristics that determine the calibration relationship. For example, activated carbon is prepared and sold in batches, which are then used by laboratories to construct devices with that carbon; a single plastic melt is sold to laboratories who manufacture many ATDs from that batch.
- 9.6 **Becquerel per Cubic Meter (Bq/m³)** A unit of radioactivity representing one disintegration per second per cubic meter: 1 Bq/m³ (0.027 pCi/L).
- 9.7 **Blank Measurements** Blanks are detectors deployed to verify and document the absence of effects on the measurement resulting from sources other than the air being tested. Since blanks are not exposed (i.e., not left open to permit *radon* to enter the detector), their measurement value should be below the minimum detectable concentration of the measurement system. See *field blanks*, *office blanks* and *lab-transit blanks*.
- 9.8 **Calibration** To adjust or determine or both, the response of an instrument or device relative to a series of conventionally true values.
- 9.9 **Charcoal Adsorption Device (CAD) Methods:** This class of device employs a material such as activated charcoal that adsorbs *radon* from the air. The amount of *radon* adsorbed depends on the design of the device, the type of charcoal, the exposure time and the *radon* concentration, temperature and relative humidity in the surrounding air. This class of device can provide an accurate representation of the average *radon* concentration during the exposure period if there are no large changes in *radon* concentration or the environment (e.g., temperature, humidity) during the exposure. Because of the half-life of *radon* and the time it takes for *radon* to adsorb, they are typically limited to exposure durations from 2 to 7 days. *Calibration* of a charcoal adsorption system is accomplished through exposures of representative sets of devices in a *STAR* for various time periods and different temperatures and humidities.

9.10 Clearance Testing	A test procedure for obtaining evidence that <i>radon</i> concentrations in all dwellings and occupied areas of a building are below the predefined <i>action level</i> .
9.11 Client	The individual(s) or parties who hire(s) or pay(s) for <i>radon</i> test services.
9.12 Collocated	Two or more simultaneous measurements within 4-8 inches (10-20 cm) of each other in the same location, or side-by-side.
9.13 Comparison Checks	<i>Collocated</i> , simultaneous measurements conducted for the purpose of assessing and monitoring measurement reliability. Comparison checks include but are not limited to <i>duplicate</i> measurements that are defined as <i>collocated</i> , simultaneous measurements using measurement devices of the same manufacturer, model, and most recent calibration date and facility.
9.14 Conditioned Space	Areas within the heated and cooled envelope of the building where HVAC systems maintain temperatures to facilitate comfort of occupants. Basement areas that maintain occupiable temperatures by virtue of ambient sources of heat or cooling, such as from the earth or adjoined air spaces are considered conditioned spaces within the heated and cooled envelope of the building.
9.15 Continuous Radon Monitor (CRM)	A CRM is an electronic device that is capable of automatically recording a retrievable time series of numeric measurements of <i>radon</i> concentration averaged over time intervals of 1 hour or less. If a device is not capable of these functions or is not set to record readings each hour, it is functioning as a <i>passive device</i> and is not considered a continuous monitor under this protocol.
9.16 Crawl Space	An open area beneath part or all of the livable space of a dwelling that typically has either a concrete slab or dirt floor. The dirt floor may be covered with gravel or a membrane. The crawl space can have an open height of a few inches to several feet. The crawl space can be storage space but is not living space.
9.17 Duplicates	<i>Collocated</i> , simultaneous measurements conducted with instruments or devices that are identical (including manufacturer, model, and, for continuous monitors, the same most recent calibration facility and schedule) for the purpose of assessing and monitoring the measurement system imprecision. (See <i>Comparison Check</i> for a different category of QC measurements that do not require the use of identical devices.)
9.18 Dynamic Equilibrium:	The state where <i>radon</i> and dilution air entering a building have reasonably stabilized under closed-building conditions. Buildings are generally closed more than 70% of the year and 12 hours is usually sufficient for dynamic equilibrium to occur in most buildings.
9.19 Economizer Systems	An HVAC systems that provides additional outside air to a building in variable volumes, depending on outdoor temperature, as a means to save expenses of operating air conditioning equipment.
9.20 Electret Ion Chamber (EIC) Method:	This type of device uses an ion chamber made of, or lined with, an electrically conductive material with an electret as the detecting mechanism. The surface voltage of the positively charged electret is measured before and after the exposure to <i>radon</i> . During the exposure, <i>radon</i> passively diffuses into the ion chamber and subsequently decays. The <i>radon</i> decay and its short-lived progeny ionize the air inside the chamber. Electrons are attracted to the electret and discharge it. From the surface voltage of the electret measured before and after the exposure, and the duration of the exposure, the average <i>radon</i> concentration during the exposure can be calculated using <i>calibration</i> factors determined through exposures of devices in

a *STAR*. Ambient gamma rays also ionize air inside the chamber, and the effects of ambient gamma radiation must be taken into account. Different electret sensitivities and chamber sizes can be used in combination to measure a range of *radon* concentration ranging from 2 days to 1 year. The EIC QA requirements apply to all combinations of electrets and chambers used to measure *radon* concentration in ambient air.

- 9.21 **Extended Testing** An initial test where, if a *radon* concentration is found to be elevated, a *follow-up* confirmation test is conducted. Alternatively, initial tests conducted over an extended period of time, such as more than 90 days
- 9.22 **Facilitating staff** Individuals who work at the property being tested or work for property owners or managers such as building supervisors, maintenance staff or office managers.
- 9.23 **Field Blanks** These detectors serve to reveal any unexpected exposures that might result onsite or from handling procedures.
- 9.24 **Follow-up Test Procedures** Procedures for *radon* measurement events such as confirmation testing to verify initial test results, *post-mitigation* testing and other measurements conducted to better evaluate *radon* hazards.
- 9.25 **Ground-Contact** Indoor locations that are habitable, or could be made habitable, and:
 - a) have floors or walls in contact with ground, or
 - b) are closest to ground, such as rooms over a *crawl space*, utility tunnel or parking garage.
- 9.26 **HAC Systems** Heating and cooling (air conditioning) systems that are not designed to also supply fresh air ventilation. HAC systems are common to single-family residences.
- 9.27 **High-rise Structures** Buildings containing one or more occupied floors located higher than 75 feet (23 m) above the lowest level.
- 9.28 **HVAC Setback** HVAC “setback” is normally the automated or manual manipulation of system controls to vary operation of heating, cooling and ventilation systems between occupied periods as compared to unoccupied periods.
- 9.29 **HVAC System** Heating and cooling (air conditioning) systems that are additionally capable of supplying outdoor air ventilation. If systems do not supply outdoor air ventilation, they are more technically referred to as HAC systems.
- 9.30 **Intended to be Occupied** Locations where there are plans to occupy rooms even though unoccupied at the time of the testing procedure. Examples include, vacant locations being leased or sold and locations where renovation or repurposing is planned.
- 9.31 **Lab-transit Blanks** These detectors serve both to evaluate the quality of the laboratory and to look for unexpected exposures that might result from shipping or handling
- 9.32 **Long-Term Test Device** A *radon* measurement device or detector that is capable of producing a time weighted average for *radon* concentrations for test periods that may extend for weeks, months or a year.
- 9.33 **Lot** The term “lot” refers to bundled sets of unexposed detectors received from manufacturers or other sources at local office(s) as distinguished by the date of purchase.
- 9.34 **Measurement Professional** (See *Qualified Measurement Professional*)
- 9.35 **Mitigation** Efforts to reduce *radon* concentrations in the indoor air of a building.

9.36 Mitigation System	A system designed to reduce <i>radon</i> concentrations in the indoor air of a building.
9.37 Multifamily Building	Buildings having more than one attached dwelling or other occupied unit under the same ownership or designated maintenance or management authority.
9.38 Multi-Zone Systems	Independent systems and controls for different areas within the same dwelling, room or <i>unique sector</i> . See Exhibit 6, Group 2.
9.39 Normal occupiable indoor temperatures	Indoor temperatures of between 65° and 80° F (18° - 27° C).
9.40 Normal Occupied Operating Condition	The operational condition for the building or unique sector of the building that exists during the greatest amount of significantly occupied time. See " <i>Significantly occupied</i> "
9.41 Notice of Radon Testing	Written notices to inform occupants and <i>facilitating staff</i> about testing and required test conditions associated the <i>radon</i> testing.
9.42 Occupied	Any area of the building that is occupied on a regular basis for more than 4 hours a day. See " <i>Significantly occupied</i> " and " <i>Occupied Weeks</i> "
9.43 Occupied Work or School Weeks	Those weeks that do not include vacation days such as national or religious holidays, winter breaks or similar weeks where test conditions do not represent <i>normal occupied operating conditions</i> for the building. See " <i>Normal Occupied Operating Condition</i> ", " <i>Occupied</i> " and " <i>Significantly Occupied</i> "
9.44 Office Blanks	These detectors serve to reveal any unexpected exposures that might result from storage or handling.
9.45 Passive Device	<i>Radon</i> measurement detectors or systems that collect a time-weighted average and do not provide hourly readings. Passive detectors include electret ion chambers; activated charcoal kits; liquid scintillation vials; alpha-track detectors; and continuous monitoring devices that are not set to or capable of automatically recording a retrievable time series of 1 hour measurements.
9.46 Performance Testing (Mitigation)	A test procedure to characterize the degree of general effectiveness for <i>mitigation</i> efforts within a specific area of a building.
9.47 Picocurie per Liter (pCi/L)	A unit of concentration of radioactivity corresponding to 0.037 decays per second or 2.22 decays per minute in a liter of air or water. 1 pCi/L = 37 becquerels per cubic meter (<i>Bq/m³</i>).
9.48 Qualified Measurement Professional	An individual that has demonstrated a minimum degree of appropriate technical knowledge and skills specific to <i>radon</i> measurement procedures in homes with additional knowledge needed when testing multifamily buildings and schools or other large buildings.
9.49 Quality Assurance (QA)	A complete program designed to produce results that are valid; scientifically defensible; and of known precision, bias, and accuracy, including planning, documentation, and <i>quality control</i> activities.
9.50 Quality Control (QC)	The system of activities to ensure a quality product, including measurements made to ensure and monitor data quality. For <i>radon measurement devices</i> includes calibrations and background, <i>duplicate</i> , <i>blank</i> and <i>spiked measurements</i> ; inter-laboratory comparisons; audits; and other control activities.
9.51 Radon (Rn)	A colorless, odorless, naturally occurring, radioactive, inert, gaseous element formed by radioactive decay of radium (Ra-226) atoms. The atomic number is 86.

Although other isotopes of *radon* occur in nature, in this document, *radon* refers to the gas Rn-222.

- 9.52 Radon Decay Products (RDP)** Often termed "*radon* progeny," each *radon* atom after emitting an alpha particle transforms to become different radioactive elements in a series where the short-lived decay products of *radon* (Po-218 and Po-214) also emit alpha particles as they decay. These decay products are solid elements rather than gaseous and are left suspended in the air we breathe.
- 9.53 Radon Test Detector** The element of a *radon* measurement device or system that detects *radon*. The detector may be a separate component from the analysis equipment such as for many passive *radon* measurement systems or may be housed within a device that functions as a combined detector and analysis instrument.
- 9.54 Radon Test Device** A *radon* measurement system regardless if configured as a combined detector and analysis instrument or as a system where detectors and analysis equipment are separate components.
- 9.55 Return-Air** Air being pulled towards an *HVAC* air handling fan unit. When the *HVAC* fan activates, air enters return air vent openings and gaps in ductwork. This air then travels through return air ductwork to the *HVAC* air handling unit. When the *HVAC* fan activates, air within the ductwork is under negative pressure relative to indoor air or other surrounding environment.
- 9.56 Setback** See *HVAC Setback*.
- 9.57 Short-Term Test Device** A *radon* measurement device or detector that is capable of producing a time weighted average for *radon* concentrations for periods of two or more days.
- 9.58 Significantly Occupied** The time period when the building is typically occupied by the majority of the workers or students. See "*Normal Occupied Operating Condition*", "*Occupied*", "*Significantly Occupied*" and "*Occupied Weeks*".
- 9.59 Single-Family Dwelling** A residence or home intended to house a single family.
- 9.60 Spiked Measurements** Spikes are detectors that have been exposed in an approved chamber to a known concentration of *radon* (i.e. "spiked" with *radon*). Spikes help evaluate the accuracy of a laboratory analysis and/or how accurately detectors supplied by a laboratory measure *radon*.
- 9.61 Structurally Isolated Airspace** A portion of a building where structural components, such as doors and walls result in an isolated airspace that resists air movement between the isolated airspace and surrounding portions of the building.
- 9.62 State Radon Office** An office established by a state government to provide information about *radon* and in some cases, to regulate *radon* activities in a manner as required by local statute.
- 9.63 Summary Report** A summary or executive summary report is a short section of a document that summarizes a longer report or a group of related reports in such a way that readers can rapidly become acquainted with a large body of material without having to read it all.
- 9.64 Test Interference** The altering of test conditions prior to or during a measurement to change the *radon* or *radon decay product* concentrations, or the altering of the performance of the measurement equipment.

9.65 Time-Sensitive	Situations where <i>mitigation</i> decisions are needed relatively quickly, such as within several days or weeks. Time sensitive measurement strategies entail a single phase of testing with enhanced <i>quality control</i> measures.
9.66 Unique Sector	Portions of a common building that are classified by the general design and intended purpose of each active heating, cooling and ventilation system (HVAC).
9.67 Valid Sample Time	The period representing occupied conditions after stabilizing building conditions with initiation of the closed-building protocol. Examples of valid sampling times include: The period beginning 12 hours after closed-building protocols are initiated or 24 hours after activation of a <i>radon mitigation system</i> . Valid sampling time is further defined by all other related requirements within this standard.
9.68 Variable Air Volume Systems (VAV)	HVAC designs where airflow from a single air handle is distributed among multiple dwellings or rooms that temper room temperatures using thermostats to vary the volume of heated or cooled air delivered into rooms. See Exhibit 6, Group 4 Systems.
9.69 Variable Outdoor Air Ventilation	Systems that seasonally vary outdoor air ventilation for seasonal comfort or energy savings. See Exhibit 6, Group 3 Systems.
9.70 Working Level (WL)	A unit of <i>radon decay product</i> concentration. One WL equals any combination of short-lived <i>radon decay products</i> in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential-alpha energy. It is approximately the alpha-particle energy released from the decay products in equilibrium with 100 pCi of Rn-222.

INFORMATIVE EXHIBIT 1

SAMPLE FORM— AUTHORIZATIONS AND LINES OF COMMUNICATION

Dear Client and Managing staff,

Please return this form as soon as possible to help us clarify lines of communication and responsibilities.

Client Authorizations

Staff authorized for responding to occupant and public inquiries:

Title/name: _____ Phn# _____

Title/name: _____ Phn# _____

Person(s) authorized to receive report data and any incremental reports:

Title/name: _____ Phn# _____

Title/name: _____ Phn# _____

Frequency of reports: () Prior to testing () After each phase of testing () When testing is complete

Client or Authorized Agent Name: _____

Signature: _____ Date _____

Please ensure all contacts and authorizations are provided prior to testing events.

Client and Facilitating Staff Member Contact Information

Client or Authorized Agent: _____ Phn# _____

Onsite logistics supervisor: _____ Phn# _____

Building/dwelling access: _____ Phn# _____

HVAC operations: _____ Phn# _____

Other contact title/name: _____ Phn# _____

Radon Testing Professional Contact Information

Scheduling and logistics: _____ Phn# _____

Overseeing Professional: _____ Phn# _____

Jobsite Quality Control: _____ Phn# _____

Jobsite Quality Control: _____ Phn# _____

Field Technician: _____ Phn# _____

Field Technician: _____ Phn# _____

INFORMATIVE EXHIBIT 2

SAMPLE FORM—CLIENT COMMITMENT TO COMPLIANCE

MANAGEMENT COMMITMENT

To the extent reasonably possible, I, on behalf of _____, commit to helping ensure that building conditions required to achieve reliable radon tests are met, as portrayed herein.

Client or Authorized Agent Name: _____

Signature: _____ Date _____

BUILDING ONSITE SUPERVISOR COMMITMENT

To the extent reasonably possible, I commit to helping ensure that building conditions required to achieve reliable radon tests are met, as portrayed herein, by accepting the following responsibilities:

- 1) Prior Notifications:** Notices will be distributed to all tested, non-tested dwellings and posted in publicly accessible areas such as in corridors, elevators and offices in a timely manner, no later than required by local law for gaining access to a dwelling or not later than the day before testing; and
- 2) Access:** Access will be provided to each location being tested within a building with intent to access all locations within a building on the same day for both the event of placing test devices and a second event for retrieving test devices.

Onsite Logistics Supervisor —Name: _____

Signature: _____ Date _____

BUILDING OPERATIONS STAFF COMMITMENT AND ATTESTATIONS

To the extent reasonably possible, I commit to helping ensure that building conditions required to achieve reliable radon tests are met, as portrayed herein, by accepting the following responsibilities:

- 1. Building Preparation:** I accept responsibility that, no later than 12 hours prior to testing, each building scheduled for testing will be reviewed for compliance with closed-building requirements.
- 2. Compliance Verification:** I accept responsibility for taking actions that could include adjustments to HVAC units and repairs, such as for broken windows, where completion is required no later than 12 hours prior to testing. Verification will be provided as initialed below or initialed on a log sheet to be provided.

HVAC Operations Supervisor—Name: _____

Signature: _____ Date _____

Building address(s) _____ Date completed _____ Initials _____

Building address(s) _____ Date completed _____ Initials _____

Building address(s) _____ Date completed _____ Initials _____

INFORMATIVE EXHIBIT 3

SAMPLE NOTICE—GENERAL NOTICE PRIOR TO TESTING

Radon Testing Scheduled

Dear Residents,

An important step is being taken to help protect the health of all occupants in this building. Radon testing is being conducted in portions of this building.

Radon is a naturally occurring radioactive gas often found in soil that can be present in buildings at concentrations greater than recommended.

The only way to know what the radon concentrations are for any building is to test.

Starting Day: _____ Date _____ **(Windows must be closed the night before)**

Ending Day: _____ Date _____ Ending Time: Close of business hours.

Access into your unit is: ☐ required on _____
☐ not required

**Please help to maintain these required test conditions throughout the building
(12 hours before the test and during the test).**

Heating and cooling systems	Set to normal occupied operating conditions with normal temperatures between 65° and 80° F (18° - 27° C)
Bathroom fans	Operate normally
Fireplaces (that burn solid, liquid or gas fuels unless a primary/normal source of heat for the building)	Do not operate

For general health information:

Copies of EPA's *A Citizen's Guide to Radon* can be found online at www.epa.gov/radon.

For inquiries or reporting concerns.

Contact Person: _____ Phone: _____

We thank you for your cooperation in helping to ensure a safe and healthy building.

INFORMATIVE EXHIBIT 4

SAMPLE PRIOR NOTICE—PUBLIC NOTICE POSTER

Radon Survey in Progress

Dear Residents,

An important step is being taken to protect your health. Radon testing is being conducted for this building.

Radon is a naturally occurring radioactive gas that can be present in some buildings at concentrations greater than recommended. Testing for radon is recommended for all homes. Radon gas is the second leading cause of lung cancer and the leading cause of lung cancer for nonsmokers in the United States.

The only way to know what the radon concentrations are for any building is to test.

Radon testing is scheduled for:

Building(s): _____

Building Area(s): _____

Test Deployment: Day _____ Date _____ (please close windows the night before)

Test Completion: Day _____ Date _____ Time: Before close of business hours

Please help to maintain these required test conditions throughout the building (12 hours prior the test and during the test).	
Exterior doors (except for momentary entry and exit)	keep closed on all levels of the building including areas not being tested
Systems that temporarily ventilate with outdoor air for seasonal comfort or energy savings	Set to the lowest seasonal ventilation
Exhausts Systems (that temporarily draw air from the building such from laundries, workshops, community kitchens or for local control of fumes)	Avoid excessive operation

For general health information:

Copies of EPA's *A Citizen's Guide to Radon* can be found online at www.epa.gov/radon.

For inquiries or reporting concerns.

Contact Person: _____ Phone: _____

We thank you for your cooperation in helping to ensure a safe and healthy building.

INFORMATIVE EXHIBIT 5

SAMPLE NOTICE—BUILDING OPERATIONS STAFF INSTRUCTIONS

<div style="text-align: right; color: blue; font-size: 2em;">→</div> <p>Windows</p>	
<p>Other openings to the exterior as a result of discrepancy in construction or structural defect.</p>	<p>Close or seal on all levels of the building, including areas not being tested</p> <p>Exception: Do not close openings to outside air designed to provide air needed for combustion appliances.</p>
<p>Heating and cooling systems</p>	<p>temperatures: 65° - 80° F (18° - 27° C).</p> <p>Note—Maintenance inspections of HVAC systems are recommended, but not required.</p>
<p>Automated or manually operated systems that seasonally vary outdoor air ventilation for energy savings or comfort, for:</p> <ul style="list-style-type: none"> — individual rooms and dwellings — multiple rooms and dwellings; or — the whole building. <p>Such systems include: Manually operated dampers, Energy Economizer systems, Energy Recovery Ventilators (ERV) and Evaporative cooling systems.</p>	<p>Close outside air inlet dampers or set to minimum outdoor air intake settings that apply at all times of the year when a building is <i>significantly occupied</i>.</p> <p>For other systems, such as window air conditioners, dampers to outside air shall be closed.</p>
<p>Variable Air Volume (VAV) Systems (if any)</p> <p>Systems that temper room temperatures using thermostats to vary the volume of heated or cooled air coming into rooms.</p>	<p>Set all thermostats to between 65-80° F (18-27° C) in all rooms that are served by the system.</p>
<p>Return-Air Ducts laid In Soil (if any)</p> <p>Where return-air air ductwork is located under a slab or otherwise laid in soil.</p>	<p>Alert the testing company immediately</p>
<p>HVAC setback in non-residential locations</p> <p>If non-residential rooms are operating with HVAC setback temperatures during nights or weekends that are outside of normal occupied temperatures of 65° and 80° F (18° - 27° C).</p>	<p>Alter to retain temperatures within the range of 65° and 80° F (18° - 27° C)</p> <p>Or, contact the testing company</p>

INFORMATIVE EXHIBIT 6

HVAC GROUP DESCRIPTIONS

Page 1 of 3

Definitions of basic and complex HVAC systems as applicable to this standard of practice.

Advisory—If it is unclear what type of system is present, consult with the building representative, a mechanical engineer or a qualified heating and air conditioning contractor.

HVAC - DEFINITIONS AND SPECIAL CONSIDERATIONS	
<p>Group 1: Basic Heating and Cooling</p> <p>A dedicated system for each dwelling or unique area that does not provide seasonally <i>variable outdoor air ventilation</i> for added comfort or energy savings.</p> <ul style="list-style-type: none"> • Forced-air heating and air conditioning (HAC) systems such as normally seen in single-family residences. • Ductless Systems <ul style="list-style-type: none"> — Non-Forced-Air Hot and Cold Water Circulation (sometimes called radiator systems). — Window AC (w/fresh air closed). — Unit Ventilators (w/fresh air closed). — Wall or Baseboard heating/cooling. • Ductless Split Systems: One system for cooling and one for heat (e.g., Window AC for cooling and Baseboard heat). 	No Special Consideration
<p>Group 2: Multi-zone Systems</p> <p>Independent systems and controls for different areas within the same dwelling or unique sector.</p>	See Section 3.5 for testing recommendations
<p>Group 3: Variable Outdoor Air Ventilation</p> <p>HVAC systems that temporarily vary outdoor air ventilation for seasonal comfort or energy savings in:</p> <ul style="list-style-type: none"> - individual dwellings; - multiple dwellings; or - the whole building. <p>Such systems include those known as: Energy Economizer systems, Energy Recovery Ventilators (ERV) and Evaporative (swamp) cooling systems.</p>	See Section 4.2.2 for additional testing requirements
<p>Group 4: Variable Air Volume Distribution</p> <p>HVAC systems where airflow from a single air handler is distributed among multiple dwellings with independent thermostat controls in each dwelling that variably open and close dampers for heated or cooled supply air.</p> <p>Such systems are commonly called Variable Air Volume (VAV) systems.</p>	See Section 4.2.3 for additional testing requirements

Group 1: BASIC HEATING AND COOLING (HAC)

Dedicated system(s) that do not supply additional outdoor air for ventilation.

HAC Systems:

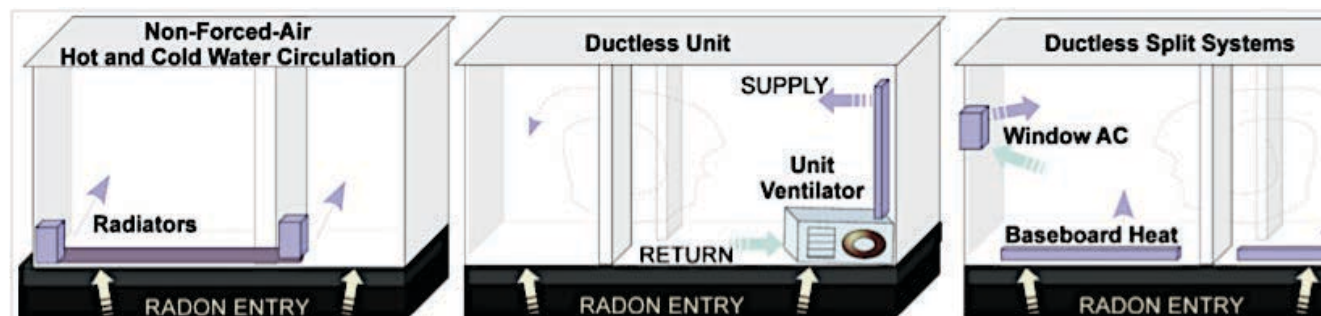
Many buildings have forced-air heating and air conditioning (HAC) systems.

Supply and return ducts distribute air around the building.

**Ductless Systems:**

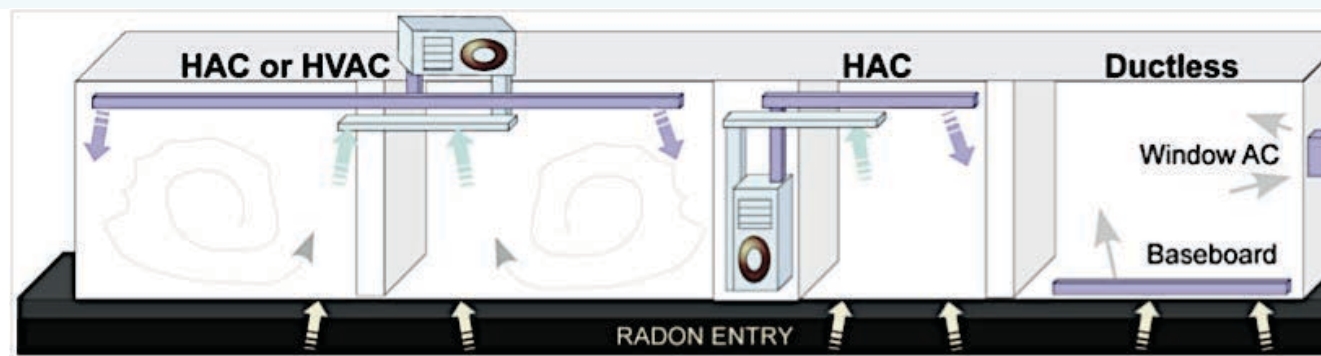
Some rooms or dwellings do not have ducted forced-air distribution.

- Hot and Cold-Water Circulation (sometimes referred to as "radiator" systems).
- Window Air Conditioners.
- Wall or Baseboard Heating/Cooling Systems.
- Ductless Split Systems with one unit for cooling and another unit for heat (i.e. Window AC for cooling and Baseboard or Wall units for heat).

**Group 2: MULTI-ZONE SYSTEMS**

Multi-zone systems are those where different air handlers or systems are employed and independently controlled for different areas within the same dwelling or common use area of a building.

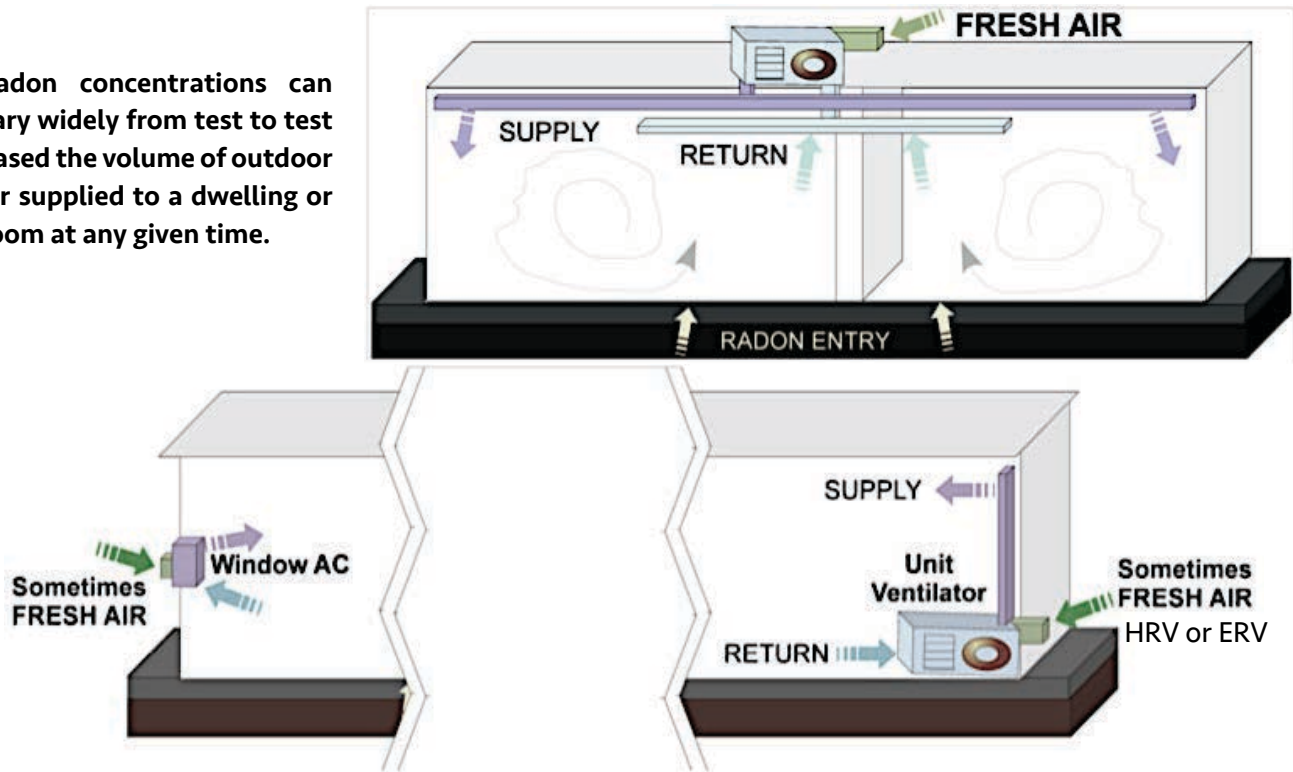
Radon concentrations can vary from room to room based upon variances in system operations.



Group 3: VARIABLE OUTDOOR AIR VENTILATION

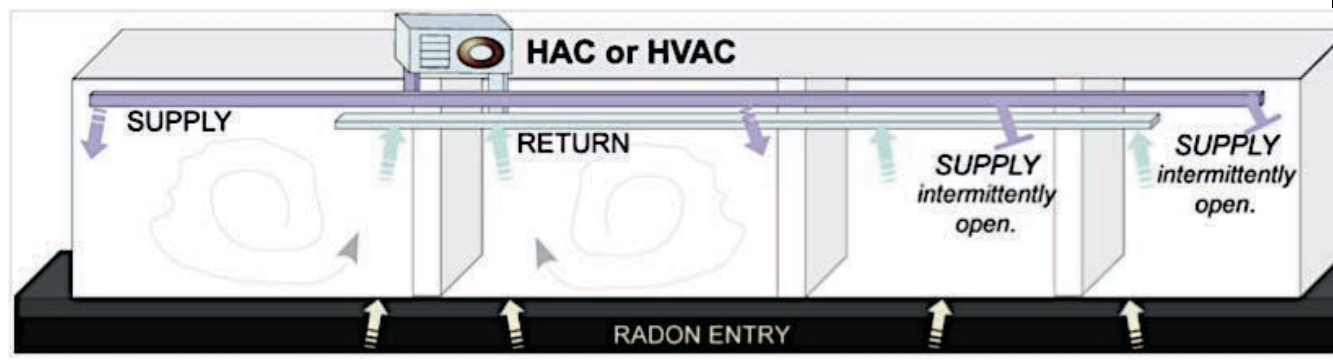
Variable Outdoor Air Ventilation (HVAC) systems are those that add outdoor air ventilation for seasonal comfort or energy savings. Such systems may service a whole building, multiple dwellings or a single dwelling or unit ventilator.

Radon concentrations can vary widely from test to test based the volume of outdoor air supplied to a dwelling or room at any given time.



Group 4: VARIABLE AIR DISTRIBUTION

Variable Air Distribution systems are those where airflow from a single air handler is distributed to multiple dwellings, rooms or common use areas with independent controls within each area that open and close duct dampers. The normal operation of these systems can cause changes in distribution of radon or ventilation air and can also affect pressure relationships that can enhance or diminish radon entry.



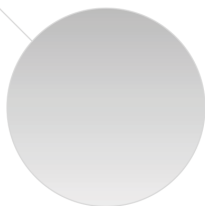
INFORMATIVE EXHIBIT 7

EXAMPLE—FLOOR PLAN DIAGRAM

"X" = Detectors
 "D" = Duplicate Detectors
 "B" = Field *Blank* Detectors



INFORMATIVE EXHIBIT 8
SAMPLE—DOOR HANGER NOTICE & DEVICE LABELS



**RADON TEST
IN PROGRESS**

Keep closed

Windows & Exterior doors
except for momentary use)

**Set to lowest
outdoor
ventilation**

**Systems that temporarily
ventilate with outdoor air
for seasonal comfort or
energy savings**

**Avoid excessive
operation**

**clothes dryers, range hoods
and bathroom fans**

Do not operate

**Fireplaces that burn
solid, liquid or gas fuels,**

Do not disturb test devices.

Radon Test Device

Do not discard or disturb
Questions call

Radon Test Device



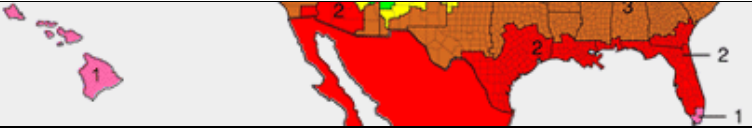

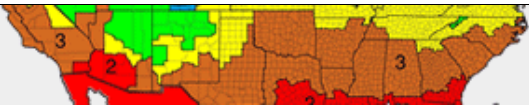


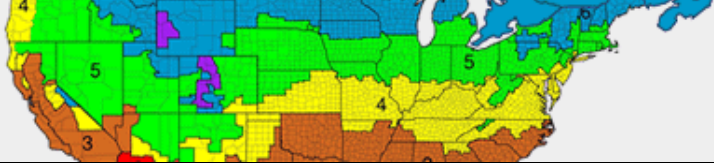

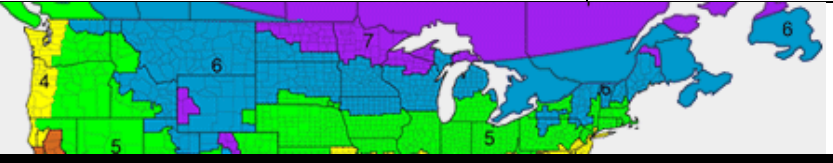


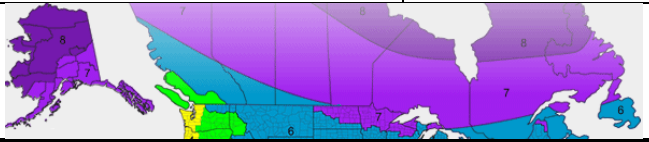
Do not discard or disturb

Radon Test Device

Do not discard or disturb

NORMATIVE APPENDIX A

REPORTING REQUIREMENTS FOR BUILDING OPERATING CONDITIONS

TEMPERATURE ZONES as designated in ASHRAE standards 90.1 and 90.2 (The American Society of Heating, Refrigerating and Air-Conditioning Engineers) https://www.ashrae.org			
Climate Zone	Example North American States or Cities	Average Annual Temperature	
 1 Very Hot	Southern Florida and Hawaii	Miami	76° F (24 C)
 2 Hot	Florida, New Orleans, Houston, Mexico	New Orleans	68° F (20 C)
			
 3 Warm	North Carolina to Southern California	Atlanta	61° F (16 C)
			
 4 Mixed	NYC, PA, NJ, VA, KT, TN KS, MO, Seattle WA, and Portland OR.	Kansas City	54° F (12 C)
 5 Cool	MA, NY, OH, MI, IN, IL, IA, NE, CO, UT and NV.	Chicago	49° F (9 C)
			
 6 Cold	ME, NH, VT, WI, MN, ND, WY, SD and ND.	Montreal	43° F (6 C)
			
 7 Very Cold	Minot, ND; Anchorage, AK; Winnipeg, Canada	Winnipeg	36° F (2 C)
 8 Subarctic	Fairbanks Alaska; Cambridge Bay, Canada	Fairbanks	26° F (-3 C)
			

A-1.0 Reporting Operating Condition Comparisons

Data from the applicable climate table(s) in this **Appendix A** shall be provided for reporting the *normal occupied building operating condition(s)* for buildings and *unique sectors* within a building.

Exception: Calculations based on **Section A-2.2 b** for identifying the *normal occupied building operation* of a specific test location are permitted based on local weather data for annual weather or portions of the year, such as for schools, when a test location is *significantly occupied*.

A- 1.1 Data and format

Table A-1 specifies data and information that shall be reported. Information that compares *normal occupied building operating conditions* to the operating conditions that occurred during a test shall be portrayed together for easy comparison, such as in **Table A-1**.

Table A-1 * Required data Comparison of building operating conditions			
<i>Outdoor Temperatures</i>		Prevailing Annually	Prevailing During the Test
	<i>Average</i>	<i>Avg. annual outdoor temperature</i> *	<i>Average temperature during test</i> *
<i>Operating Condition</i>			
	<i>Heating Conditions</i>	<i>percentage of year</i> *	<i>percentage during test</i> *
	<i>Cooling Conditions</i>	<i>percentage of year</i> *	<i>percentage during test</i> *
<i>Prevailing Operating Condition</i>			
	<i>Average</i>	<i>prevailing operating condition</i> *	<i>prevailing condition during test</i> *
Condition less likely to inhibit characterization of a radon hazard		<i>conditions for clear characterization</i> *	<i>conditions during test</i> *

A-2.0 Calculating test conditions

A-2.1 Operating Conditions

Outdoor temperature conditions that dictate the building operation condition at any point in time shall be used to report the percentage of time that each building operation condition occurs during a test, or time period of interest, as required in provisions a), b) and c) of this **Section A 2.1**.

- Heating conditions shall be expressed based on durations when outdoor temperatures are less than 65°F (18° C).
- Cooling conditions shall be expressed based on durations when outdoor temperatures exceed 83° F (28° C).
- Mixed conditions, where neither heating nor cooling conditions prevail, shall be expressed based on durations when outdoor temperatures are in the range of 65°F (18° C) to 83° F (28° C).

Outdoor air ventilation systems with fixed minimum settings or conditions as they will be at all times of the year shall be regarded as an “as is” condition, much the same as small gaps to outside air around windows and doors that allow infiltration of outside air.

A-2.2 *Test period calculations*

The duration of outdoor temperatures that dictate the building operating condition shall be based on local weather data using methods a) or b) of this **Section A 2.2**:

- a) It shall be acceptable to total the hours of each building operation condition, based on hourly data published by local weather services, and report the percentage of time during the test that each operating condition occurred, as defined in **Section A 2.1**; or
- b) It shall be acceptable to use average outdoor temperatures that occur during the test, or time period of interest, for estimating the percentage of building operations across time. When using this method, the percentage of each operating condition shall be based on the percentage of outdoor temperature values, as defined in **Section A 2.1**, that fall between the high and low outdoor temperatures during the test or time period of interest.

A-2.3 *Variable outdoor air ventilation*

Because the duration and volume of outside air is dynamically variable for energy recovery ventilation and *economizer systems*, additional testing that meets requirements in a) or b) of this **Section A 2.3** are required before any valid assumptions can be made. In absence of these procedures, no assumptions shall be reported regarding the effects of varying the volume of outdoor air ventilation.

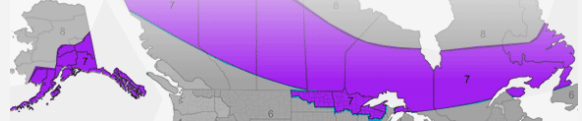
- a) Simulation of conditions requires both:
 - 1. A calculation that plots incremental changes of outdoor temperatures across a 365 day period and the corresponding volumes of modulated outdoor air introduced into the building at any given time, and
 - 2. Radon testing to confirm the degree of outdoor air required for maintaining concentrations to below the *action level*.
- b) For radon testing of dwellings, or other 24 hour occupancies, the test duration shall be nominally 365 days or 180 days. The 180 day option shall include half of the heating season, half of the cooling season and the duration in between.

Note—These testing options account for widely varying degrees of outdoor air introduced into the building where the outdoor air volume is modulated in response to incremental changes in outdoor temperature.

<div>24 Hour Averages</div> <div>For dwellings and other 24 hour occupancies</div>															
Hour		Annual Avg	School Avg	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
8 SubArctic Fairbanks, AK		27	17	45	25	4	-6	-8	-2	11	31	49	60	62	57
Operating Conditions				Prevailing Annually											
Normal Operating Condition			Heating Conditions												
<div>Daytime Averages</div> <div>For non-residential occupancies</div>															
Daytime		Annual Avg	School Avg	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
8 SubArctic Fairbanks, AK		32	21	50	29	8	-3	-4	3	18	37	55	65	67	62
Normal Operating Condition			Heating active												
Additional Considerations			Additional radon testing under extreme weather conditions, such as during periods when outdoor temperatures are continually < 0° F (-18°C)												

Climate Zone 7

Includes portions of many Canadian provinces and utmost northern locations in the United States



24 Hour Averages

For dwellings and other 24 hour occupancies

Operating Condition

Cooling Conditions

-

Condition less likely to inhibit characterization of a radon hazard

- Heating and air distribution systems active

Daytime Averages

For non-residential occupancies

Daytime

Annual Avg

School Avg

Sep

Oct

Nov

Dec

Jan

Feb

Mar

Apr

May

Jun

Jul

Aug

7-Very cold

Minot, ND

45

36

63

51

31

19

11

16

26

47

59

67

75

74

Operating Condition

Mixed Conditions

25%

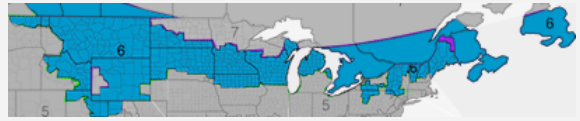
-

Condition less likely to inhibit characterization of a radon hazard

- Heating and air distribution systems active

Climate Zone 6

Includes portions of ME, NH, VT, WI, MN, ND, WY, SD, ND and Canada.

**24 Hour Averages**

For dwellings and other 24 hour occupancies

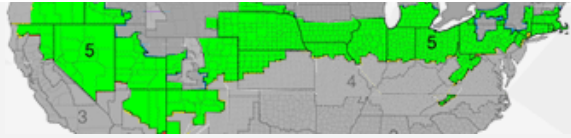
Operating Condition			
	Cooling Conditions	-	
Condition less likely to inhibit characterization of a radon hazard		Heating and air distribution systems active	

Daytime Averages														
For non-residential occupancies														
Daytime	Annual Avg	School Avg	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
6 Cold Minneapolis, MN	50	41	66	55	37	23	17	23	35	51	64	73	78	76

Operating Condition			
	Cooling Conditions	16%	11%
	Mixed Conditions	16%	-
Condition less likely to inhibit characterization of a radon hazard		Heating and air distribution systems active	

Climate Zone 5

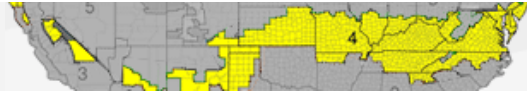
Includes portions of MA, NY, OH, MI, IN, IL, IA, NE, CO, UT and NV.

**24 Hour Averages**

For dwellings and other 24 hour occupancies

Operating Condition			
	Heating Conditions	75%	
	Cooling Conditions	-	-
Condition less likely to inhibit characterization of a radon hazard		Heating and air distribution systems active	
<div>Daytime Averages</div> <div>For non-residential occupancies</div>			
Operating Condition			
	Cooling Conditions	16%	-
Condition less likely to inhibit characterization of a radon hazard		Heating and air distribution systems active	

This data is based on Philadelphia, PA



g and other 24 hour occupancies

Hour Annual Avg
4 Mixed Philadelphia, PA 55

p	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
	57	47	36	32	34	42	53	63	72	77	76

Operating Condition

Cooling Conditions

16%

Condition less likely to inhibit characterization of a radon hazard

Heating and air distribution systems active

Daytime Averages

For non-residential occupancies

Daytime Annual Avg School Avg
4 Mixed Philadelphia, PA 59 52

Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
73	62	51	40	36	38	47	58	68	77	82	81

Operating Condition

Mixed Conditions

16%

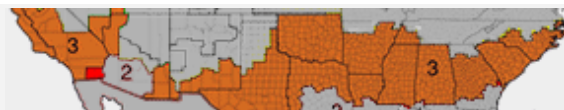
22%

Condition less likely to inhibit characterization of a radon hazard

Heating and air distribution systems active

Climate Zone 3


Includes portions of various states ranging from North Carolina to Southern California.



24 Hour Averages

For dwellings and other 24 hour occupancies

Operating Condition															
	Heating Conditions														
Condition less likely to inhibit characterization of a radon hazard			Heating and air distribution systems active No variance in outdoor air ventilation												
<div><div>Daytime Averages</div><div>For non-residential occupancies</div></div>															
ime		Annual Avg	School Avg	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
3 Warm	Atlanta, GA	67	61	78	68	58	50	48	51	59	68	75	82	84	84
Operating Condition															
	Cooling Conditions														
Condition less likely to inhibit characterization of a radon hazard			Heating and air distribution systems active No variance in outdoor air ventilation												

Hot Climate Zone 2 Includes portions of FL, LA, TX, AZ and many southern portions of North America.			
<p style="text-align: center;"><u>24 Hour Averages</u> For dwellings and other 24 hour occupancies</p>			
<i>Operating Condition</i>		Prevailing Annually	
Condition less likely to inhibit characterization of a radon hazard		Heating and air distribution systems active No variance in outdoor air ventilation	
<p style="text-align: center;"><u>Daytime Averages</u> For non-residential occupancies</p>			
<i>Operating Condition</i>			
	<i>Heating Conditions</i>	25%	33%
Normal Operating Condition		Cooling systems active.	• Intermittent heating and cooling conditions.

This data is based on Miami, FL																																									
<p>Days and other 24 hour occupancies</p> <table border="1"> <thead> <tr> <th>Year</th> <th>Annual Avg</th> <th>Oct</th> <th>Nov</th> <th>Dec</th> <th>Jan</th> <th>Feb</th> <th>Mar</th> <th>Apr</th> <th>May</th> <th>Jun</th> <th>Jul</th> <th>Aug</th> </tr> </thead> <tbody> <tr> <td>2019</td> <td>76</td> <td>79</td> <td>74</td> <td>69</td> <td>68</td> <td>69</td> <td>72</td> <td>75</td> <td>79</td> <td>82</td> <td>83</td> <td>83</td> </tr> </tbody> </table>																Year	Annual Avg	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	2019	76	79	74	69	68	69	72	75	79	82	83	83
Year	Annual Avg	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug																													
2019	76	79	74	69	68	69	72	75	79	82	83	83																													
Operating Condition																																									
	Cooling Conditions	50%																																							
Condition less likely to inhibit characterization of a radon hazard		<p>When each day tested includes periods of both:</p> <ul style="list-style-type: none"> a) outdoor temperatures below 84° F (29° C), and; b) cooling systems active with some degree of regularity. <p>No variance in outdoor air ventilation</p>																																							
<p align="center"><u>Daytime Averages</u></p> <p align="center">For non-residential occupancies</p>																																									
Operating Condition		Prevailing Annually					School (prevailing across 9 months)																																		
Condition less likely to inhibit characterization of a radon hazard		<p>When each day tested includes periods of both:</p> <ul style="list-style-type: none"> a) daytime outdoor temperatures below 84° F (29° C), and; b) cooling systems active with some degree of regularity. 																																							
Additional Considerations		<p>Consider additional testing to evenly account for each condition or an <i>Assessment of Occupied Versus Unoccupied Conditions</i>.</p>																																							

NORMATIVE APPENDIX B

EVALUATION OF OCCUPIED VERSUS UNOCCUPIED CONCENTRATIONS

When conducting an evaluation of *occupied* versus unoccupied *radon* concentrations as an additional line of evidence relative to mitigation decisions, the evaluation shall comply with requirements of this **Appendix B**.

B-1.1 *Measurement equipment or processes*

Devices, such as CRMs, or other testing processes that can accurately measure the difference between average radon concentrations during occupied compared to unoccupied conditions are required.

B-1.2 *Measurement duration*

Testing shall be conducted for durations of not less than 46 hours to achieve average concentrations at each location for at least two occupied days compared to two unoccupied nights, as proportional to the percentage of *significantly occupied* and unoccupied durations.

B-1.3 *Reporting the evaluation*

Reported measurements shall include:

- a) The average radon concentration for the full measurement period;
- b) One average derived from the combined averages of the occupied periods across a test duration; and
- c) A second average derived from the combined averages of the unoccupied periods across a test.

B-1.4 *Simulation Testing*

When unable to test under the *normal occupied operating condition* for the building or *unique sector*, testing to simulate those conditions is permitted. Simulations to evaluate occupied versus unoccupied influences on radon concentrations shall be conducted by manipulating *HVAC* controls to simulate various *HVAC* operating conditions. The procedure shall include provisions a), b) and c) of this **Section B-1.4**.

- a) The evaluation shall include:
 1. Building operating conditions that simulate *normal occupied operating conditions*, in accordance with Section **2.7.4**, and
 2. Conditions required regarding minimum *outdoor air ventilation* and *variable air distribution*, as applicable, in accordance with Section **4.2**;
- b) Details that shall be recorded and provided in reports include:
 1. *HVAC* control settings and duration of activation for each simulated condition, and
 2. Radon concentration measurements associated with each simulated condition; and
- c) The simulation measurements shall be made in each operational mode of concern for durations that are compatible with:
 1. *HVAC* system capacity to achieve *dynamic equilibrium* for radon concentrations in the building or *unique sector*, and
 2. Measurement device capabilities to achieve statistically accurate measurements for the duration of each operating condition.

Informative advisory— Simulations to evaluate occupied versus unoccupied radon concentrations should only be made in coordination with building staff responsible for *HVAC* operations.

NORMATIVE APPENDIX C

RADON SOURCES OTHER THAN SOIL GAS

C-1 Follow-up Procedures

Where elevated radon concentrations are found in upper floor test locations or other locations where there is evidence that soil gas may not be the cause, an evaluation shall be conducted for whether unusual soil gas migration, building materials, water supplies or inadequate ventilation are the cause of elevated radon concentrations.

C.1.1 *Process of elimination*

As a step-by-step process of elimination, it shall be permitted to mitigate known or suspected sources of radon gas, such as soil gas in ground contact areas, prior to initiating evaluations of upper floors or other locations. While flexibility is permitted for procedures and the order they occur, the evaluations shall focus on lines of evidence for characterizing radon hazards throughout the building.

C.1.2 *Upper Floor Evaluations*

Where elevated radon concentrations are found in upper floor test locations, efforts for initial or *follow-up* measurements to characterize upper floor areas of the building shall include:

- a) a radon measurement conducted in all dwellings and nonresidential rooms *intended for occupancy* on the floor closest to ground where elevated radon concentrations were found, and
- b) a radon measurement conducted in all dwellings and non-residential rooms for no less than one additional upper floor, whether or not elevated radon concentrations were initially found there.

A report that complies with **Section 8 Test Reports** shall be provided with test results and recommendations or guidance consistent with the findings of this characterization.

C.1.3 *Localized ventilation or building materials*

Where initial characterizations, such as conducted in **Section C.1.2** for upper floors, indicate inadequate ventilation or building materials specific to certain dwellings or rooms are the problem:

- a) a visual review shall be conducted and reported in writing for all other locations in the building where lack of ventilation or similar building materials could be the cause of elevated radon concentrations; and
- b) Confirmation that these conditions are the cause of elevated radon concentrations is not required. However, it shall be permitted to attempt confirmation by simultaneous radon measurements:
 1. in a room where poor ventilation or building materials are suspected as the cause, and
 2. in a nearby room suspected of having radon concentrations that are below the *action level*.

C.1.4 *Building materials common to the structure*

If measurements indicate building materials common to the entire building or portion of the building are the problem, the measurement evaluation shall be repeated on one or more additional upper floors unless there is reliable evidence to support a different course of action. Where measurements support the likelihood that building materials common to the entire building or portion of the building are the problem, reports shall recommend *mitigation* for all floors.

C.1.5 *Radon in water*

Where radon in water is suspected to be the cause of elevated radon concentrations in air, measurements for radon in water shall be conducted in accordance with ANSI/AARST MW-RN *Protocol for the Collection, Transfer and Measurement of Radon in Water*.

C-2 Clearance Testing Upper Floors

Actions required for *clearance testing* after efforts to mitigate *radon* hazards on upper floors shall include requirements in a) and b) of this **Section C-2**.

C.2.1 Radon from soil gas

Where efforts to mitigate elevated radon concentrations on upper floors included *mitigation* of soil gas entry into the building or other *mitigation* method for addressed *ground-contact* locations, *clearance testing* shall include:

- a) *Clearance testing* as required with **Section 7.3**, and
- b) Testing all upper floor locations where elevated radon concentration have been observed.

C.2.2 Radon from Building Materials or Inadequate Ventilation

Where elevated *radon* is identified to be caused by building materials or inadequate ventilation, post-mitigation clearance testing shall be conducted for:

- a) All dwellings and non-residential rooms where efforts have been made to mitigate *radon* from building materials or address inadequate ventilation;
- b) All locations not tested but that demonstrate similar potential for causing elevated *radon* concentrations; and
- c) Where *mitigation* efforts include enhanced ventilation techniques, post-*mitigation clearance testing* shall include seasonal verification in accordance with **Section 7.3.2 b** within the first year of occupancy or ownership of property management.

C.2.3 Radon from Water Supplies

Where *mitigation* efforts included reducing *radon* in water supplies, *clearance testing* shall include:

- a) *Duplicate* measurements of *radon* in water for both untreated and treated water in accordance with ANSI/AARST MW-RN *Protocol for the Collection, Transfer and Measurement of Radon in Water*; and
- b) Testing indoor air for *radon* in one or more locations within each *unique area* where elevated *radon* has been found.



Measurement Committee Participants

Sincere appreciation is both expressed and deserved for contributions of time and wisdom

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Non-voting Assist Team: Gary Hodgden

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(Chambers)	Jim Burkhardt	The Radon Lab
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Assist Team Members: Joanna Mandecki, Nanci Hermberger, Denise Bleiler and Marilyn Patrick

INFORMATIONAL SUPPLEMENT

The information contained on this page is not part of proposed updates to these ANSI/AARST American National Standards (ANS) and does not contain requirements necessary for conformance to these standards.

Preliminary Results from the EARTH Study: Partial Testing of Multifamily Buildings Will Misrepresent Radon

“Evaluating and Assessing Radon Testing in Housing with Multifamily Financing” (EARTH) is a HUD-funded Healthy Homes Technical Study led by Health Research Inc. for the New York State Department of Health with assistance from the National Center for Healthy Housing. The primary aim of the study is to develop an evidence-based, statistically sound protocol for measurement professionals to correctly characterize a multifamily building’s radon level that is sufficiently protective of occupant health without being unduly burdensome to transactions or property owners.

The below table presents the probability of missing a unit with a radon level above the EPA action level, based on the % of units sampled, according to the analysis of data for 8,000 units across 600 multifamily buildings in the US. The data indicate, across building sizes, that it is not possible to characterize radon levels correctly in a multifamily building unless radon measurement occurs in at least 90% of the ground-contact units. While subsequent publications (such as the final report to HUD and related journal article) will contain additional information, the data and trend presented by this table will not change.

Table I

Probability of ANY units above 4 pCi/L in a building given all sampled units are below 4 pCi/L
[Inclusion requirement: Building with at least as many values below 4 pCi/L as the number sampled]

# GF units	25% sampled			50% sampled			75% sampled			90% sampled		
	N	Probability	95% CI	N	Probability	95% CI	N	Probability	95% CI	N	Probability	95% CI
05-06	121	35%	(27%,44%)	112	29%	(22%,38%)	91	13%	(8%,22%)	79	0%	NA (1)
07-08	162	36%	(29%,44%)	155	34%	(27%,41%)	127	19%	(13%,27%)	103	0%	NA (1)
09-10	92	36%	(27%,46%)	89	34%	(25%,44%)	80	26%	(18%,37%)	73	19%	(12%,30%)
11-12	98	34%	(25%,43%)	95	32%	(23%,41%)	86	24%	(17%,34%)	77	16%	(9%,25%)
13-16	74	36%	(26%,48%)	71	34%	(24%,45%)	65	28%	(18%,40%)	55	15%	(8%,26%)
17-20	50	48%	(35%,61%)	50	48%	(35%,61%)	47	45%	(31%,59%)	37	30%	(17%,46%)

(1) All units are sampled, so the probability must be 0%

The work that provided the basis for this document was supported by funding under cooperative agreement # NYHHU0038-17 from the U.S. Department of Housing and Urban Development’s Office of Lead Hazard Control and Healthy Homes. The substance and findings of the work are dedicated to the public. The author and publisher are solely responsible for the accuracy of the statements and interpretations contained in this presentation. Such interpretations do not necessarily reflect the views of the Government.