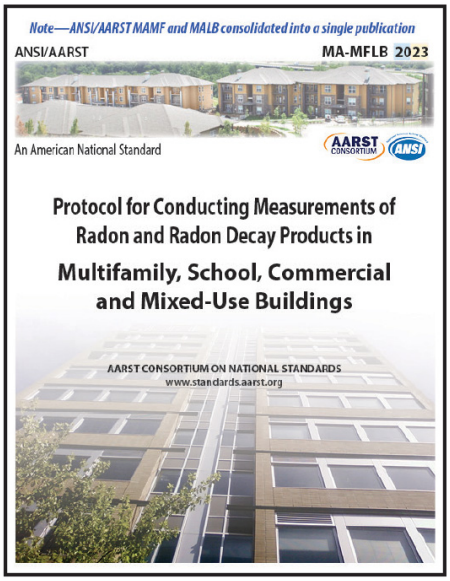
2024 Public Review of MA-MFLB 2023

Consistent with plans relative to our continuous maintenance program, the latest publication of ANSI/AARST MA-MFLB is being published for public review. Processes are still underway for repopulating the standing Radon Measurement committee tasked with review and update of this standard. This public review is intended to garnish comments that will lead to improvements in upcoming publications.

ANSI/AARST standards are available for review and for purchase at www.standards.aarst.org. A link to ensure you receive future public review notices can be found at www.standards.aarst.org/public-review.



2024 Public Review: MA-MFLB 2023

COMMENT DEADLINE: **May 20th, 2020**

REQUESTED PROCESS AND FORM FOR FORMAL PUBLIC REVIEW COMMENTS

Submittals (MS Word preferred) may be attached by email to StandardsAssist@gmail.com

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

Public Reviewed Item and Its Date: MA-MFLB 2023

- **Name:** Affiliation:
- **Clause or Subclause**:
- **Comment/Recommendation**:
- **Substantiating Statements**:

Repeat the four bullet items above for each comment.

AARST Consortium on National Standards

Website: www.standards.aarst.org Email: StandardsAssist@gmail.com

527 N Justice Street, Hendersonville, NC 28739

The Consortium 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 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).

Notices

Notice of right to appeal: Bylaws for the AARST Consortium on National Standards are available at www.standards.aarst.org/public-review. Section 2.1 of Operating Procedures for Appeals (Appendix B) states, "Persons or representatives who have materially affected interests and who have been or will be adversely affected by any substantive or procedural action or inaction by AARST Consortium on National Standards committee(s), committee participant(s), or AARST have the right to appeal; (3.1) Appeals shall first be directed to the committee responsible for the action or inaction."

MA-MFLB
Table of Contents

MA-MFLB 2023

Protocol for Conducting Measurements of Radon and Radon Decay Products in Multifamily, School, Commercial and Mixed-Use Buildings

1.0 SCOPE

1.1 Scope and Purpose

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 purposes 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* [5]

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 childcare 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.

[5] 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 any time of year for locations that are significantly occupied both day and night.

Informative Advisory—Measurements are more likely to provide an accurate reflection of occupant exposure to radon hazards when conducted under conditions that most closely align to the normal building operating condition that prevails during the greatest amount of time each year.
See Normative Appendix A for information on how to determine when testing should occur.

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 (Building operating conditions).

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 concerns.

2.3 Test Devices

2.3.1 *Approved test devices required*

All test devices used for deciding if mitigation is warranted shall be devices that are listed by one of the following authorities:

a) As required by local jurisdictions that have a program for evaluating and approving devices; or

b) A national certification or listing program, such as the National Radon Proficiency Program (NRPP), the National Radon Safety Board (NRSB), or an equivalent program that verifies device compliance with the latest publication of ANSI/AARST MS-PC (Performance Specifications for Instrumentation Systems Designed to Measure Radon Gas in Air).

Note—Identification of two existing bodies that have a program for evaluating and listing devices that meet specified quality requirements is not an endorsement of either program.

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.

Note—Section CG-3 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, the person(s) or team, regardless of business organizational structure, shall operate under a quality assurance (QA) program. The QA program shall include 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, school, commercial or mixed-use 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 buildings, schools and other non-residential or mixed-use buildings:

a) as established in certification requirements of a national program that is compliant with requirements in Normative Appendix D; 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 quality control (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:

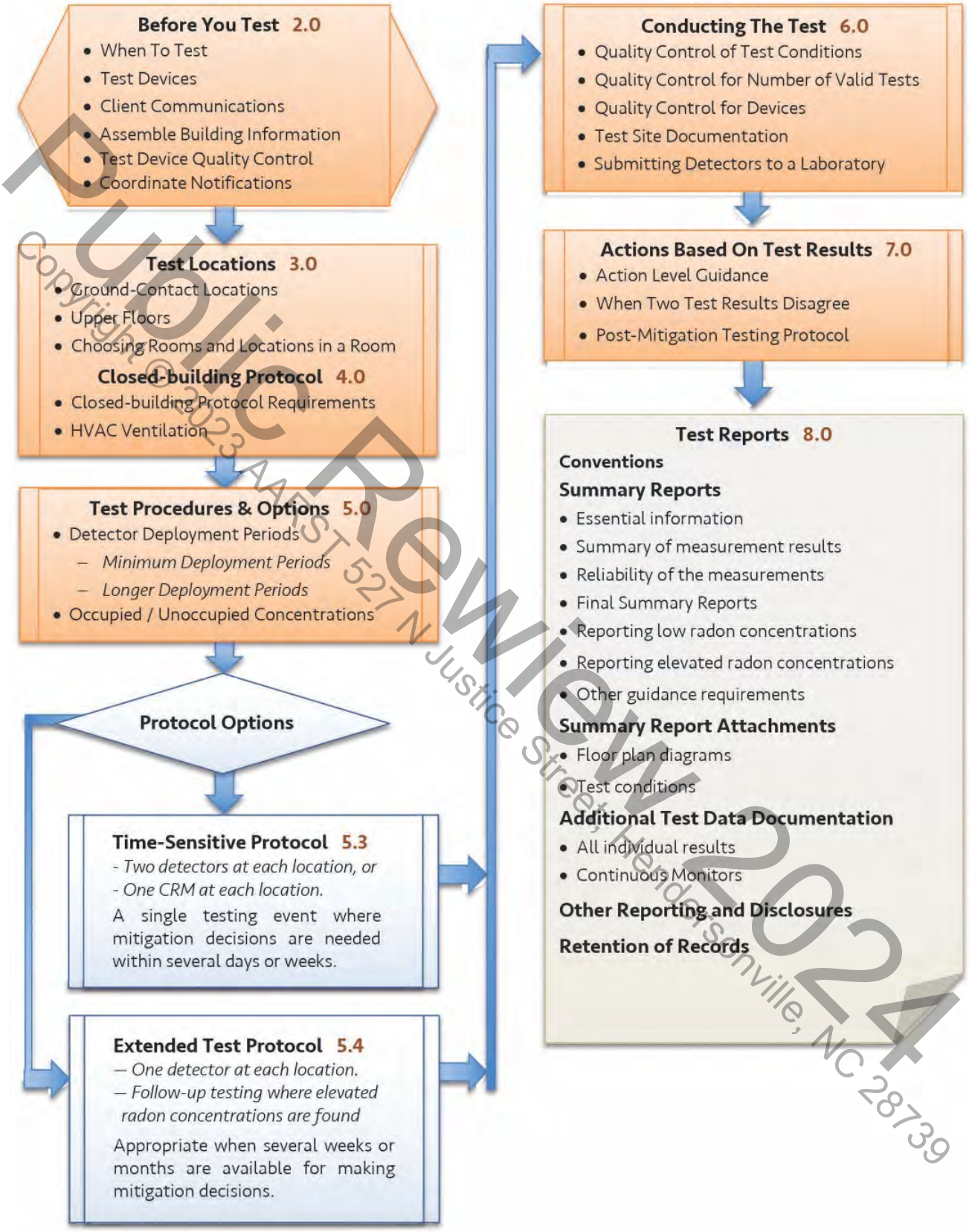
a) Create and present a written work plan specific to apportioned tasks and obtain evidence that the work plan is understood by all participants.

Note—Section CG-4 in the attached Companion Guidance provides guidance for work plan training; 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 a training class approved by a national program that is compliant with requirements in Appendix D or state licensure or certification program where applicable.

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 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:

a) to match current addresses,

b) the current use of non-residential rooms, and

c) 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 Appendix A.

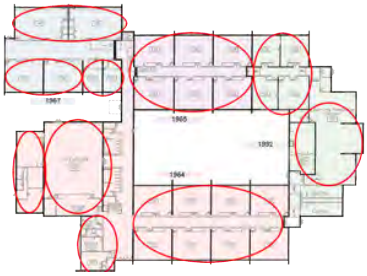
Planning and conducting measurements additionally require identification of conditions that temporarily inhibit clear characterization of radon hazards. These are conditions that do not exhibit regularity for at least intermittent periods during a test regarding:

a) Activity of heating or cooling system blowers, where applicable to the HVAC system, and

b) 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:

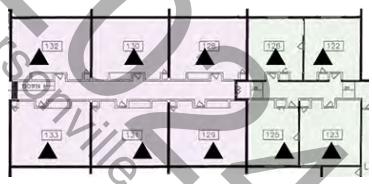


a) Variable outdoor air ventilation;

b) Variable air volume (VAV);

c) Return-air ducts laid in soil; and

d) 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 (QC)* 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 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 blanks that meet the following requirements are to be conducted prior to or in conjunction with initiating test deployments:
1. Three *lab-transit blanks* (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 *office blanks* (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 *field blanks* (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 because 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 radon 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.

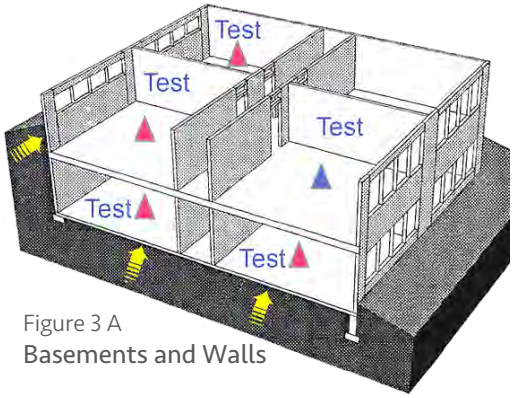


Figure 3 A
Basements and Walls

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.

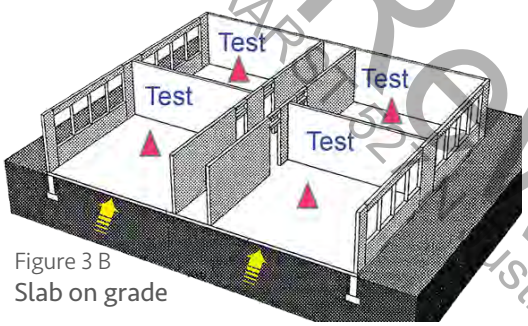


Figure 3 B
Slab on grade

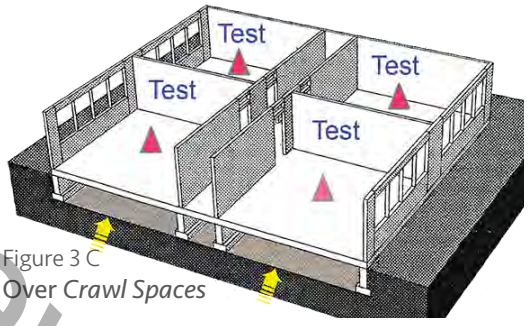


Figure 3 C
Over *Crawl Spaces*

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.

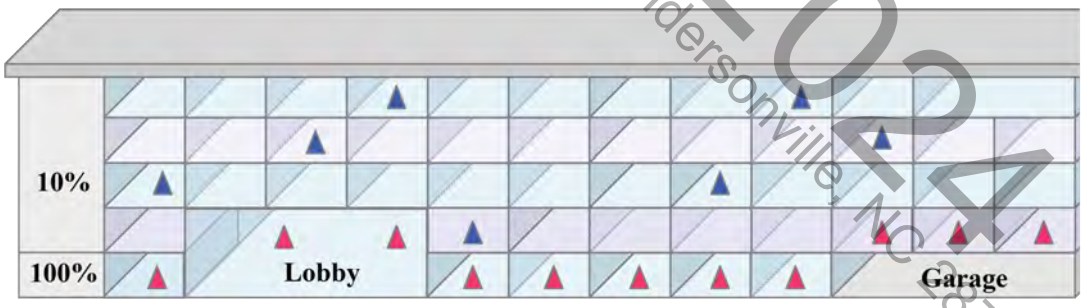


Figure 3 D
Upper floors

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 Plan Design

For large rooms and open plan designed areas that may include partitioned rooms that do not have closeable doors, one or more detectors shall be placed for every 2,000 square feet (186 m^2) of the room or open area and for any remaining portion of the area that is less than 2,000 square feet (186 m^2).

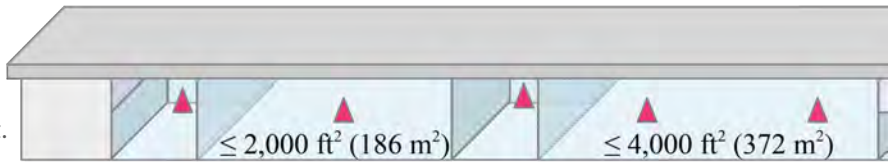


Figure 3 E
2,000 Sq. Ft.

3.4.1 *Pod Design*

Where an open-plan or pod design area has moveable walls that can physically separate an area into individual rooms, the movable walls 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.

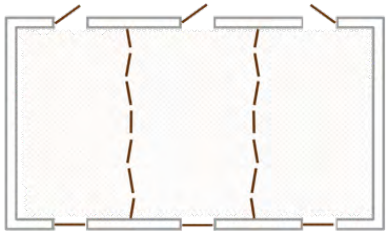


Figure 3 F Moveable walls

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.

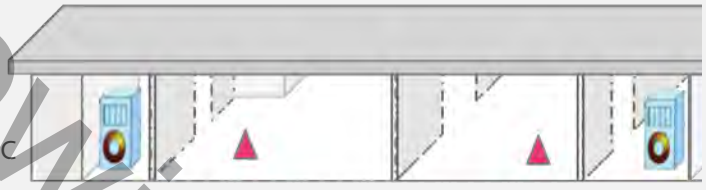


Figure 3 G
Multi-zone HVAC

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.

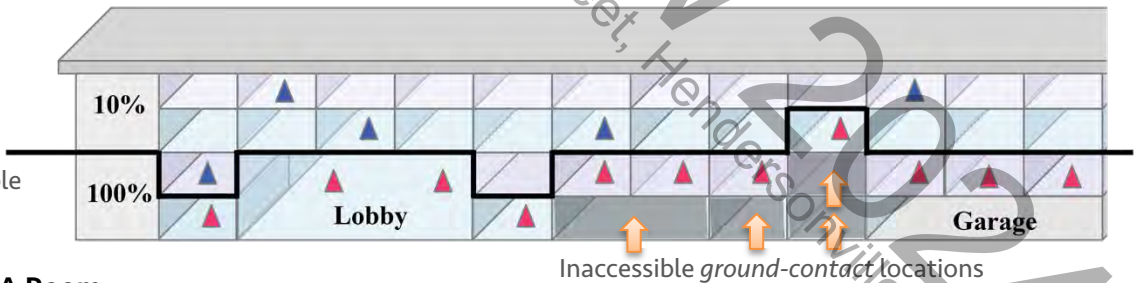


Figure 3 H
Inaccessible

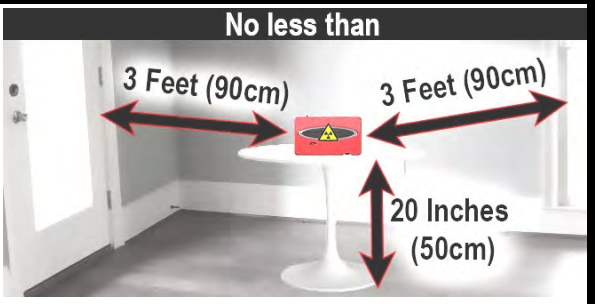
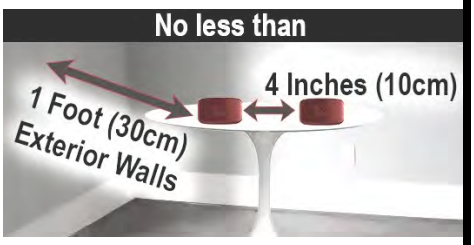
3.7 Choosing A Room

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 nearby 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 when seeking to use the average test result of two side-by-side detectors for QC checks and mitigation decisions. 
Place detectors where not easily disturbed	*Informative Advisory*—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, crawl spaces 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. *Informative Advisory*—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 72 hours, 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 normal occupiable temperature	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	Operate normally
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 crawl space vents	Set vents to the condition that prevails during the greatest amount of time each year
Crawl space 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 most 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

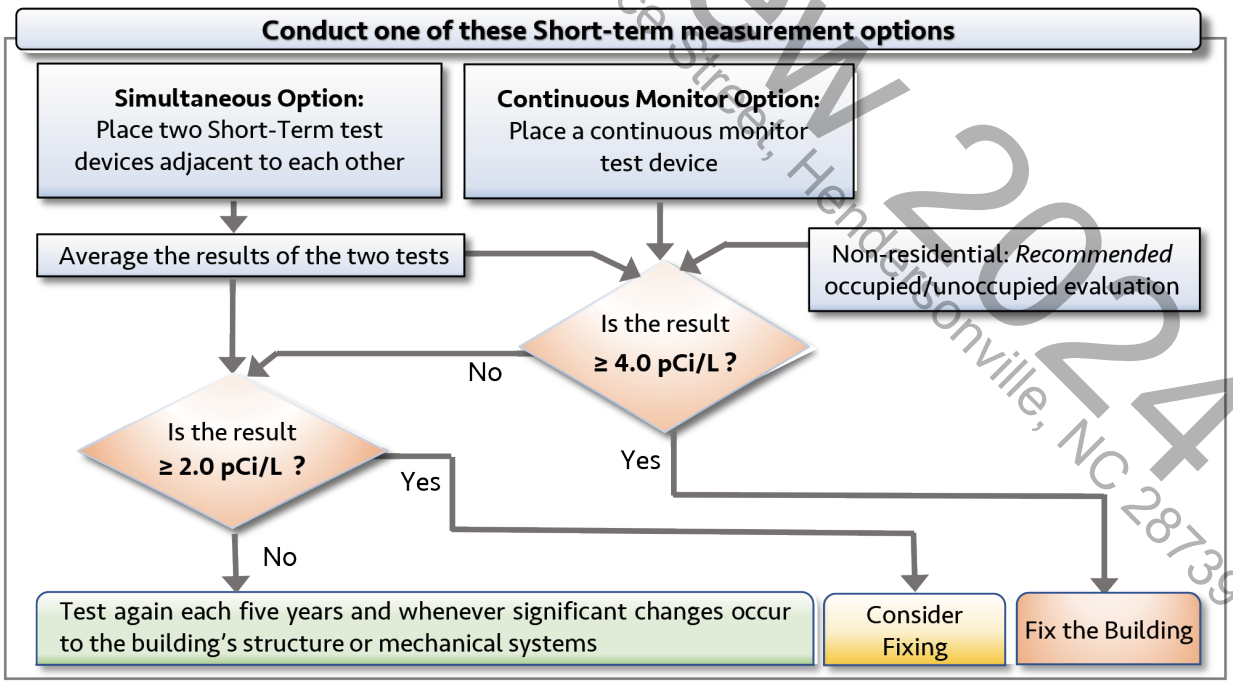
Note—This protocol builds upon protocols developed by EPA, relative to EPA's *"Home Buyer's and Seller's Guide to Radon."*

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 short-term test devices 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 radon concentrations are additionally recommended for non-residential locations.
Step 2		**Decisions to Fix the Building**
		Mitigation decisions are to be based on the average result from a continuous monitor 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 action level, e.g., 4 pCi/L. Consider fixing the building if results are greater than half the action level, 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 short-term device.
		Evaluations of occupied versus unoccupied radon concentrations are additionally recommended for non-residential locations.
Step 2	*Follow-up Test Options*	**Retest locations that meet or exceed the action level, e.g., 4 pCi/L. Follow-up testing requirements allow the following options:** [1, 2]
	a) A second test with a short-term device is conducted. Where a first test is twice the action level or greater, this confirmation test should be conducted without delay; or	
	b) Where a first test is less than twice the action level, testing can be conducted with a long-term test device for an extended period if the situation allows a closer evaluation of annual average to radon concentrations; or	
	c) Evaluation of occupied versus unoccupied radon concentrations for non-residential locations.	
Step 3	**Decisions to Fix the Building**	
	Mitigation decisions are to be based on the average of the two test results from short-term devices or the results from long-term testing [3, 4] **Fix the building** if test results meet or exceed the action level, e.g., 4 pCi/L. Consider fixing the building if results are greater than half the action level, e.g., between 2 and 4 pCi/L.	

[1] Where follow-up testing is not completed within 12 months after completing Step 1, the testing procedure shall be restarted with Step 1, in accordance with either Section 5.3 or this Section 5.4.

[2] Note—While decisions to mitigate 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.

[3] Note—Section 7.2 provides requirements for when the test result from two short-term test devices disagree in terms of making a mitigation decision.

[4] 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.

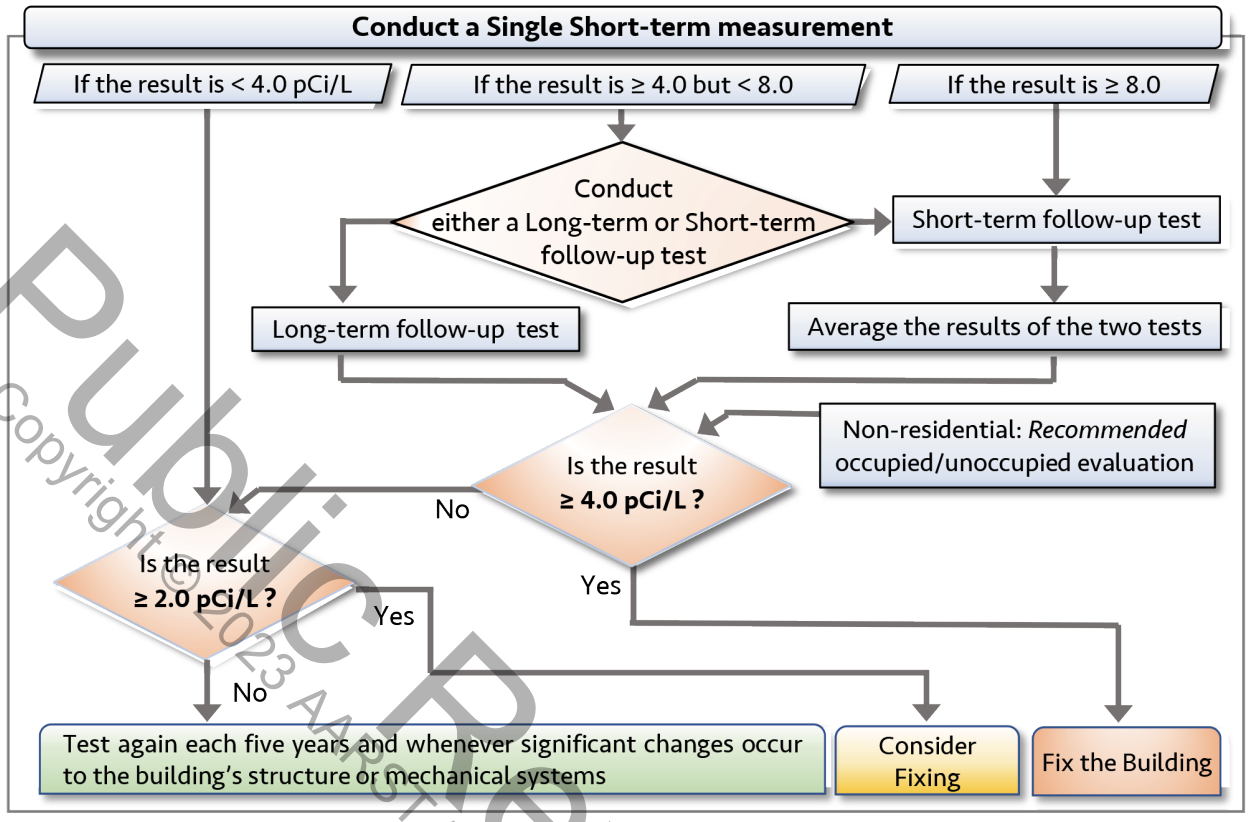
5.4.1 *Client Advisory required*

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:

a) Test results from Steps 1 and 2 of the Extended testing protocol are to be used for mitigation decisions, and

b) 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 5.1.4 to account for seasonal conditions and either:

a) the test location is a residential dwelling or living space, or

b) the test location is non-residential with HVAC systems that are not operated differently during nights and weekends compared to when occupied by most 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 Testing A Single Room or Dwelling

Note—Section 6.1.3 adds additional required conditions when testing only individual rooms or dwellings.

5.6 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).

5.7 Post-Mitigation Testing Protocols

Testing after mitigation efforts shall be conducted in accordance with Section 7.3 where effectiveness is judged based on one test event with one or more test devices at each location to be tested.

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 72 hours. 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 extends not less than 72 hours 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, which 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.

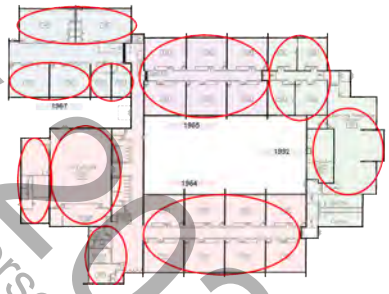
6.1.7 *Visual Inspections*

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 6.1.6 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 (Individual dwellings or rooms). 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 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 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

Unless it is decided at any juncture to proceed with mitigation, testing and follow-up testing shall continue until a valid test, compliant with all requirements of this standard, is achieved at all locations intended to be tested.

Exception: Allowances shall be permitted due to inaccessible locations or missing detectors upon retrieval, to the extent allowed by requirements in a), b) and c) of this Section 6.2.

These allowances shall be applicable individually for two distinctly different areas within each building: (1) the number of required ground-contact test locations, and (2) the number of tests required on upper floors.

a) Where all valid measurement results at the property are less than 4.0 pCi/L (150 Bq/m^3) and all valid measurement results in the building are less than 2.7 pCi/L (100 Bq/m^3), the number of missing valid tests shall not exceed the allowance in Table 6.2.1.[6]

Table 6.2.1

Test Locations:	3-5	6-10	9-11	12-16	15-20	18 or more
Allowance:	1	2	3	4	5	≤ 33%

b) Where any valid measurement at the property is 4.0 pCi/L (150 Bq/m^3) or more, or where any valid measurement result in a building is 2.7 pCi/L (100 Bq/m^3) or more, the number of missing valid tests for the property or for the building, respectively, shall not exceed the allowance in Table 6.2.2.[7]

Table 6.2.2

Test Locations:	< 4	4-7	8-11	12-15	16-19	20 or more
Allowance:	0	1	2	3	4	≤ 25%

Note—This allowance observes that the parcel of land where buildings reside has been shown to produce radon in soil sufficient to lead to elevated indoor radon concentrations.

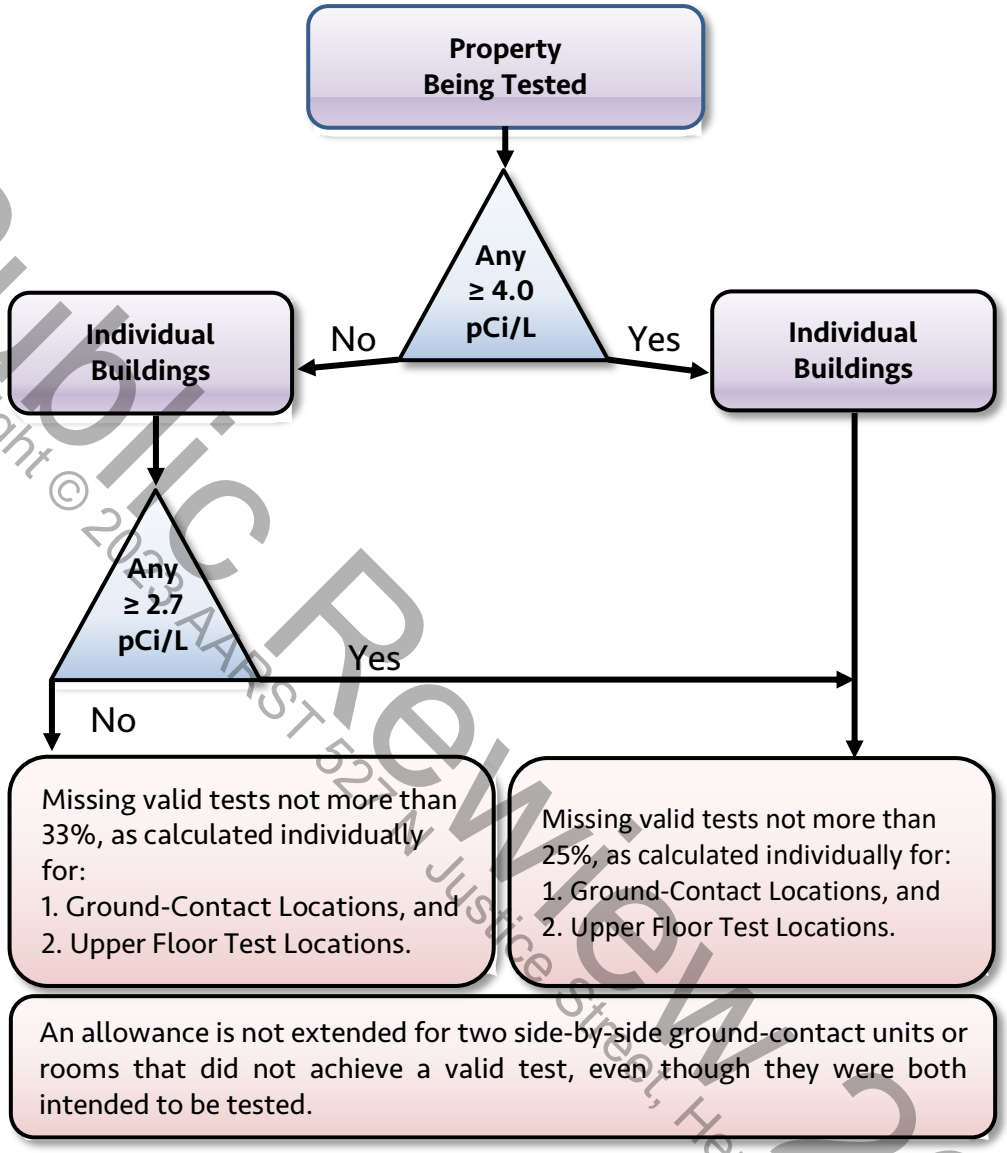
c) An allowance is not extended for two side-by-side ground-contact units or rooms that did not achieve a valid test, even though they were both intended to be tested.

[6] MIL-STD-105E, MILITARY STANDARD (1989): Sampling Procedures and Tables for Inspection by Attributes.

[7] Evaluating and Assessing Radon Testing in Housing with Multifamily Financing (EARTH).

Figure 6.2

Quality Control Flowchart for Number of Valid Tests



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.[8][9]

[8] 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

[9] 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

6.3 Quality Control for Test 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.

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 (≥ 150 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 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/m^3).

  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/m^3).

  When measurement devices indicate concentrations lower than about 2.0 pCi/L (75 Bq/m^3), 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 difference*

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 Difference
   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 after 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) and b) 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) 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/m^3) 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 MA-MFLB, 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. Procedures for conducting such evaluations are provided in Normative Appendix C.

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*

Summary reports provided when all test procedures required by this standard are complete for the building(s) shall include a statement confirming that valid measurements were achieved at all required test locations unless missing valid tests exceed allowances in Section 6.2. Where exceeding those allowances, the summary report shall instead provide a description of efforts for locations where conditions could not be overcome to achieve the required number of valid tests.

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.

Table 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."

b) Mitigation Prior to Test Completion

When multiple test locations in nearby dwellings or non-residential rooms 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.

c) 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.

d) Seasonal Verification

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, in accordance with Section 7.3.2, 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.

e) Upper Floors and 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.

f) 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.

Note—As more explicitly required in Section 10.5 (OM&M Manuals) within ANSI/AARST SGM-MFLB, (Soil Gas Mitigation Standards for Existing Multifamily, School, Commercial and Mix-Use Buildings):

"Where a radon mitigation system is installed or found in a building at the property, OM&M procedures provided in the OM&M manual shall include all of the following:

1. Quarterly inspection to verify operation of fans and other mechanical components;
2. Testing all buildings at the property at least every 5 years. All radon measurements shall be conducted in compliance with ANSI/AARST MA-MFLB. The clearance test procedure required includes testing all ground-contact dwellings and non-residential rooms that are occupied or intended to be occupied; not less than 10% of dwellings and non-residential rooms on each upper floor; and any mitigated areas on upper floors.
3. After post-mitigation clearance testing and in between 5-year clearance test events, test all previously tested locations for mitigated areas at nominally 2-year intervals, to ensure continued effectiveness.

   It is permitted to suspend testing at 2-year intervals where the required effectiveness of a mitigation system has consistently demonstrated for a period of not less than eight years, and such systems are:

   a. inspected quarterly to verify fan operation,
   b. inspected biennially for mechanical equipment performance and integrity,
   c. all buildings at the property and mitigated areas are retested every 5 years;
4. Each of these stewardship testing events to include mechanical inspections conducted by a qualified professional to verify continued performance of equipment; and
5. The following or equivalent instructions:

   Testing to verify continued effectiveness is to be conducted in conjunction with any sale of a building and after any of the following events occur:

   - ✓ New adjoining additions, structures or parking lots;
   - ✓ Building reconfiguration or rehabilitation;
   - ✓ A ground contact area not previously tested is occupied or a building is newly occupied;
   - ✓ Heating or cooling systems are altered with changes to air distribution or pressure relationships;

- ✓ Ventilation is altered by extensive weatherization efforts;
- ✓ Sizable openings to soil occur due to:
  - — groundwater or slab surface water control systems or sewer lines are added or altered (e.g., sumps, drain tiles, shower/tub retrofits, etc.) or
  - — natural settlement causing major cracks to develop;
- ✓ Earthquakes, blasting, fracking, or formation of sink holes nearby; or
- ✓ An installed mitigation system is altered."

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 resulted 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 for the effect of weather and building operating conditions on the reliability of a test to reflect occupant risk from radon, the summary report attachments shall include:

a) The minimum, maximum and average outdoor temperature that existed 12 hours prior to and during the test period;

b) If the degree of precipitation was near to flood or drought conditions and if the ground is covered by snow or ice; and

c) The seasonal relationship between test conditions and annual average conditions, in accordance with Normative Appendix A. Reporting this relationship shall include:

1. The percentage of time across the year for each differing occupied operating condition, and
2. 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:

1. 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.
2. 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.
3. 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

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 results.

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, Polunium-218 and Polunium-218, 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 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/m^3)** — A unit of radioactivity representing one disintegration per second per cubic meter: 1 Bq/m^3 (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 radon concentrations in all dwellings and occupied areas of a building are below the predefined action level.

9.11 **Client** The individual(s) or parties who hire(s) or pay(s) for radon 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** Collocated, simultaneous measurements conducted for the purpose of assessing and monitoring measurement reliability. Comparison checks include but are not limited to duplicate measurements that are defined as collocated, 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 radon 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 passive device 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** Collocated, 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 Comparison Check for a different category of QC measurements that do not require the use of identical devices.)

9.18 **Dynamic Equilibrium:** The state where radon and dilution air entering a building have reasonably stabilized under closed-building conditions. Buildings are typically 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, 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 radon. During the exposure, radon passively diffuses into the ion chamber and subsequently decays. The radon 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 radon concentration during the exposure can be calculated using calibration 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 when calculating test results. 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, 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 can produce 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	**Mitigation**	Efforts to reduce radon concentrations in the indoor air of a building.
9.35	**Mitigation System**	A system designed to reduce radon concentrations in the indoor air of a building.
9.36	**Multifamily Building**	Buildings having more than one attached dwelling or other occupied unit under the same ownership or designated maintenance or management authority.
9.37	**Multi-Zone Systems**	Independent systems and controls for different areas within the same dwelling, room or unique sector. See Exhibit 6, Group 2.
9.38	**Normal occupiable indoor temperatures**	Indoor temperatures of between 65˚and 80˚ F (18˚ - 27˚ C).
9.39	**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 "Significantly occupied"
9.40	**Notice of Radon Testing**	Written notices to inform occupants and facilitating staff about testing and required test conditions associated the radon testing.
9.41	**Occupied**	Any area of the building that is occupied on a regular basis for more than 4 hours a day. See "Significantly occupied" and "Occupied Weeks"
9.42	**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 normal occupied operating conditions for the building. See "Normal Occupied Operating Condition", "Occupied" and "Significantly Occupied"
9.43	**Office Blanks**	These detectors serve to reveal any unexpected exposures that might result from storage or handling.
9.44	**Passive Device**	Radon 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.
9.45	**Performance Testing (Mitigation)**	A test procedure to characterize the degree of general effectiveness for mitigation efforts within a specific area of a building.
9.46	**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 (Bq/m^3).
9.47	**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 quality control activities.
9.48	**Quality Control (QC)**	The system of activities to ensure a quality product, including measurements made to ensure and monitor data quality. For radon measurement devices includes calibrations and background, duplicate, blank and spiked measurements; inter-laboratory comparisons; audits; and other control activities.

9.49 **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.

9.50 **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.

9.51 **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.

9.52 **Radon Test Device** A radon measurement system, regardless of if configured as a combined detector and analysis instrument or as a system where detectors and analysis equipment are separate components.

9.53 **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.

9.54 **Setback** See HVAC Setback.

9.55 **Short-Term Test Device** A radon measurement device or detector that can produce a time weighted average for radon concentrations for periods that may extend for multiple days or weeks.

9.56 **Significantly Occupied** The 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".

9.57 **Single-Family Dwelling** A residence or home intended to house a single family.

9.58 **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.

9.59 **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.

9.60 **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.

9.61 **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.

9.62 **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.

9.63 **Time-Sensitive** Situations where mitigation decisions are needed quickly, such as within several days or weeks. Time sensitive measurement strategies entail a single phase of testing with enhanced quality control measures.

9.64 **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).

9.65 **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 radon mitigation system. Valid sampling time is further defined by all other related requirements within this standard.

9.66 **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.

9.67 **Variable Outdoor Air Ventilation** Systems that seasonally vary outdoor air ventilation for seasonal comfort or energy savings. See Exhibit 6, Group 3 Systems.

9.68 **Working Level (WL)** A unit of radon decay product concentration. One WL equals any combination of short-lived radon decay products 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 COMPLANCE

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

Note—Text versions of this exhibit in *both English and Spanish* can be downloaded at www.standards.aarst.org/public-review by choosing "Measurement, User Tools"

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).	
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 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**

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: _____

INFORMATIVE EXHIBIT 4

SAMPLE PRIOR NOTICE—PUBLIC NOTICE POSTER

Note—Text versions of this exhibit in *both English and Spanish* can be downloaded at www.standards.aarst.org/public-review by choosing "Measurement, User Tools"

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).	
Windows	**Keep closed**
Exterior doors (except for momentary entry and exit)	on all levels of the building including areas not being tested
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 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**

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: _____

INFORMATIVE EXHIBIT 5

SAMPLE NOTICE—BUILDING OPERATIONS STAFF INSTRUCTIONS

Note—Text versions of this exhibit in *both English and Spanish* can be downloaded at www.standards.aarst.org/public-review by choosing "Measurement, User Tools"

Actions required at least 12 hours prior to initiating the test	
Building Component →	**Action Required**
Windows **Exterior doors** (except for momentary entry and exit) **Other openings to the exterior** as a result of disrepair, incomplete construction or structural defect.	Close or seal on all levels of the building, including areas not being tested Exception: Do not close openings to outside air designed to provide air needed for combustion appliances.
Heating and cooling systems	Set to operate at normal occupied temperatures: 65˚ - 80˚ F (18˚ - 27˚ C). Note—Maintenance inspections of HVAC systems are recommended, but not required.
Variable Outdoor Air Ventilation Systems (if any) Automated or manually operated systems that seasonally vary outdoor air ventilation for energy savings or comfort, for: — individual rooms and dwellings — multiple rooms and dwellings; or — the whole building. Such systems include: Manually operated dampers, Energy Economizer systems, Energy Recovery Ventilators (ERV) and Evaporative cooling systems.	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 *significantly occupied.* For other systems, such as window air conditioners, dampers to outside air shall be closed.
Variable Air Volume (VAV) Systems (if any) Systems that temper room temperatures using thermostats to vary the volume of heated or cooled air coming into rooms.	Set all thermostats to between 65-80˚ F (18-27˚ C) in all rooms that are served by the system.
Return-Air Ducts laid In Soil (if any) Where return-air air ductwork is located under a slab, or otherwise laid in soil.	**Alert the testing company immediately**
***HVAC setback* in non-residential locations** 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).	Alter to retain temperatures within the range of 65˚and 80˚ F (18˚ - 27˚ C) **Or contact the testing company**

INFORMATIVE EXHIBIT 6

HVAC GROUP DESCRIPTIONS

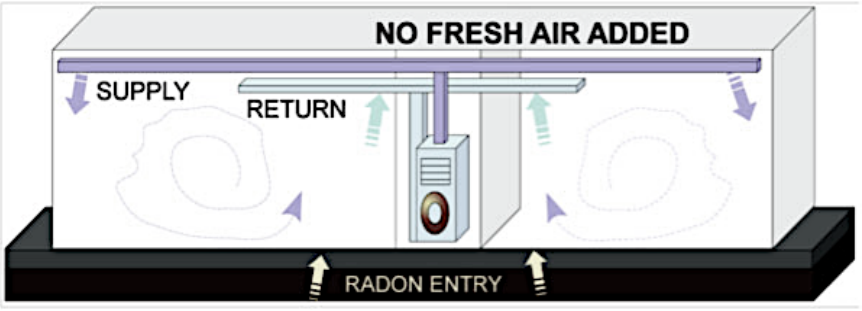
Definitions of basic and complex HVAC systems as applicable to this standard of practice.

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	
Group 1: Basic Heating and Cooling A dedicated system for each dwelling or unique area that does not provide seasonally variable outdoor air ventilation for added comfort or energy savings. • **Forced-air** heating and air conditioning (HAC) systems such as normally seen in single-family residences. • **Ductless Systems** — 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
Group 2: Multi-zone Systems Independent systems and controls for different areas within the same dwelling or unique sector.	See Section 3.5 for testing recommendations
Group 3: Variable Outdoor Air Ventilation HVAC systems that temporarily vary outdoor air ventilation for seasonal comfort or energy savings in: - individual dwellings; - multiple dwellings; or - the whole building. Such systems include those known as: Energy Economizer systems, Energy Recovery Ventilators (ERV) and Evaporative (swamp) cooling systems.	See Section 4.2.2 for additional testing requirements
Group 4: Variable Air Volume Distribution 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. Such systems are commonly called Variable Air Volume (VAV) systems.	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.

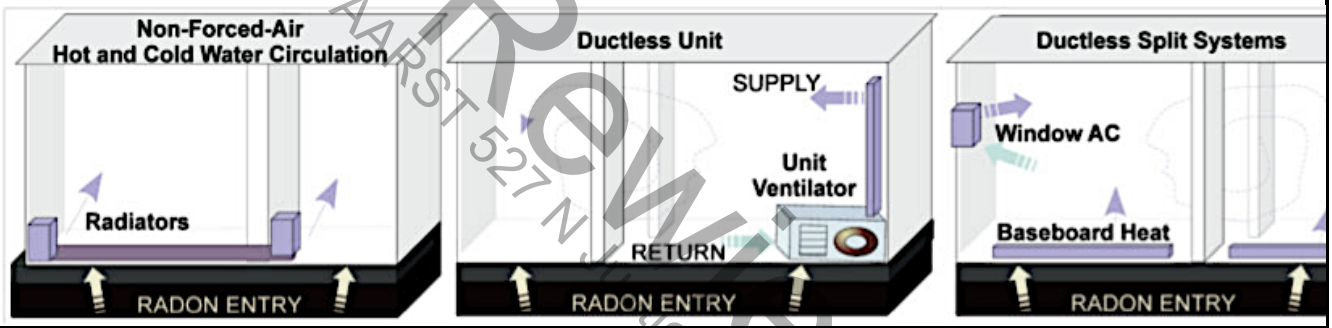


HAC Systems:
Many buildings have forced-air heating and air conditioning (HAC) systems.

Supply and return ducts distribute air around the building.

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

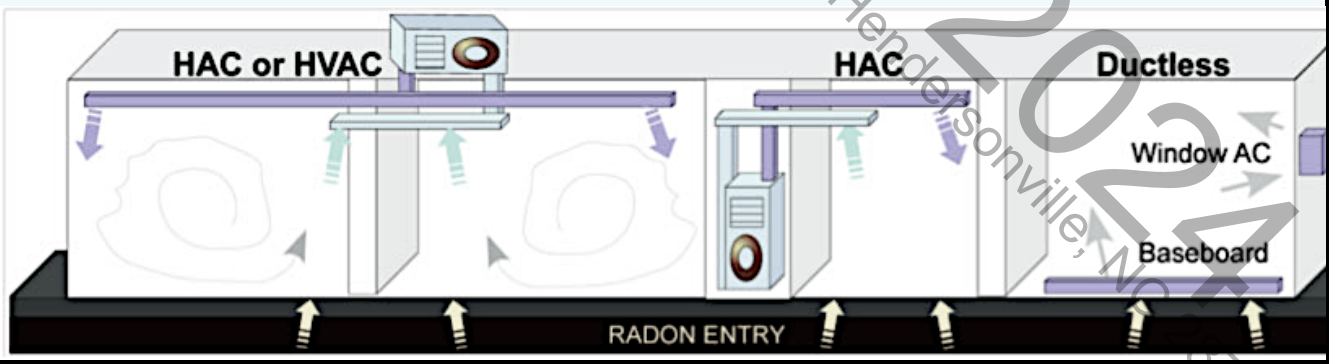
- Hot and Cold-Water Circulation (sometimes referred to as "radiator" systems).
- Window Air Conditioners.
- Wall or Baseboard Heating/Cooling Systems.
- Ductless Split Systems with one unit for cooling and another unit for heat (i.e., Window AC for cooling and Baseboard or Wall units for heat).



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.

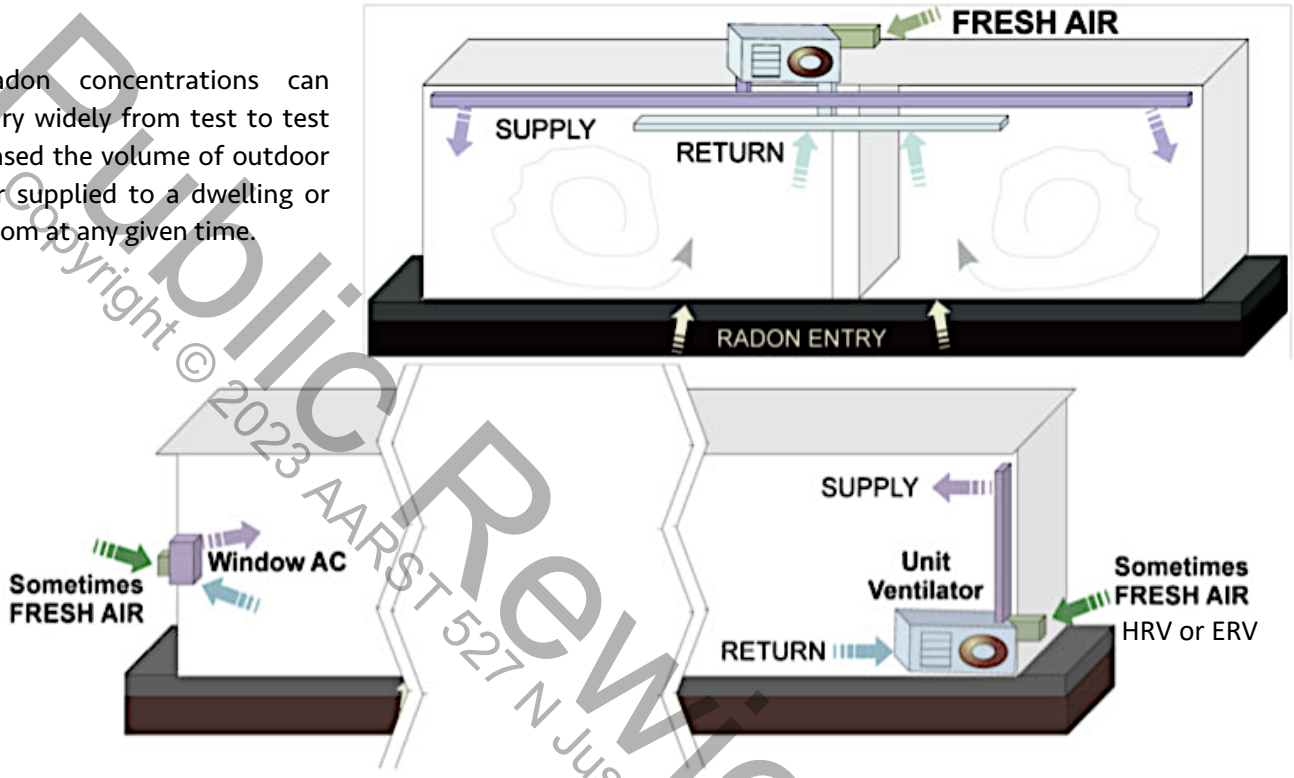
Radon concentrations can vary from room to room based upon variances in system operations.



Group 3: VARIABLE OUTDOOR AIR VENTILATION

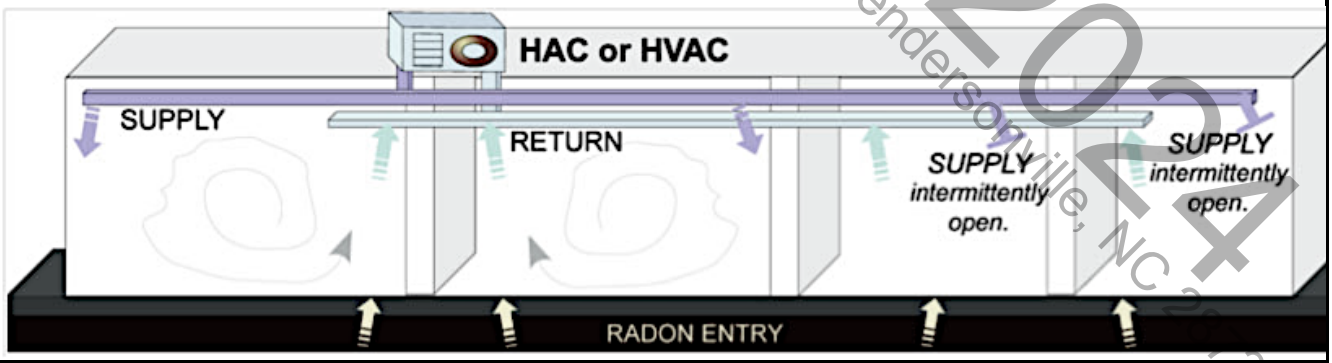
Variable Outdoor Air Ventilation (HVAC) systems are those that add outdoor air ventilation for seasonal comfort or energy savings. Such systems may service a whole building, multiple dwellings or a single dwelling or unit ventilator.

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

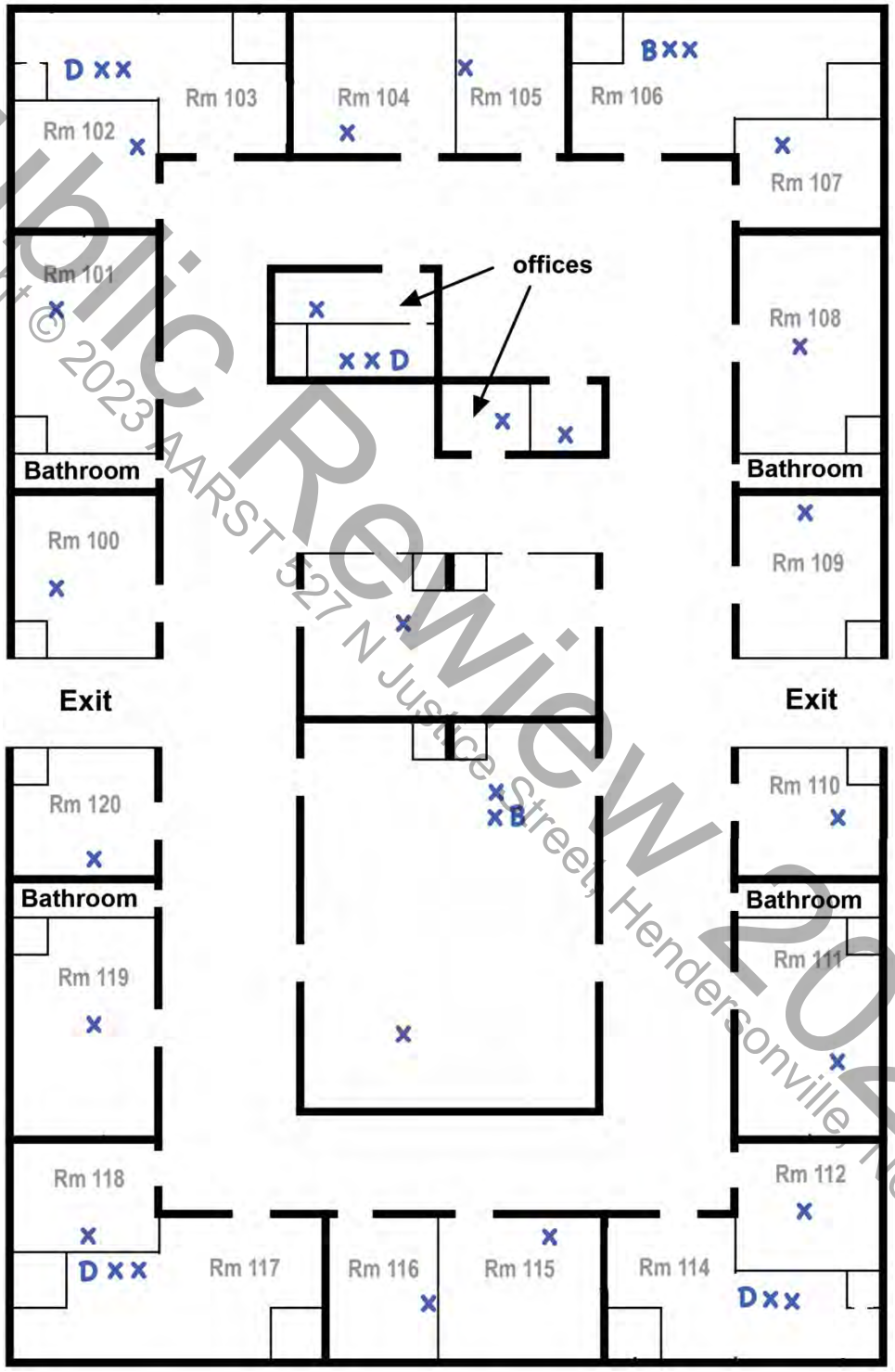
Variable Air Distribution systems are those where airflow from a single air handler is distributed to multiple dwellings, rooms or common use areas with independent controls within each area that open and close duct dampers. The normal operation of these systems can cause changes in distribution of radon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

RADON TEST IN PROGRESS

Required closed-building conditions
(12 hours prior to the test and during the test)

Keep closed	**Windows & Exterior doors** *(except for momentary use)*
Set to normal	**Heating & Cooling systems** *keep between about 65˚ - 80˚ F)*
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	**Whole-house and window fans**
	Fireplaces that burn solid, liquid or gas fuels, unless they are the primary sources of heat for the building

Radon Company
Anytown, USA 800-000-0000

Do not disturb test devices.

Note—Text versions of the door hanger in both English and Spanish can be downloaded by choosing "Measurement, User Tools" at www.standards.aarst.org/public-review

Radon Test Device
Do not discard or disturb
For questions, call _____

Radon Test Device
Do not discard or disturb
For questions, call _____

Radon Test Device
Do not discard or disturb
For questions, call _____

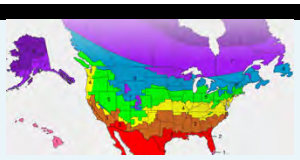
Radon Test Device
Do not discard or disturb
For questions, call _____

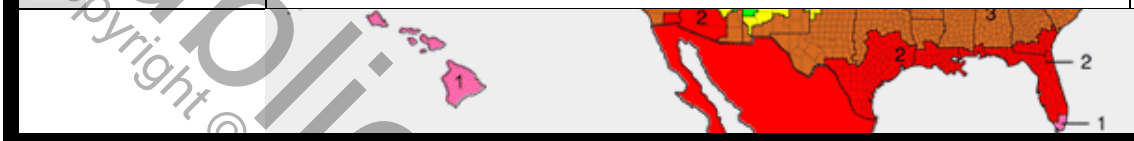
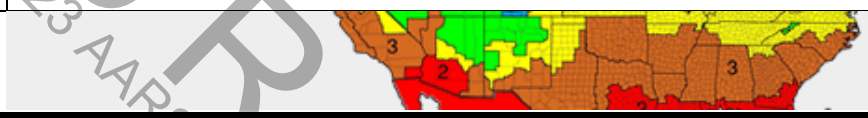
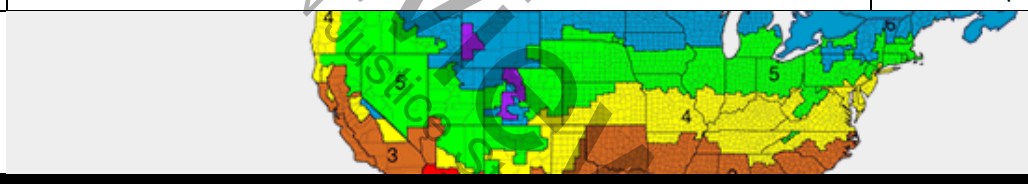
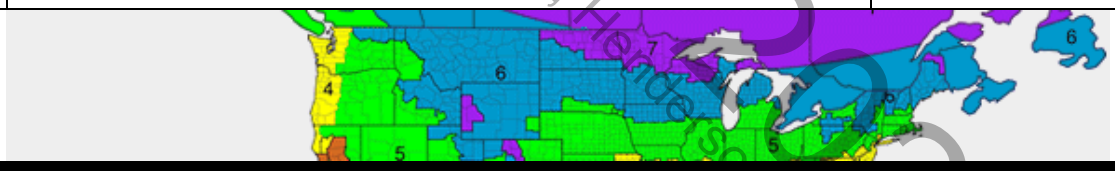
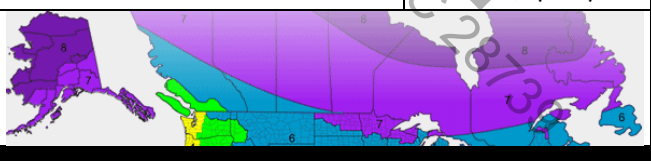
Radon Test Device
Do not discard or disturb
For questions, call _____

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, Tables A-1 through A-8, 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 CG-5 of the Companion Guidance are permitted.

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.

Table A
Comparison of building operating conditions
* Required data

		Prevailing Annually	Prevailing During the Test
Outdoor Temperatures	*Average*	*Avg. annual outdoor temperature* *	*Average temperature during test* *
Operating Condition			
	Heating Conditions	*percentage of year* *	*percentage during test* *
	Cooling Conditions	*percentage of year* *	*percentage during test* *
	Mixed Conditions	*percentage of year* *	*percentage during test* *
Prevailing Operating Condition			
	Average	*prevailing operating condition* *	*prevailing condition during test* *
Condition less likely to inhibit characterization of a radon hazard		*conditions for clear characterization* *	*conditions during test* *

A-2.0 *Calculating test conditions*

Note—Table A-0 (Climate Zone Overview) provides a quick reference for expected building operating conditions relative to average outdoor temperatures during a test that complies with requirements of this Section A 2.

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 period of interest, as required in provisions a), b) and c) of this Section A 2.1.

a) Heating conditions shall be expressed based on durations when outdoor temperatures are less than 65°F (18° C).

b) Cooling conditions shall be expressed based on durations when outdoor temperatures exceed 83° F (28° C).

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.

Note—Table A-0 provides a quick reference for expected building operating conditions relative to average outdoor temperatures during a test.

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.

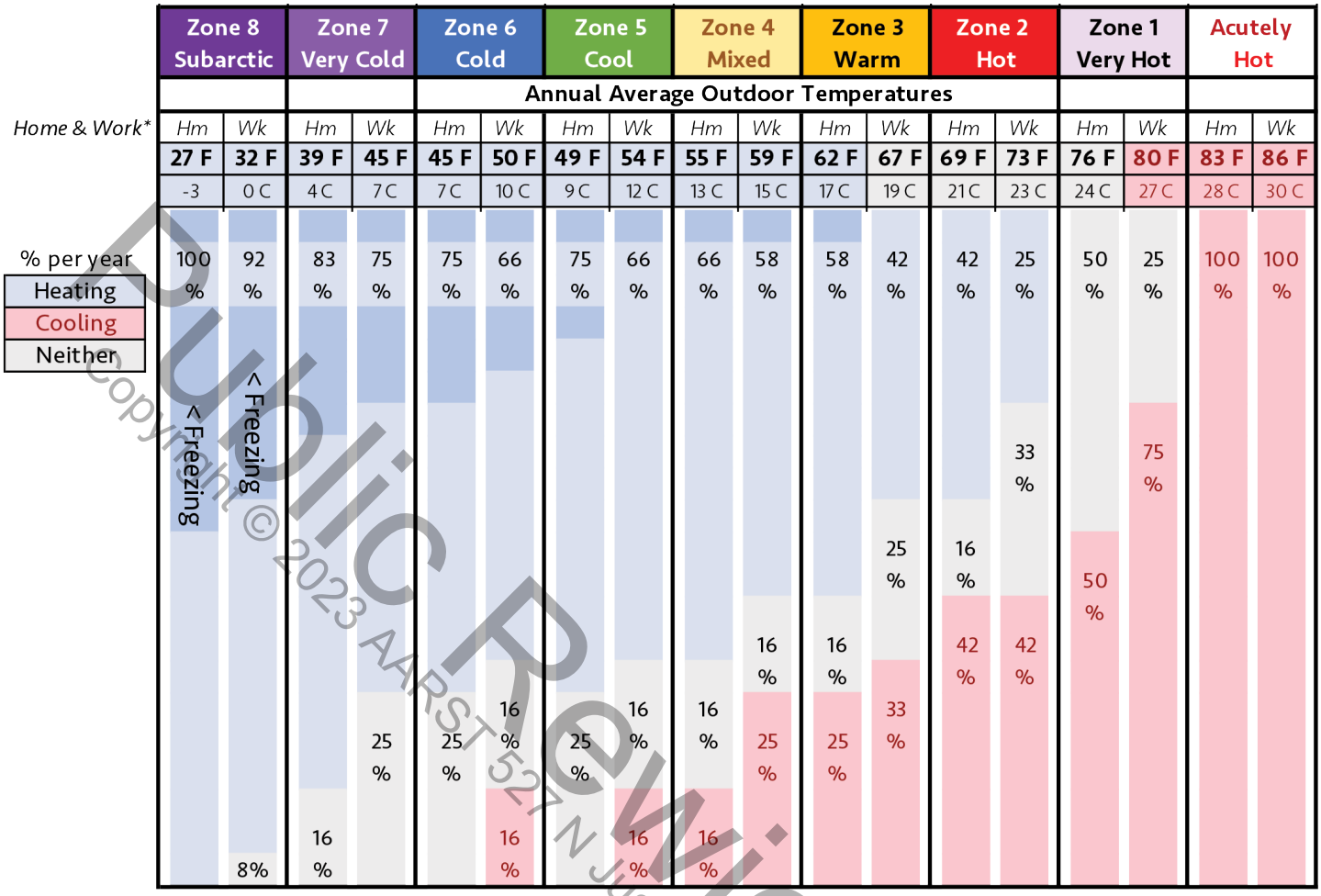
a) Simulation of conditions requires both:

   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.

Table A-0 **Climate Zone Overview—Quick Reference***



Climate zone temperatures based 30-year averages published online (e.g., the National Centers for Environmental Information-NOAA) for a major city located within each climate zone. Zone classifications reflect ASHRAE (The American Society of Heating, Refrigerating and Air-Conditioning Engineers) standards 90.1 / 90.2. For additional information, visit www.ashrae.org.

* *More detail for each climate zone is provided in the following tables.*

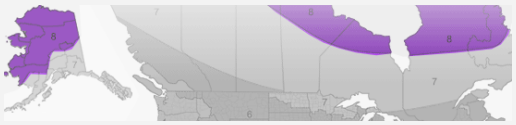
* *Home (Hm) is based on 24-hour temperature averages. Work (Wk) is based daytime temperatures only.*

Note—For discussion purposes, this table illustrates both:

1) Seasonal expectations, and
2) Expected percentages of time that different building operating conditions occur across test periods of multiple days, weeks or months when the outdoor temperature average across the test period is nominally equal to any temperature shown in the table.

Each operating condition influences test results. The measured concentration in each building or unique sector within a building across any span of time is the product of dynamic interactions between factors that include: building capacity for stack effect strength; soil permeability that relates to the volume of soil gas available to enter a building; natural (closed building) ventilation rates with outdoor air; and both natural and mechanical air distribution within the building.

Table A-8

Subarctic **Climate Zone 8** The utmost northern portions of North America. This data is based on Fairbanks, Alaska	

24 Hour Averages

For dwellings and other 24 hour occupancies

24 Hour		Annual 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

		Prevailing Annually	
Operating Condition	*Heating Conditions*	*100%*	
	Cooling Conditions	-	
	Mixed Conditions	-	
Normal Operating Condition		• Heating Conditions	
Condition less likely to inhibit characterization of a radon hazard		• Heating and air distribution systems active	
Additional Considerations		Avoid radon testing under extreme weather conditions, such as during periods when outdoor temperatures are continually < 0˚ F (-18˚C)	

Daytime Averages

For non-residential ocupancies

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

		Prevailing Annually	***School (prevailing across 9 months)***
Operating Condition	*Heating Conditions*	*92%*	*100%*
	Cooling Conditions	-	-
	Mixed Conditions	*8%*	-
Normal Operating Condition		• Heating active	
Condition less likely to inhibit characterization of a radon hazard		• Heating and air distribution systems active	
Additional Considerations		Avoid radon testing under extreme weather conditions, such as during periods when outdoor temperatures are continually < 0˚ F (-18˚C)	

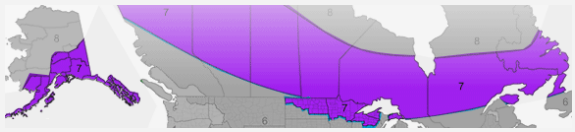
Table A-7

Very Cold

Climate Zone 7

Includes many Canadian provinces, mountain tops, and utmost northern locations in the United States

This data is based on Minot, ND



24 Hour Averages

For dwellings and other 24 hour occupancies

24 Hour		Annual Avg	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
7-Very cold	Minot, ND	39	56	45	26	14	6	11	21	41	53	61	68	67

		Prevailing Annually	
Operating Condition	*Heating Conditions*	*83%*	
	Cooling Conditions	-	
	Mixed Conditions	*16%*	
Normal Operating Condition		• Heating conditions • No variance in outdoor air ventilation	
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

		Prevailing Annually	***School (prevailing across 9 months)***
Operating Condition	*Heating Conditions*	*75%*	*100%*
	Cooling Conditions	-	-
	Mixed Conditions	*25%*	-
Normal Operating Condition		• Heating conditions • No variance in outdoor air ventilation	
Condition less likely to inhibit characterization of a radon hazard		• Heating and air distribution systems active	

Some Cities in This Climate Zone

Note—Exact percentages will vary slightly depending upon location

Caribou ME
Quebec, CA
Marquette MI
Duluth MN
Winnipeg, CA
Grand Forks, ND
Anchorage, AK
Breckenridge, CO
Aspen, CO

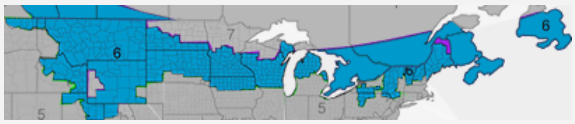
Table A-6

Cold

Climate Zone 6

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

This data is based on Minneapolis, MN



24 Hour Averages

For dwellings and other 24 hour occupancies

24 Hour		Annual Avg	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
6 Cold	Minneapolis, MN	45	61	50	33	19	13	18	31	46	59	68	73	71

		Prevailing Annually	
Operating Condition	*Heating Conditions*	*75%*	
	Cooling Conditions	*-*	
	Mixed Conditions	*25%*	
Normal Operating Condition		• Heating conditions • No variance in outdoor air ventilation	
Condition less likely to inhibit characterization of a radon hazard		• Heating and air distribution systems active	

Daytime Averages

For non-residential ocupancies

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

		Prevailing Annually	***School (prevailing across 9 months)***
Operating Condition	*Heating Conditions*	*66%*	*88%*
	Cooling Conditions	*16%*	*11%*
	Mixed Conditions	*16%*	*-*
Normal Operating Condition		• Heating conditions • No variance in outdoor air ventilation	
Condition less likely to inhibit characterization of a radon hazard		• Heating and air distribution systems active	

Some Cities in This Climate Zone

Note—Exact percentages will vary slightly depending upon location

Portland, ME
Buffalo, NY
Burlington, NH
Milwaukee, WI
Minneapolis, MN
Bismarck, ND
Pierre, SD
Cheyenne, WY
Billings, MT
Helena, MT

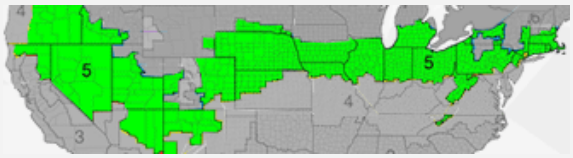
Table A-5

Cool

Climate Zone 5

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

This data is based on Chicago, IL



24 Hour Averages

For dwellings and other 24 hour occupancies

24 Hour		Annual Avg	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
5 Cool	Chicago, IL	49	65	53	40	27	22	26	37	49	59	69	74	72

		Prevailing Annually	
Operating Condition	*Heating Conditions*	*75%*	
	Cooling Conditions	-	-
	Mixed Conditions	*25%*	-
Normal Operating Condition		• Heating conditions • No variance in outdoor air ventilation	
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
5 Cool	Chicago, IL	54	46	70	58	44	31	26	30	41	54	65	75	79	77

		Prevailing Annually	***School (prevailing across 9 months)***
Operating Condition	*Heating Conditions*	*66%*	*88%*
	Cooling Conditions	*16%*	-
	Mixed Conditions	*16%*	*11%*
Normal Operating Condition		• Heating conditions • No variance in outdoor air ventilation	
Condition less likely to inhibit characterization of a radon hazard		• Heating and air distribution systems active	

Some Cities in This Climate Zone

Note—Exact percentages will vary slightly depending upon location

Boston,
Albany, NY
Pittsburg, PA
Cleveland, OH
Columbus, OH
Indianapolis, IN
Chicago, IL
Des Moines, IA
Omaha, NE

Denver, CO
Colorado Springs, CO
Albuquerque, NM
Salt lake, UT
Reno, NV
Boise, ID

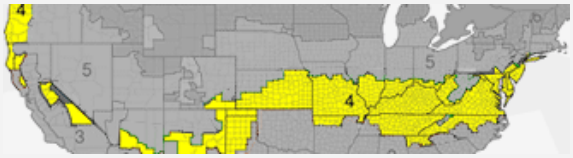
Table A-4

Mixed

Climate Zone 4

Includes portions of NY, NJ, PA, MD VA, KT, TN, KS, MO, WA and OR.

This data is based on Philadelphia, PA



24 Hour Averages

For dwellings and other 24 hour occupancies

24 Hour		Annual Avg	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
4 Mixed	Phillidelpia, PA	55	68	57	47	36	32	34	42	53	63	72	77	76

		Prevailing Annually	
Operating Condition	*Heating Conditions*	*66%*	
	Cooling Conditions	*16%*	
	Mixed Conditions	*16%*	
Normal Operating Condition		• Heating conditions • No variance in outdoor air ventilation	
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
4 Mixed	Phillidelpia, PA	59	52	73	62	51	40	36	38	47	58	68	77	82	81

		Prevailing Annually	School (prevailing across 9 months)
Operating Condition	*Heating Conditions*	*58%*	*78%*
	Cooling Conditions	*25%*	-
	Mixed Conditions	*16%*	*22%*
Normal Operating Condition		• Heating conditions • No variance in outdoor air ventilation	
Condition less likely to inhibit characterization of a radon hazard		• Heating and air distribution systems active	

Some Cities in This Climate Zone

Note—Exact percentages will vary slightly depending upon location

New York, NY
Philadelphia, PA
Richmond, VA
Washington, DC
Baltimore, MD
Louisville, KY
Cincinnati, OH
Nashville, TN
Saint Louis, MO
Kansas City, MO
Amarillo, TX
Portland, OR
Seattle, WA

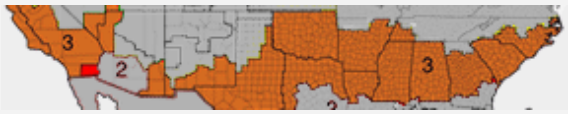
Table A-3

Warm

Climate Zone 3

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

This data is based on Atlanta, GA



24 Hour Averages

For dwellings and other 24 hour occupancies

24 Hour		Annual Avg	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
3 Warm	Atlanta, GA	62	73	63	53	45	43	46	53	62	70	77	79	79

		Prevailing Annually	
Operating Condition	*Heating Conditions*	*58%*	
	Cooling Conditions	*25%*	
	Mixed Conditions	*16%*	
Normal Operating Condition		• Heating active	
Condition less likely to inhibit characterization of a radon hazard		• Heating and air distribution systems active • No variance in outdoor air ventilation	

Daytime Averages

For non-residential oocupancies

Daytime		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

		Prevailing Annually	***School (prevailing across 9 months)***
Operating Condition	*Heating Conditions*	*42%*	*55%*
	Cooling Conditions	*33%*	*11%*
	Mixed Conditions	*25%*	*33%*
Normal Operating Condition		• Heating active	
Condition less likely to inhibit characterization of a radon hazard		• Heating and air distribution systems active • No variance in outdoor air ventilation	

Some Cities in This Climate Zone

Note—Exact percentages will vary slightly depending upon location

Atlanta, GA
Charlotte, SC
Montgomery, AL
Birmingham, AL
Jackson, MS
Memphis, TN
Little Rock, AR
Oklahoma City, OK
Dallas, TX
San Antonio TX
Austin, TX
El Paso, TX
Las Vegas, NV
San Diego, CA
Los Angeles, CA
Fresno, CA
San Francisco, CA

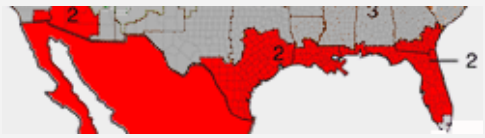
Table A-2

Hot

Climate Zone 2

Includes portions of FL, LA, TX, AZ and many southern portions of North America.

This data is based on New Orleans, LA



24 Hour Averages

For dwellings and other 24 hour occupancies

24 Hour		Annual Avg	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
2 Hot	New Orleans, LA	69	79	70	61	55	52	55	62	69	76	81	82	82

		Prevailing Annually	
Operating Condition	*Heating Conditions*	*42%*	
	Cooling Conditions	*42%*	
	Mixed Conditions	*16%*	
Normal Operating Condition		• Virtually equal portions of the year for heating or cooling.	
Condition less likely to inhibit characterization of a radon hazard		• Heating and air distribution systems active • No variance in outdoor air ventilation	
Additional Considerations			

Daytime Averages

For non-residential occupancies

Daytime		Annual Avg	School Avg	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
2 Hot	New Orleans, LA	73	69	83	75	66	60	57	60	67	74	80	85	87	86

		Prevailing Annually	***School (prevailing across 9 months)***
Operating Condition	*Heating Conditions*	*25%*	*33%*
	Cooling Conditions	*42%*	*22%*
	Mixed Conditions	*33%*	*44%*
Normal Operating Condition		• Cooling systems active.	• Intermittent heating and cooling conditions.
Condition less likely to inhibit characterization of a radon hazard		• Heating conditions at least some portion of the test period. • No variance in outdoor air ventilation.	
Additional Considerations		• Consider additional testing to evenly account for each condition or an Assessment of Occupied Versus Unoccupied Conditions.	

Some Cities in This Climate Zone

Note—Exact percentages will vary slightly depending upon location

Melbourne, FL
Tampa, FL
Mobile, AL
New Orleans, LA
Houston, TX
Brownsville, TX
Phoenix, AZ
Tucson, AZ

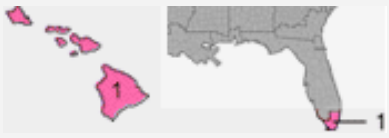
Table A-1

Very Hot

Climate Zone 1

Certain tropical areas such as Hawaii and the southern tip of Florida

This data is based on Miami, FL



24 Hour Averages

For dwellings and other 24 hour occupancies

24 Hour		Annual Avg	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1 Very Hot	Miami, FL	76	82	79	74	69	68	69	72	75	79	82	83	83

		Prevailing Annually
Operating Condition	*Heating Conditions*	-
	Cooling Conditions	*50%*
	Mixed Conditions	*50%*
Normal Operating Condition		• Virtually equal periods of cooling and inactive HVAC.
Condition less likely to inhibit characterization of a radon hazard		• When each day tested includes periods of both: a) outdoor temperatures below 84˚ F (29˚ C), and; b) cooling systems active with some degree of regularity. • No variance in outdoor air ventilation
Additional Considerations		Consider Long-Term or additional testing to account for both conditions.

Daytime Averages

For non-residential occupancies

Daytime		Annual Avg	School Avg	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1 Very Hot	Miami, FL	80	78	85	82	77	73	72	73	76	79	83	85	86	87

		Prevailing Annually	***School (prevailing across 9 months)***
Operating Condition	*Heating Conditions*	-	-
	Cooling Conditions	*75%*	*66%*
	Mixed Conditions	*25%*	*33%*
Normal Operating Condition		• Cooling systems active	
Condition less likely to inhibit characterization of a radon hazard		• When each day tested includes periods of both: a) daytime outdoor temperatures below 84˚ F (29˚ C), and; b) cooling systems active with some degree of regularity. • No variance in outdoor air ventilation	
Additional Considerations		• Consider additional testing to evenly account for each condition or an *Assessment of Occupied Versus Unoccupied Conditions.*	

Some Cities and Locations in This Climate Zone

Note—Exact percentages will vary slightly depending upon location

Miami, FL
Puerto Rico
Virgin Islands
Honolulu, HI
Guam

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

ELEVATED RADON CONCENTRATIONS IN UPPER FLOORS

C-1 Evaluation Procedures

Where elevated radon concentrations are found in upper floor test locations, an evaluation shall be conducted to determine the extent and cause of the elevated concentrations. A report that complies with all applicable portions of Section 8 (Test Reports) shall be provided relative to the results of each step of the evaluation. The report shall recommend that mitigation efforts are to comply with national standards. [10]

C.1.1 Step 1—*Soil gas and water*

C.1.1.1 Soil Gas

It shall be permitted to mitigate known or suspected sources of soil gas entry prior to initiating radon measurement evaluations of upper floors. When making this choice, post-mitigation testing shall include upper floor measurements in accordance with Section C.1.2 Step 2.

C.1.1.2 Water

It shall be permitted to conduct measurements, in accordance with national standards[11], and mitigation for radon in water prior to initiating radon measurement evaluations of indoor air on upper floors. Where mitigation included reducing radon in water supplies, post-mitigation testing shall include testing indoor air for radon in one or more locations within each dwelling or non-residential room where elevated radon concentrations had been found.

C.1.2 *Step 2—Measurement Evaluations*

Measurements shall be conducted to characterize elevated radon concentrations in upper floor areas of the building that include:

a) a radon measurement 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 in all dwellings and non-residential rooms for no less than one additional upper floor, regardless of whether elevated radon concentrations were initially found there.

Exception: Where the cause and extent of elevated concentrations are confirmed to be radon in water.

C.1.3 *Step 3—Localized ventilation or building materials*

C.1.3.1 Step 3 A: Visual Evaluation

Where the measurements conducted in accordance with Section C.1.2 Step 2 indicate inadequate ventilation or building materials specific to certain dwellings or non-residential rooms are the cause of elevated concentrations:

a) A visual review shall be conducted 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.

[10] ANSI/AARST SGM-MFLB *(Soil Gas Mitigation in Existing Multifamily, School, Commercial and Mixed-Use Buildings).*

[11] ANSI/AARST MW-RN *(Protocol for the Collection, Transfer and Measurement of Radon in Water).*

A report shall be provided with a summary of the visual review and any measurements conducted to include recommendations or guidance consistent with the findings of this characterization.

C.1.3.2 Step 3 B: Common To The Structure

Where evaluations indicate inadequate ventilation or building material sources are a cause of elevated concentrations common to the entire building or portions of the building, the measurement evaluation in Section C.1.2 shall be repeated on one or more additional upper floors unless there is reliable evidence to support a different course of action. Where evaluations confirm concerns that the cause is common to the entire building or portion of the building, reports shall recommend mitigation for all floors or portions of the building identified with similar conditions.

C.1.3.3 Step 3 C: Clearance Testing—Inadequate Ventilation or Building Materials

Where elevated radon is identified to be caused by inadequate ventilation or building materials, clearance testing after attempts to mitigate resulting indoor radon concentrations shall be conducted for:

a) All dwellings and non-residential rooms where efforts have been made to mitigate radon from inadequate ventilation or building materials; and

b) All locations not tested but that demonstrate similar potential for causing elevated radon concentrations.

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.

NORMATIVE APPENDIX D

NATIONAL CERTIFICATION/LISTING PROGRAMS

D-1 National Certification/Listing Programs

For private sector certifications of qualified measurement professionals identified in Section 2.4, this standard requires a national program that evaluates and lists qualified individuals, training courses and other products or services, such as laboratory services, integral to achieving public health goals intended by this standard. Programs meeting the purpose, need and requirements of this standard are those with policies as established in a), b) and c) of this Appendix D.

a) Programs with published policies that:

1. require persons to undergo education and an impartial examination process prior to granting personal certification or certificates of educational achievement; and
2. require surveillance of continued competence, not less than as demonstrated by continuing education on standards updates, compliance and other related technical knowledge and skills, prior to granting recertification or renewed certificates or listings; and
3. require, for the certification of radon measurement laboratories, initial demonstration and scheduled ongoing surveillance of compliance with ANSI/AARST MS-QA (Radon Measurement Systems Quality Assurance).

b) Programs that:

1. have a written policy and means for receiving and adjudicating complaints against individuals or companies who have been granted a credential; and
2. have publicly published educational and examination requirements for each credential or listing available online where readily accessible for consumers of credentialed services.

b) Programs that include educational prerequisites as follow:

1. Qualified Radon Measurement Professional—Multifamily and Commercial
   Listing or certification credentials granted that qualify individuals as proficient in placement, retrieval, and analysis (as applicable) of *radon* detectors and to design, plan, and implement quality procedures when conducting *radon* measurements in multifamily, school, commercial and mixed-use buildings are to include:
   a. current certification as a qualified radon measurement professional in homes; and
   b. additional education and processes approved by the program relative to tasks required in the most current version of this standard ANSI/AARST MA-MFLB (Protocol for Conducting Measurements of Radon and Radon Decay Products in Multifamily, School, Commercial and Multi-Use Buildings) prior to granting this advanced level certification or listing and recertifications or relisting.

2. Qualified Radon Measurement Professional—Homes
   Certifications granted that qualify individuals as proficient in conducting radon measurements in existing homes are to include:
   a. no less than 16 hours education prior to granting certification that focuses on tasks required in ANSI/AARST MAH (Protocol for Conducting Measurements of Radon and Radon Decay Products in Homes); and

b. biennial recertifications after completing continuing education requirements and any other program surveillance activities.

Informative Note 1—The National Radon Proficiency Program (NRPP), the National Radon Safety Board (NRSB), or equivalent programs that also meet requirements of a), b) and c) of this normative Appendix D meet the requirements of this standard.

Note that identification of existing certification bodies is not an endorsement of their programs.

Informative Note 2—The purpose of requirements in this **Appendix D** is to ensure contractors have an appropriate degree of technical, engineering, and scientific knowledge to protect occupants by providing reliable measurements of *radon gas* present in indoor air.

Acknowledgments

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

Measurement Committee (Consensus Body) Participants 2018-2023

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(Regulated States alternate)	Patrick Daniels (IL)	Illinois Emergency Mgmt. Radon Program
(Proficiency Program)	Kyle Hoylman (KY)	National Radon Proficiency Program
(Federal Government)	Tommy Bowles (DC)	U.S. Environmental Protection Agency
(Public Health NGO)	Kevin Stewart (PA)	American Lung Association
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(Home Inspectors alternate)	Kurt Salomon (UT)	Home Inspection Professional
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MA-MFLB
Companion Guidance

AARST CONSORTIUM

Advisory—The information contained in this guidance document is not part of this ANSI/AARST American National Standard (ANS) and does not contain requirements necessary for conformance to this standard. The information contained in this guidance document has not been processed in accordance with ANSI's requirements for an ANS. As such, this guidance document may contain material that has not been subjected to public review or a consensus process.

CONTENTS

Informational
Introduction to Radon

A. Radon Facts

Radon is a naturally occurring radioactive gas that is a part of the uranium-238 decay chain. The immediate parent of radon-222 is radium-226. Radon comes from the breakdown (radioactive decay) of uranium that is found in soil and rock all over the world. Radon is a component of the air in soil that enters buildings through cracks and other pathways in the foundation. Eventually, it decays into radioactive particles (decay products) that can become trapped in your lungs when you inhale. As these particles decay, they release small bursts of radiation that can damage lung tissue and lead to lung cancer over the course of a lifetime. Studies by the U.S. Environmental Protection Agency (EPA) have found that radon concentrations in outdoor air average about 0.4 pCi/L (picocuries per liter) of air. However, radon can reach much higher concentrations inside a building.

Radon gas is colorless, odorless and tasteless. The only way to know whether elevated concentrations of radon are present in any building is to test.

B. Radon's Health Effects

Radon is a known human carcinogen. Prolonged exposure to elevated radon concentrations causes an increased risk of lung cancer. Like other environmental pollutants, there is some uncertainty about the magnitude of radon health risks, but EPA calculates that radon may cause 21,000 lung cancer deaths in the United States each year. The U.S. Surgeon General has warned that radon is the leading cause of lung cancer deaths in nonsmokers in the United States. Only smoking causes more lung cancer deaths than radon.

Not everyone who breathes radon decay products will develop lung cancer. An individual's risk of getting lung cancer from radon depends primarily on three factors: the concentration of radon, the duration of exposure and the individual's smoking habits. In addition, some people are more susceptible to lung cancer than others.

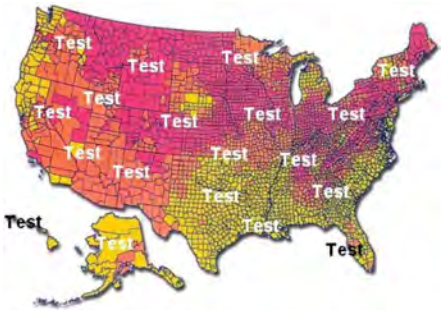
Risk increases as an individual is exposed to higher concentrations of radon over a longer period. Smoking combined with radon is an especially serious health risk. The risk of dying from lung cancer caused by radon is much greater for smokers than it is for nonsmokers.

C. Radon Exposure

Because many people spend much of their time at home, the home is likely to be where the most significant radon exposure occurs. According to EPA, nearly one out of every 15 homes in the United States is estimated to have radon concentrations that exceed the EPA action level. For most people, the second largest exposure to radon is likely to be at their school or workplace.

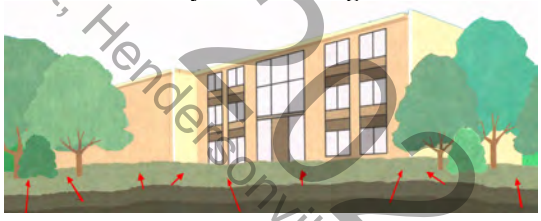
Elevated concentrations of radon have been found in homes and other buildings in every U.S. state and similarly throughout the world. According to EPA studies, nearly one out of every five schools in the United States are estimated to have radon concentrations that exceed the EPA action level in at least one frequently occupied ground-contact room.

While elevated radon may be more common in some areas, any building can have a problem. It is recommended that ALL buildings be tested regardless of the area of the country and that maps should not be used to determine whether to test.



The concentration of radon in the air within a building should be reduced below the federally established radon action level or as established by the state or other local jurisdiction. Action levels, such as 4 pCi/L established in the United States, are based largely on the ability of current mitigation technologies to consistently reduce radon concentrations. Any radon exposure creates some risk; no concentration of radon is safe. Even radon concentrations below the action level pose some risk, and the risk of lung cancer can be reduced by further lowering indoor radon concentrations. Depending on the building characteristics, radon concentrations in some buildings can be reduced well below the action level. In others, reducing radon concentrations below the action level may be more difficult.

D. Radon Entry into Buildings



Radon in soil gas is the main source of radon problems. Pathways for radon to enter a building include cracks in the slabs and walls, the expansion joints between floor and walls, porous concrete block walls, open sump pits, crawlspaces and openings around utility penetrations. Some buildings have other pathways for radon to enter a building such as sub-slab utility tunnels and heating, ventilating and air conditioning (HVAC) ducts.

Radon gas may also enter buildings in well water. Radon from well water used in a building can off-gas and raise concentrations in the air within the building. For buildings or small communities that use well water, a test of the water

for radon should be considered, especially if the building is vacant or there is no water use when testing for radon in air. Radon in water testing is covered in a separate document and is beyond the scope of this testing protocol. More information on radon in drinking water is available at state radon offices, local drinking water safety programs or at federal water safety programs (e.g., EPA's Drinking Water Hotline (800) 426-4791

Sometimes building materials that contain uranium and radium can produce radon in sufficient amounts to result in elevated radon concentrations in the air. A radiation professional or local radiation program can help you evaluate this possibility.

Factors Influencing Radon Entry

Many factors contribute to the entry of radon gas into buildings. As a result, building managers cannot know without testing if elevated concentrations of radon are present. The following factors determine why some buildings have elevated radon concentrations and others do not:

- **Source Strength:** The concentration of radon in the soil gas**;**
- **Gas Mobility:** The permeability of the soil or sub-surface geology under the building;
- **Structure and Construction** of a building; and,
- **Mechanical Systems:** The type, design, operation, and maintenance of the heating, ventilating, and air-conditioning system.

Source strength: The radon concentration in soil gas under structures can vary greatly from one building to the next. It can even vary greatly under different parts of the same building.

Gas mobility: Certain geological features beneath a building, such as cracks, fissures or solution cavities, can serve as a direct connection between the radon-producing minerals and the building's foundation. Such a direct connection can cause one room or portion of a building to have a radon concentration significantly higher than other nearby areas. The permeability of the soil under a building along with the differences between the air pressure inside a building and the air pressure under a building's foundation influence the radon entry rate. For example, if the air pressure in the building is greater than the air pressure under the building's foundation, radon is less likely to enter through the openings of a building's foundation. If the air pressure in the building is less than the air pressure under the building's foundation, radon in the soil gas will enter through any openings in the building's foundation.

Structure and construction: Any building can have a radon problem even though building design and construction impact radon entry and ventilation once radon enters. Testing is the only way to know if elevated concentrations of radon are present.

Heating, cooling and ventilation systems:

Depending on their design and operation, HVAC systems can influence radon concentrations in buildings:

- Ventilation with outdoor air serves to dilute indoor radon concentrations; however, radon gas potency most often overwhelms the practical limits of increasing ventilation to adequately reduce occupant exposure.
- Poor ventilation provides less dilution of indoor radon concentrations.
- Depressurized buildings draw radon inside.
- Pressurizing a building helps keep radon out.

The frequency and thoroughness of HVAC maintenance can sometimes play an important role. For example, air intake filters that are not periodically cleaned and changed can significantly reduce the amount of outdoor air needed to dilute indoor contaminants. An understanding of the design, operation and maintenance of a building's HVAC system and its influence on indoor air is helpful for managing radon problems and other indoor air quality problems in buildings. However, since HVAC systems are only one of many factors that affect radon concentrations in a building, their modifications are often not an effective stand-alone radon mitigation strategy.

E. Contacts for Additional Information

In the United States:

- EPA website http://www.epa.gov/radon
- State radon offices: https://www.epa.gov/radon/epa-map-radon-zones-and-supplemental-information#datainfo
- Regional EPA offices: https://www.epa.gov/aboutepa/visiting-regional-office
- The National Radon Proficiency Program (NRPP): www.nrpp.info
- The National Radon Safety Board (NRSB) - Radon Proficiency Program: www.nrsb.org

In Canada:

- Health Canada https://www.canada.ca/en/health-canada/services/health-risks-safety/radiation/radon.html
- Canadian—National Radon Proficiency Program (C-NRPP): https://c-nrpp.ca/

CG Section 2

Guidance for Building Managers

A. Introduction and Planning

The purpose of radon testing is to identify locations that have elevated radon concentrations and to determine if radon mitigation is necessary to protect the health of current and future occupants. -n 02

Planning

Planning to test a building for radon requires a basic understanding of the testing process and the steps that are necessary to ensure results are reliable. Radon testing requires careful planning and record-keeping. It requires determining appropriate test locations and handling large numbers of devices.

Use a trained professional who has demonstrated a minimum degree of appropriate technical knowledge and skills specific to design and implementation of the radon testing program.

If considering existing staff personnel, they should obtain national, and if applicable, local state certification or licensure prior to testing. Demonstration of personal proficiency by means of a license or certification is required by some jurisdictions.

Preparation

Poorly designed studies can lead to unnecessary expense, disruption and misinterpretation of data. Specifically, to plan for radon testing, you will need to:

- Become familiar with testing methods;
- Become familiar with building conditions required to conduct reliable radon tests;
- Gather building information pertinent to the design of a radon testing plan, including floor plan diagrams for ground-contact dwellings and non-residential rooms;
- Review logistics and estimate the number of detectors, including those for quality control (QC), when evaluating costs and competitive bids from companies providing radon testing services;
- Design, implement and document a plan to coordinate activities between staff and radon professionals;
- Investigate whether any previous tests have been conducted and collect any available test results; and
- Become familiar with radon reduction recommendations.

B. Communication Plan

Develop a written communication plan for disseminating information throughout the process to all affected parties. Include senior staff, health and safety staff, appropriate communications staff, maintenance staff, and the radon measurement professional when developing the communication plan. This plan should be agreed to and signed by the responsible parties.

Prior to the test:

- Develop notices (with general information, instructions, and point of contact for inquiries) that can be made specific for each affected audience, including:
  - — Facilitating staff
    These are people responsible for oversight of test devices and building conditions during the testing period such as building managers, maintenance managers, teachers, and other supervisors;
  - — Occupants, which for non-residential occupancies may include students and workers; and
  - — Guardians of occupants under supervised care that may include students
- Develop timetables and methods for distribution of notices.
- Specify the staff member responsible for onsite activities.

- Specify additional communication paths between senior staff, facilitating staff, maintenance staff and the professional radon service provider.
- Specify the procedure for internal distribution of radon test data including:
  - Who is designated to receive data or reports from the radon measurement professional.
  - What situations, if any, warrant reporting interim and incomplete test results prior to completion of all test phases. This should be decided prior to any situation where follow-up testing is a component of the chosen test strategy.
- Identify who is responsible for developing contingency plans for unexpected challenges during the testing.
- Identify who is granted permission to respond to public inquiries.
- Specify the procedure and mechanism for disclosing the radon test results and the person(s) allowed to discuss test results with occupants, parents or other parties.

Pre-test notifications

Distribute notices of radon testing at least two weeks in advance of beginning testing and again a few days before the test to appropriate staff and occupants. Poor communications prior to testing can lead to test disruption and unusable data, creating unnecessary expense and aggravation.

Note—Section 2.6 and Exhibits 2 through 5 provide details and sample notification forms.

After the test – A Recommendation

Full public disclosure of radon test results for large buildings is strongly recommended and, in some localities, required by law. Failure to disclose test results can deprive current and future occupants of information necessary to avoid risk, thereby increasing the culpability of building owners and managers.

C. Selecting a Radon Measurement Professional

The goal is to select a radon measurement professional who will provide reliable services and procedures. Use experienced professionals that have 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.

Test devices:

All equipment used for measuring radon must meet requirements of the local jurisdiction or be listed by a nationally recognized radon proficiency program if the jurisdiction has no device verification program.

D. Role of a Facility's Personnel

Because the facility's personnel frequently have knowledge of the building and the occupants, they can play a key role during the testing process, especially in planning and efficient use of professional services. By providing floor plan diagrams, when available, and timely access to rooms, the facility personnel can help the radon measurement professional to quickly plan the testing strategy and achieve reliable results.

It is strongly recommended that untrained personnel serve only in these support roles for trained and certified or licensed radon measurement professionals. Specific training that includes demonstration of proficiency in the use of detectors should be obtained prior to assisting a qualified radon measurement professional in placing and retrieving detectors.

E. Documenting the Testing Program

The building managers or owners should maintain a record of the testing program for future reference.

F. When to Test

While testing at any time can provide valuable information, confidence that elevated radon concentrations are not present is best achieved with tests conducted during periods that reasonably represent:

a) The normal occupied operating condition for the building or unique sector of the building.

b) Testing periods when the operating conditions are most likely to emphasize a clear characterization of a radon hazard.

Note—For most locations in the U.S., this would be during the heating season (e.g., winter). See Appendix A for more information.

G. Retesting When Tests Have Indicated Low Radon Concentrations

Retesting the building at least every 5 years is recommended. Testing may be conducted more often to gain more information. Many factors can cause indoor radon concentrations in a building to change over time. These changes may produce variations in radon concentrations compared to previous tests.

It is recommended to test again when any of the following circumstances occur:

- ✓ A new addition is constructed, or significant renovation takes place;
- ✓ A ground contact area not previously tested is occupied or subsequent to taking occupancy of a building;
- ✓ Heating or cooling systems are significantly altered resulting in changes to air pressures or distribution;
- ✓ 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 (e.g., sumps, perimeter drain tile, shower/tub retrofits, etc.); or
  - — natural settlement causing major cracks to develop;
- ✓ Earthquakes, construction blasting, or formation of sink holes nearby; or
- ✓ An installed mitigation system is altered, modified or repaired.

H. Mitigation

Timing

How quickly to begin the mitigation process will depend on the initial radon concentration detected. Radon concentrations of more than twice the action level requires a more rapid response, e.g., more than 8 pCi/L (296 Bq/m^3).

The Need for Professional Mitigation Guidance

Lowering radon concentrations requires special training, skills and experience. Persons qualified in varied disciplines with different skill sets are often needed. It is critical that persons, including radon professionals, be qualified for their apportioned task.

To successfully lower radon concentrations with confidence, the management team, contractor or contracting team needs to include individuals with experience in radon mitigation who have demonstrated a minimum degree of appropriate technical knowledge and skills specific to radon mitigation in the size of building being mitigated.

Prior Design Diagnostics

Conditions in the entire building must be evaluated. Diagnostic procedures to evaluate air pressure relationships within and under a building are needed to identify the appropriate radon reduction technique and design.

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

"Evaluating and Assessing Radon Testing in Housing with Multifamily Financing" (EARTH) was 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 was 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 units in 276 multifamily buildings in the US. These data indicate, across building sizes, that to characterize radon levels correctly in multifamily buildings with up to 20 ground-contact units, i.e., achieve 95% confidence that no units in the building have radon ≥4 pCi/L, 100% testing is required. For the vast majority of multifamily building sizes, all ground-contact units in the buildings should be tested for radon.

Average probability (%) of partial sampling missing a unit in a building* with≥4 pCi/L with various sampling percentages.

Number of ground contact units	Number of buildings	10% sampled	25% sampled	50% sampled	75% sampled	90% sampled
05-06	45	58	34	19	4.7	0.0†
07-08	71	55	36	15	4.6	0.0†
09-10	40	65	39	24	8.5	3.8
11-12	37	52	41	21	8.1	2.8
13-14	14	51	35	20	7.4	2.2
15-16	20	47	32	15	5.0	1.3
17-18	15	59	39	21	8.1	1.9
19-20	12	69	46	23	8.9	2.6
21-26	22	52	34	18	6.7	2.3
All	276	58%	38%	19%	6.5%	1.7%

**Ground contact units only. Includes buildings with at least one unit ≥4 pCi/L.*

†*Note that for 90% sampling all units are tested for buildings with 9 or fewer units.*

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.

CG Section 3
DESCRIPTIONS OF TEST DEVICES

Passive Device Measurement Systems

As used in this standard, "Passive devices" are measurement systems that collect a time-weighted average and do not provide hourly readings.

- *Charcoal adsorption detectors (CAD)*
  CAD detectors employ activated charcoal that adsorbs radon from the surrounding air. Exposure durations are typically limited to 2-7 days. After exposure, detectors must be sent to the laboratory without delay. Detectors are configured for either Gamma-ray Spectroscopy or Liquid Scintillation Spectroscopy analysis.
- *Alpha-track detectors (ATD)*
  ATD detectors utilize a piece of plastic inside a container. Alpha particles emitted from radon strike the plastic detector and create damaged "tracks" that are visible with a microscope. The track density is determined by the laboratory to achieve an average radon concentration for the time the detector is exposed.
- *Electret ion chamber detectors (EIC)*
  EIC detectors use a chamber made of, or lined with, an electrically conductive material with an electrically charged electret as the detecting mechanism. The decay of radon discharges voltage from the electret. The radon concentration is calculated by comparing the electret voltage measured before and after exposure.
- *Electronic integrating devices (EID)*
  An EID is an electronic measuring device is like a continuous monitor but is not recording a retrievable time series of 1-hour measurements. EID devices are categorized as passive devices because such devices do not provide the additional measurement data points needed for making mitigation decisions.

Continuous Radon Monitors (CRM)

A CRM is an electronic device that is automatically recording a retrievable time series of numeric measurements of radon concentration averaged over time intervals of 1 hour or less. These additional data points can help to judge whether there was an unusual occurrence during the test that might invalidate the overall measurement.

TERMINOLOGY ASSOCIATED QUALITY CONTROL (QC)

Duplicate or Comparison Check Measurements

Duplicates or comparison check measurements are pairs of detectors or monitors deployed in the same location, side-by-side, approximately every tenth measurement (i.e., 10%). The purpose is to evaluate and track imprecision or agreement between detectors or monitors across time. Using calculations for relative percent difference (RPD):

- In an environment with a radon concentration ≥ 4 pCi/L, the goal for agreement is an RDP ≤14%. The warning limit is an RPD ≥ 28% and the control limit is an RPD ≥ 36%.
- Between 2 and 4 pCi/L, the goal for agreement is an RDP of ≤25%. The warning limit is an RPD ≥ 50% and the control limit is an RPD ≥ 67%.

Calibration

Calibration means to adjust or determine or both, the response of an instrument or device relative to a series of conventionally true values. Ongoing annual calibration of each CRM is part of all quality assurance efforts.

Blank Measurements

Blanks are CAD, ATD or EIC devices deployed for at least 5% of the number of measurements conducted 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 lower limit of detection.

Spiked Measurements

Spikes are CAD, ATD or EIC detectors that have been exposed in an approved reference chamber to a known concentration of radon (i.e., "spiked" with radon). Spikes are conducted for at least 3% of the devices deployed for field measurements. Using spiked measurements helps to validate the accuracy of a laboratory analysis and/or detectors supplied by a laboratory.

See ANSI/AARST MS-QA, "Radon Measurement Systems Quality Assurance" for more detailed information.

CG Section 4
CHAIN OF CUSTODY

For Support Staff under direct supervision of a Qualified Measurement Professional

Correlation of Tasks and Technical Skills Commonly Associated with Placing and Retrieving Detectors

Note—This informational table is not intended to stipulate what apportioned tasks are assigned to an individual and thereby not intended to stipulate what combination of instructions or training are appropriate for a specific assigned task.

Task	Instructions or Training associated with each task	QMP's Required Outcome
Identify test locations within a room	Sufficient to know where not to test and required distances away from floors; ceilings; exterior windows, doors, and walls; and other devices and objects.	- Devices deployed in compliance with Table 3.8
Manage devices and documentation during placement and retrieval	Sufficient to document test locations, device serial numbers; start and stop dates and times; and where QC check devices were deployed. Sufficient to update addresses and document occupancies, conditions and mechanical systems that are different than anticipated. Sufficient to document and seek guidance if test reliability concerns are encountered. Sufficient to use devices in compliance with manufacturer's instructions.	- 6.4.2: Documented details are recorded that are required for processing test result analysis and reports - 6.4.1: Updated records and floor-plan diagrams - 2.3.2: Devices used in compliance with manufacturer instructions
Identifying which dwellings and rooms are to be tested	Sufficient to understands which dwellings and rooms to test, compared to where not to test. Sufficient to seek guidance and document locations that were designated to test but could not be tested or where a valid test could not be completed due to missing, lost and non-retrievable detectors	- 3.0: The required dwellings and rooms are tested - 6.2: Locations intended to test but did not achieve a valid test are identified
Quality control of test conditions	Sufficient to inspect for and understand when closed-building conditions were not or cannot be maintained; and to seek guidance if unanticipated conditions are encountered. Sufficient to ensure "radon test in progress" notices are posting in conspicuous locations. Sufficient to identify unexpected HVAC conditions, which can include variable outdoor air ventilation, variable air volume systems and return air ducts under slabs.	- Tables 4-A, 4-B and 4-C and Section 6.1: Compliance with closed-building requirements - 6.1.6: To include posting "Radon test in progress" notices
"QC" measurements	Sufficient to integrate duplicate and blank measurement detectors, where instructed.	- 6.3: QC measurements are conducted and reported
Temporary conditions and protocol deviations	Sufficient to understand, document or seek guidance on temporary conditions and deviations from protocol that may adversely affect test reliability	- 8.2.3 Report conditions that may adversely affect test reliability

CG Section 5
CALCULATING AVERAGE BUILDING OPERATING CONDITIONS

The following methodology is intended to be simplistic yet reasonable for use.

1) Know The Average Occupied Indoor Temperature: 74˚ F (23˚ C)
   Due to required comfort for occupants, the average indoor temperature is usually maintained with stability between 68˚ to 82˚ F (20˚ to 28˚ C). Use an average of about 74˚ F (23˚ C) during estimations unless known to be specifically different. HVAC systems are set to respond to needs for maintaining this comfort range during significantly occupied periods.

2) Identify When the Building Is Significantly Occupied

3) Identify The Average Local Outdoor Temperatures During Significantly Occupied Months
   HVAC systems respond to changes in outdoor temperatures by activating heating, cooling and ventilation air handlers including certain designs that introduce outdoor air ventilation into a building.

4) Identify Periods When Heating and Cooling Systems Activate

Heating Systems	In response to needs for indoor comfort: Heating systems will often activate when outdoor temperatures drop to below about 65° F (18˚ C).
Cooling Systems	In response to needs for indoor comfort: Cooling systems will normally be active when outdoor temperatures exceed about 75° F (28˚ C).

Examples of Heating and Cooling Activity

24 Hour Averages

Daytime Only Averages

24 Hour Temp Averages

ZONE		Annual Avg	9 mo School Avg	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1 Very Hot	Miami, FL	76	74	82	79	74	69	68	69	72	75	79	82	83	83
2 Hot	New Orleans, LA	69	64	79	70	61	55	52	55	62	69	76	81	82	82
3 Warm	Atlanta, GA	62	56	73	63	53	45	43	46	53	62	70	77	79	79
4 Mixed	Phillidelpia, PA	55	48	68	57	47	36	32	34	42	53	63	72	77	76
5 Cool	Chicago, IL	49	42	65	53	40	27	22	26	37	49	59	69	74	72
6 Cold	Minneapolis, MN	45	37	61	50	33	19	13	18	31	46	59	68	73	71
7-Very cold	Minot, ND	39	30	56	45	26	14	6	11	21	41	53	61	68	67
8 SubArctic	Fairbanks, AK	27	17	45	25	4	-6	-8	-2	11	31	49	60	62	57
8 SubArctic	Cambridge Bay	6	-6	32	11	-9	-21	-27	-27	-22	-7	15	36	47	44

Daytime Temp Averages

ZONE		Annual Avg	9 mo School Avg	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1 Very Hot	Miami, FL	80	78	85	82	77	73	72	73	76	79	83	85	86	87
2 Hot	New Orleans, LA	73	69	83	75	66	60	57	60	67	74	80	85	87	86
3 Warm	Atlanta, GA	67	61	78	68	58	50	48	51	59	68	75	82	84	84
4 Mixed	Phillidelpia, PA	59	52	73	62	51	40	36	38	47	58	68	77	82	81
5 Cool	Chicago, IL	54	46	70	58	44	31	26	30	41	54	65	75	79	77
6 Cold	Minneapolis, MN	50	41	66	55	37	23	17	23	35	51	64	73	78	76
7-Very cold	Minot, ND	45	36	63	51	31	19	11	16	26	47	59	67	75	74
8 SubArctic	Fairbanks, AK	32	21	50	29	8	-3	-4	3	18	37	55	65	67	62
8 SubArctic	Cambridge Bay	9	-3	33	14	-6	-18	-24	-24	-18	-2	19	39	51	46

5) Identify The Normal Average Occupied Operating Condition

A. **Calculate the Average Occupied Operating Condition**
The operational condition for the building or unique sector of the building that represents the greatest amount of significantly occupancy time.

B. **Clear Characterization**
Identify the operating conditions most likely to emphasize a clear characterization of a radon hazard. This is primarily time periods when the difference between indoor and outdoor temperatures cause:

a) Some degree of regularity for natural negative air pressure inside the building as compared to outside of the building (e.g., stack effect), and;

b) Some degree of regularity in the activity of heating or cooling system blowers.

This would not include time periods when the volume of outdoor air introduced into the building exceeds the minimum amounts required to maintain occupant health.

EXAMPLE WORKSHEET

1) Identify the average occupied indoor temperature: ❑ 74˚ F (23˚ C) ❑ Other _____.

2) Identify the months per year that represent significant occupancy for each unique sector of the building.

❑ 12 months (as common for dwellings and most large buildings that house business occupancies).

❑ 9 months (as common for many school buildings).
❑ Other _____

Identify the hours of the day that represent significant occupancy for each unique sector of the building.

❑ 10-hour occupancies (e.g., Work or school day plus routine afternoon meetings, classes or sports).
❑ 24-hour occupancies (e.g., Dwellings and 24/7 services such as hospitals).
❑ Other _____

3) Identify the average outdoor temperatures during periods of significant occupancy.

Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
___	___	___	___	___	___	___	___	___	___	___	___	___

4) Calculate average HVAC activity during significantly occupancy periods

HVAC Mode	Months in each operational mode	Total Months	Yearly %
Heating Active	❑ Jan ❑ Feb ❑ Mar ❑ Apr ❑ May ❑ Jun ❑ Jul ❑ Aug ❑ Sep ❑ Oct ❑ Nov ❑ Dec	___	___%
Cooling Active	❑ Jan ❑ Feb ❑ Mar ❑ Apr ❑ May ❑ Jun ❑ Jul ❑ Aug ❑ Sep ❑ Oct ❑ Nov ❑ Dec	___	___%
None (mixed)	❑ Jan ❑ Feb ❑ Mar ❑ Apr ❑ May ❑ Jun ❑ Jul ❑ Aug ❑ Sep ❑ Oct ❑ Nov ❑ Dec	___	___%

Example for Schools

Daytime Averages

> 75˚F Cooling

66˚ - 75˚ F Intermittent

< 65˚F Heat

Daytime Temp Averages ZONE		Annual Avg	9 mo School Avg	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1 Very Hot	Miami, FL	80	78	85	82	77	73	72	73	76	79	83	85	86	87
2 Hot	New Orleans, LA	73	69	83	75	66	60	57	60	67	74	80	85	87	86
3 Warm	Atlanta, GA	67	61	78	68	58	50	48	51	59	68	75	82	84	84
4 Mixed	Phillidelpia, PA	59	52	73	62	51	40	36	38	47	58	68	77	82	81
5 Cool	Chicago, IL	54	46	70	58	44	31	26	30	41	54	65	75	79	77
6 Cold	Minneapolis, MN	50	41	66	55	37	23	17	23	35	51	64	73	78	76
7-Very cold	Minot, ND	45	36	63	51	31	19	11	16	26	47	59	67	75	74
8 SubArctic	Fairbanks, AK	32	21	50	29	8	-3	-4	3	18	37	55	65	67	62
8 SubArctic	Cambridge Bay	9	-3	33	14	-6	-18	-24	-24	-18	-2	19	39	51	46

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