Technical Bulletin

MA-MFLB 2023 *Protocol for Conducting Measurements of Radon and Radon Decay Products in Multifamily, School, Commercial, and Mixed-Use Buildings* (MAMF and MALB consolidated and updated)

Objective

The purpose of this document is to provide concerned parties with an overview of recent revisions to the ANSI/AARST Standards, *Protocol for Conducting Measurements of Radon and Radon Decay Products in Multifamily Buildings* (MAMF 2017) and *Protocol for Conducting Measurements of Radon and Radon Decay Products in Schools and Large Buildings* (MALB 2014). These standards were recently revised, with MAMF and MALB consolidated into a single standard.

Scope

This Technical Bulletin addresses recent revisions and consolidation of two ANSI/AARST radon measurement standards. This bulletin is relevant only to these latest revisions. It does not address revisions prior to the 2014-17 updates, nor does it address revisions to any other ANSI/AARST standards that may have been recently updated.

Background

The AARST Consortium "Committee for Radon Measurement Standards" is the body responsible for continual review and update of all ANSI/AARST radon measurement standards. This committee is made up of industry, construction and regulatory professionals, and all proposed revisions are also subject to public review and comment. During the years since the 2014 and 2017 publication of these standards, the committee has reviewed, revised, consolidated, and finalized publication of the standards identified in this document.

Historical Overview

The ANSI/AARST MALB standard was published in 2014, along with the sibling standard, MAMF, in 2017. The scope of effort entailed a complete review and update of previously published radon measurement standards. Harmonization began in 2020, using the same text for identical tasks within MAMF 2017 and MALB 2014. For needs of compliance assessment after the fact, informational content was moved from within the standard to the attached companion guidance. With many requirements being the same, the effort also sought consolidation of MAMF and MALB into a single standard.

1/21 Transitional Revisions

Prior to consolidation of MAMF and MFLB, harmonized versions were published as revisions to the existing documents. The focus included Sections 2 through 8. Most informational content was relocated to the Companion Guidance.

Section 2 (Before Testing)- Improvements for clarity in introductory 2 (Preparing for the Measurement) included harmonizing the title (Before You Test), as used in ANSI/AARST MAH (measurement in homes). Improved editorial clarity and correctness was sought for each provision. Differences between residential and commercial spaces were integrated. For instance, as applicable to MALB but not MAMF, requirements "where not occupied both day and night" were included. This type of integration allowed expansion of scope to "Mixed-Use Buildings". Relative to test devices, the use of radon decay product measurement devices is relegated to the applicable ANSI/AARST MAH standard and not repeated in Section 8. Quality control for test devices was moved to Section 2 (previously in Section 5). Requirements relative to keeping records of each dwelling/unit were enhanced. Required communication with property owners/managers were enhanced and emphasized.

Section 3 (Test Locations)- Ground-contact and upper-floor test locations were integrated for both residential and commercial spaces. New: For school and commercial spaces, the testing requirement is limited to locations that are occupied or intended to be occupied.

Section 4 (Test Conditions)- Test conditions that include closed-building protocol were moved to Section 4. For all measurement standards, this is more closely related to preparation prior to testing and applicable to most all test procedures.

Section 5 (Test Procedures and Options)- The editorial renditions are drawn more from MAMF than the older MALB. However, the recommended "evaluations of occupied versus unoccupied locations" from MALB are integrated. Post-mitigation test protocols were moved to Section 7.3.

Section 6 (Conducting the Test)- The revision now further elaborates on details specifically related to actions at the project location. Topics previously only addressed in MALB (Section 2) for complicated HVAC issues are integrated here.

Section 7 (Actions Based on Test Results)- Section 7.2 adds the requirement that where two test results at different times disagree on whether concentrations are below or above the action level, the higher test result shall be regarded as correct, unless further testing indicates otherwise.

Section 8 (Test Reports)- "Documentation, Protocols and Guidance" is now harmonized into Section 8. Clarity on summary report content was harmonized with MAMF, to provide simpler uniform reports, while still addressing complications and nuances. Initial tests that did not include testing 100% of ground-contact dwellings or units does not comply with this standard. Further testing to comply with this standard is therefore required, as previously required in MAMF Section 7.1.8.1 f.

Section 8.4 (Summary Report Attachments) includes additional elaborations and requirements for summary report attachments include reporting building operating conditions for comparing annual average and during the test. This reporting seeks to address concerns relative to concerns previously addressed in MAMF Section 7.1.8.4 b and c.

Hourly data from continuous radon monitors is now required to be provided in reports or provided to the client upon request. Records of client communications and details for disclosures to State or Federal authorities are also provided.

Normative Appendices- Normative Appendices were created for providing guidance and requirements for (a) Reporting Building Operating Procedures, (b) Evaluation of Occupied Versus Unoccupied Concentrations, (c) Elevated Radon in Upper Floors, and (d) National Certification/Listing Programs.

2023 Revisions

Due to the MAMF and MALB renditions published as 1/21 revisions being virtually identical, few edits required review prior to consolidation into a single standard. MA-MFLB 2023, includes the complete harmonization of ANSI/AARST radon measurement standards and editorial rendering more compliant with needs for compliance assessment.

Revisions were made to Section 2.4 and Normative Appendix D regarding Qualified Professionals and private proficiency programs.

Clarity was provided to Section 3.4 regarding large rooms requiring multiple devices.

Where closed-building conditions did not occur prior to the test, option 6.1.2 b, which allowed prolonging the test to achieve a valid test, was modified from a period of a minimum of 4 days to a period of not less than 72 hours.

Section 6.2 (Quality Control for Number of Valid Tests) was modified, both for clarification and relaxation of previous requirements. A flowchart was added on the following page to provide additional clarity on intended calculations.

Section 8.2.3 (Reliability of the Measurements) was clarified with more detail on reportable conditions that can impact reliability of test results.

Section 8.2.6 includes added language applicable to plans for operation, maintenance and monitoring (OM&M) to be provided where mitigation is installed or found in buildings addressed by this standard.

Summary

Conscientious attention to ensure that radon measurement standards reflect the most current methods is imperative in maintaining quality, relevant editions of these standards. This bulletin serves as a ready reference to the most recent updates.

Future Revisions

Future revisions to this standard shall be facilitated per the AARST Consortium “Committee for Radon Measurement Standards” normal process, which includes public review. Any such revisions shall be followed by a technical bulletin to address changes.

MA-MFLB
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MA-MFLB 2023

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

~~Introduction to Radon~~

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.

~~d) in multifamily structures, whether conducted for non-real estate purposes or when associated with a real estate transaction.~~

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).

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

Commented [GH1]: Moved to companion guidance

Commented [GH2]: The scope statements have changed to consolidate practices for both residential, schools, commercial and mixed-use buildings.

~~1.2.1 ***Single dwellings***~~
~~When testing a single dwelling in a multifamily building, see Section 4.6.3 for specific requirements.~~

~~1.2.2 ***Multi-use buildings***~~

~~When testing multi-use buildings that also contain educational or commercial facilities, see the most current version of ANSI/AARST MALB *"Protocols for Conducting Measurements of Radon and Radon Decay Products in Schools and Large Buildings"* for additional requirements in addition to, or as otherwise required by, local statutes.~~

~~**1.3 Limitations**~~

~~Suggested best practices to help ensure testing quality have been included, however:~~

~~1.3.1 These protocols do not address all detailed technical aspects of measurement device technology or quality assurance.~~

~~1.3.2 These protocols do not address measurement techniques to specifically identify radon sources such as radon concentrations in water supplies, the possession or handling of radioactive materials, or building materials.~~

~~1.3.3 These protocols do not address measurement techniques associated with building diagnostics.~~

~~**1.4 Radon Action Levels**~~

~~Countries worldwide have adopted Action Levels for radon exposures. Most are similar to the 4 pCi/L (148 Bq/m³) recommended by the United States Environmental Protection Agency (EPA). The Action Level cited should comply with guidance of the country, state or other local jurisdiction of authority where the test is being conducted.~~

~~**1.5 Conventions**~~

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.

~~**2.0 PREPARING FOR THE MEASUREMENT**~~

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?

Commented [GH3]: "When to test" has not changed for residential dwellings (multifamily), e.g., any time of year.

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*

Commented [GH4]: "When to test" criteria from MALB is different for schools and many commercial buildings not occupied at 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.

~~2.1 Devices and Personnel~~

2.3 Test Devices

~~2.1.1~~ 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 ~~having met minimum requirements established by~~:

~~a) the National Radon Proficiency Program (NRPP) or the National Radon Safety Board (NRSB); or~~

~~b) as required by local jurisdictions that have a program for evaluating and approving devices.~~

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.

~~2.1.2~~ 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. ~~It is recommended to consult the manufacturer to determine if the measurement system(s) or devices fulfill the requirements of the chosen testing strategy.~~

Note—Section CG-3 in the attached Companion Guidance provides descriptions of test devices.

~~2.1.3 Device Typss~~

2.3.3 *Test device types (defined)*

~~For the purpose of this document:~~

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 ~~can integrate, record and produce reviewable readings in time increments of 1 hour.~~ 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. ~~For continuous monitors, the first 4 hours of data may be discarded or incorporated into the result using system correction factors (EPA 402-R-92-004; EPA 1992). It is recommended to check with the manufacturer when evaluating hourly readings.~~

~~**8.0 RADON DECAY PRODUCT MEASUREMENTS**~~

2.3.4 *Radon Decay Products (RDP)*

Commented [GH5]: Device and personnel are dividing into to two headings.
Revisions in both sections now reflect ANSI Essential Requirements (modified in 2021) relative to how 3rd party certification programs are referenced.

Commented [GH6]: Seldom used RPD technology removed Section 8 with reference to MAH requirements (where the same text remains published).

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.

Commented [GH7]: Revisions now reflect ANSI Essential Requirements (modified in 2021) relative to how 3rd party certification programs are referenced.

~~2.1.5~~ 2.4.1 *Qualified measurement professionals*

~~All individuals conducting radon measurement activities in multifamily buildings shall be qualified for their apportioned task. For the purpose of this testing protocol, a "Qualified Measurement Professional" is defined as~~

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:

~~as established in certification requirements of the National Radon Proficiency Program (NRPP) or the National Radon Safety Board (NRSB); and~~

a) as established in certification requirements of ~~the National Radon Proficiency Program (NRPP) or the National Radon Safety Board (NRSB)~~ a national program that is compliant with requirements in Normative Appendix D; and

b) as required by local statute, state licensure or certification programs ~~where applicable~~ 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:

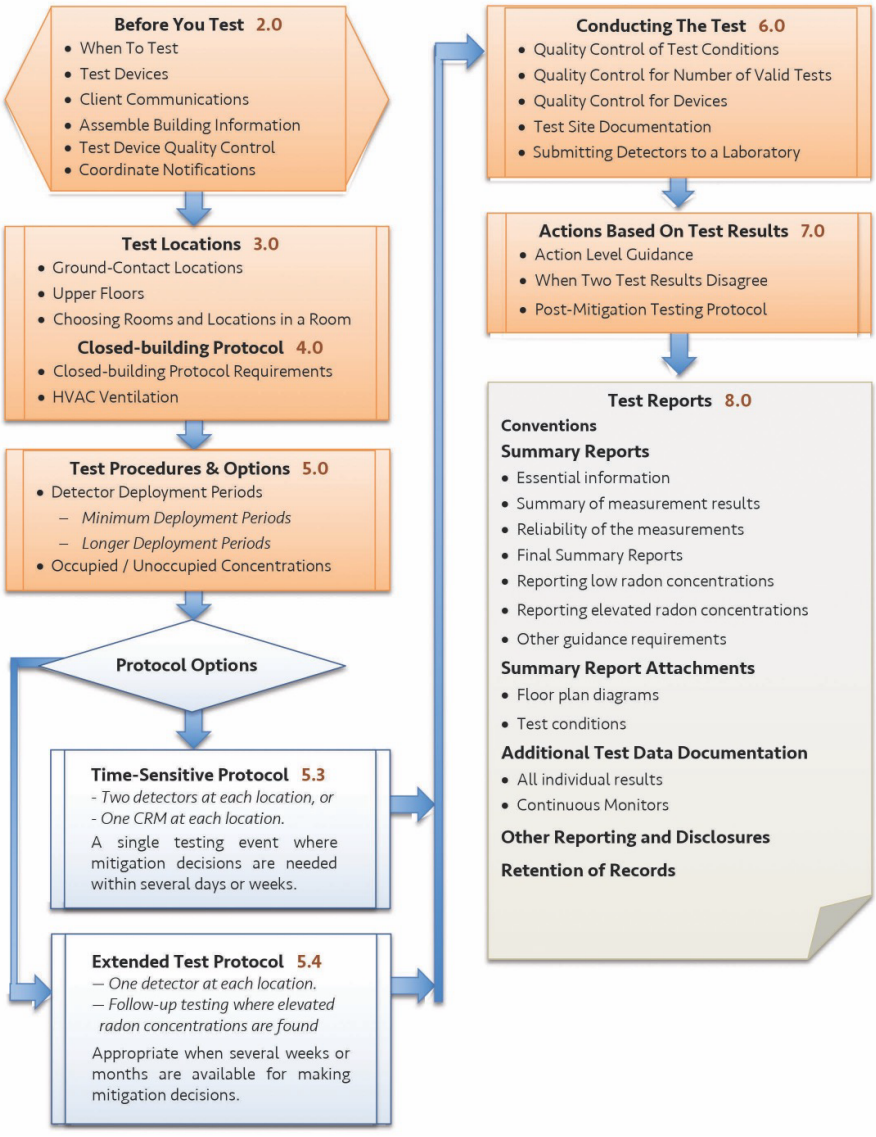
a) Create and present a written work plan specific to apportioned tasks and obtain evidence that the work plan is understood by all participants.

Note—Section CG-4 in the attached Companion Guidance provides guidance for work plan training; or

c) 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.

(informative) 2.5 Summary of Testing Procedures

Flowchart of procedures embodied in this standard



~~**2.2 Initial Client Interactions or Proposals**~~

~~2.2.1 ***Inform the client*** of required closed-building conditions and identify facilitating staff responsibilities associated with preparation for the testing. (See Exhibit 3.)~~

~~2.2.2 ***Client authorizations***~~

~~2.2.3 ***Advise the client about choices and limitations***~~

~~If the Extended Test Protocol is chosen for use under a Time-Sensitive situation, clients shall be informed in writing prior to testing that when test results from the first phase of testing (i.e., Step 1) indicate occupants may be exposed to elevated concentrations:~~

~~a) The test result from Steps 1 and 2 of this testing protocol are to be used for mitigation decisions and the nature of time-sensitive situations will often not permit long-term testing as an option for Step 2; and~~

~~b) Any untested ground-contact dwellings in the building shall be included in the second phase (Step 2) of testing. See Section 3.0 and Section 7.1.8.1 f.~~

~~4.6.2 ***Considerations for taking mitigation action prior to completing all test procedures***~~

~~When multiple test locations in close proximity to each other indicate elevated concentrations, recommendations to mitigate are permitted prior to completion of all planned test procedures. Due to the sensitive and sometimes challenging nature of such considerations, interim test data shall be reported or disclosed in a manner approved by the client and reported in accordance with a client's pre-established directives on disclosures of test data. (See Section 2.2.2.)~~

~~4.6.2.1 When data suggests that mitigation could be warranted, recommendations or response to inquiries shall include the following or equivalent statement: "Decisions on whether to mitigate are more fully informed once all testing is complete, and all information has been analyzed."~~

~~4.6.2.2 Retesting the mitigated areas: Prior to post-mitigation testing of the building, it is recommended to conduct diagnostic radon testing with short-term detectors placed in mitigated areas described in Section 4.5.6 to characterize mitigation effectiveness and its affect on adjoining areas of the building.~~

2.6 Client Communications

Commented [GH8]: Based on experiences since 2017, revisions seek to engage all parties in the quality control over coordination and test conditions.

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.

~~2.3~~ 2.7 Assemble Building Information

Commented [GH9]: Previous "instructive" style text is now rendered as minimum requirement statements to ensure clarity.

~~The following procedures are required:~~

~~2.3.1 ***Occupancy***~~

~~Determine which portions of the building are occupied and who will be responsible for closed-building conditions prior to and during the measurement period.~~

~~2.3.2 ***Diagrams***~~

~~Create or procure a floor plan diagram(s) that should identify all ground-contact dwellings and building foundation types such as slab-on-grade, basement and crawl space areas.~~

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.

~~2.3.3 ***Heating, cooling and ventilation systems (HVAC)***~~

~~Determine the nature of HVAC systems in each area of the building. If not already known, request that facilitating staff provide a written description of HVAC system designs in each area of the building. (See Exhibit 1 and Exhibit 3.)~~

~~Classify each of the following areas as a "**Unique Sector**":~~

~~a) Each area of the building where dwellings are served by individual but similar heating and cooling technology (as described in Exhibit 1 for Group 1 *Basic Heating and Cooling* or Group 2 *Multi-zone Systems*); and~~

~~b) Each ground-contact area of the building served by a central HVAC air handling system (as described in Exhibit 1 for Group 3 *Variable Air Distribution and/or Variable Outdoor Air Ventilation*).~~

~~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.~~

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*

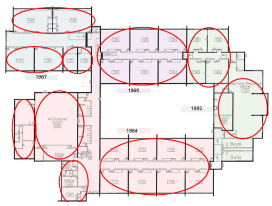
Each area served by a unique HVAC system shall be classified as a unique sector. When planning, or no later than when conducting measurements, actions are required to account for temporary conditions that can adversely affect reliability of the test result(s) where HVAC systems are designed with:

a) Variable outdoor air ventilation;

b) Variable air volume (VAV);

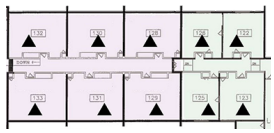
c) Return-air ducts laid in soil; and

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.



~~**5.0 QUALITY CONTROL IN TESTING MULTIFAMILY BUILDINGS**~~

~~Testing requires an overall quality assurance (QA) plan for tracking precision and bias that includes duplicate, blank and spiked measurements as stipulated in certification requirements of the AARST-NRPP or NRSB, or as required by the State Radon Office or other local jurisdiction where testing is conducted. See CG Section 3 of the Companion Guidance for general information. These requirements apply to both short-term and long-term devices. Evaluate and report these measurements as they represent an "early warning system" to identify problems.~~

Commented [GH10]: Because QC on test conditions is still also part of preparation for testing, it was removed as Section 5 and relocated to Section 2.

Inclusion of reference to ANSI/AARST MS-QA published in 2022 now provides holistic minimum practices. While text reflects what is required in MS-QA, it further elaborates on specifics not covered in MS-QA relative to large building projects. Improvements were also made relative to MAMF 2017 based on experience since published.

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.

~~5.3 Blanks~~

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 5.4~~ 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: ~~At a minimum of 50 test locations deployed, testers shall increase the number of blanks to nine detectors:~~
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. ~~These detectors serve both to evaluate the quality of the laboratory and to look for unexpected exposures that might result from shipping or handling;~~
2. Three *office blanks* (to reveal any unexpected exposures during storage) shall remain where detectors are stored and ~~then~~ be returned to the laboratory per normal procedure for the field detectors. ~~These detectors serve to reveal any unexpected exposures that might result from storage, and handling; and~~
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. ~~These detectors serve to reveal any unexpected exposures that might result onsite or from handling procedures~~.
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.

~~**Table 5.2**~~
~~**General Quality Control (QC) Measurements**~~

~~**Duplicate Measurements**~~ ~~(side-by-side detectors)~~	~~**Blank Measurements**~~ ~~(unexposed detectors)~~
~~The number of duplicate measurements shall be equal to or greater than 10% of all testing locations (or as specified by the test strategy chosen).~~	~~The number of blank measurements shall be equal to or greater than 5% of all testing locations.~~ ~~Field blanks (deployed at the testing location) are required. Allocating 3% field blanks and 2% lab transit/office blanks is recommended.~~

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.

~~**5.5 Spiked Measurements and Special Considerations for Large Deployments**~~

~~Spiked measurements for the testing project (or from the radon measurement professional's ongoing QC plan) shall also be included in the final report documentation in accordance with Section 7.3.~~

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.

~~**2.4 Prior Notifications**~~

~~The following steps shall be taken to help ensure *closed-building protocols* are maintained for Short-Term tests.~~

~~Informative note – Failure to comply with required conditions is most likely to occur when residents are not properly informed about the necessary test conditions.~~

~~2.4.1 ***Notice of radon testing to facilitating staff***~~

~~Once a testing activity has been confirmed, direct the property management team in a timely manner to distribute a ***notice of radon testing*** that is appropriate to inform and instruct facilitating staff. (See an example of this notice in Exhibit 4.) This notification shall include instructions for distributing notices to both tested and non-tested locations and site-specific or sample ***notices to occupants*** that reflect Exhibits 5 through 9. The notice to facilitating staff should also describe:~~

~~a) duties required of facilitating or maintenance staff that can include providing access and, if needed, adjustments to HVAC units; and~~

~~b) consequences for failure to achieve prior notification and closed-building conditions, which can include strained occupant relations and increased test costs.~~

~~2.4.2 ***Notices of radon testing for occupants***~~

~~Direct the property management team to distribute and post notices of radon testing for all occupants in all buildings being tested that reflect Exhibits 5, 6 and 7 no less than 24 hours prior to testing. It is recommended to verify prior to testing that facilitating staff have distributed the notices.~~

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.

Commented [GH11]: Based on experiences since 2017, requirements were revised to include notifications to both facilitating staff and occupants.

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 WHERE TO TEST (Protocol Requirements)**~~

3.0 TEST LOCATIONS

~~**3.1 Ground-Contact Dwellings**~~

~~Conduct a measurement in each ground-contact apartment, dwelling and other occupied units such as those used as office space. This means each unit that has floor(s) and/or wall(s) in contact with the ground or is over crawlspaces, utility tunnels or parking garages.~~

3.1 Ground-Contact Locations

Commented [GH12]: Revisions now include both residential and non-residential test locations. Previous "instructive" style text is now rendered as minimum requirement statements to ensure clarity.

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.

Test Locations

3.1.1 *Ground-contact dwellings*

~~Within each dwelling, test a room located in the lowest livable level that is in contact with the ground or above a crawlspace, utility tunnel or garage. If the lowest level is not currently used but could serve as a den, playroom, office, work area or an additional bedroom at some time in the future, conduct a test in this level~~

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.

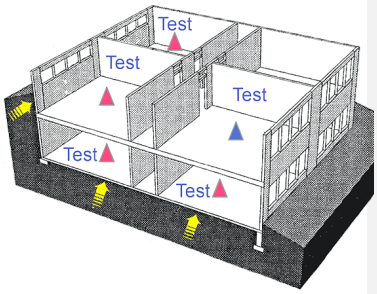


Figure 3 A
Basements and Walls

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.

Commented [GH13]: Significant change from MALB (non-residential): Only occupied or intended to be occupied locations are tested as the minimum requirement.

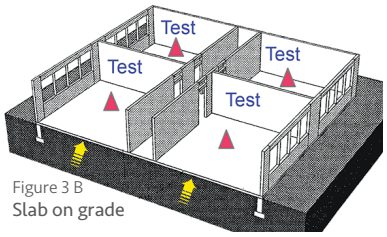


Figure 3 B
Slab on grade

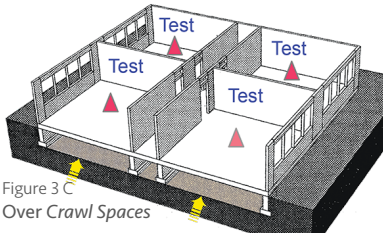


Figure 3 C
Over *Crawl Spaces*

~~**3.2 Other Ground-Contact Locations**~~

~~Also conduct a measurement in non-residential ground-contact rooms or areas (e.g. utility rooms, storage rooms, and maintenance rooms) that:~~

~~a) are occupiable with little or no modification; or~~

~~b) have air communication with occupiable areas by way of stairwells, elevator shafts or other unoccupied location that may serve as a pathway for radon into occupied spaces on upper floors~~

~~**3.4 Upper Floors**~~

~~On the upper floors, conduct a measurement in at least one apartment on each floor; include measurements in at least 10% of the dwellings on each of the higher floors. It is recommended that the upper floor test locations be selected so that units on one floor are not directly above or below units being tested on other floors.~~

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.

Commented [GH14]: Previous "instructive style" text is now rendered as minimum requirement statements to ensure clarity. Recommendations and other informational content are removed.

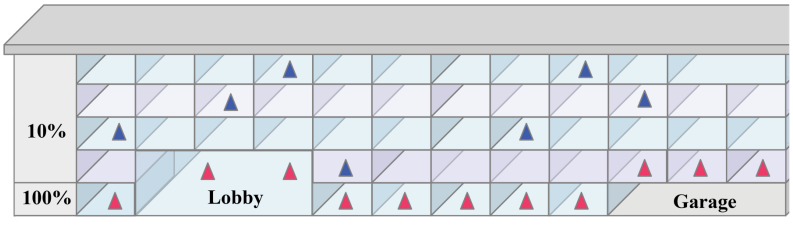


Figure 3 D
Upper floors

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.

~~**3.3 Large Rooms or Open Areas**~~

~~Place one detector every 2,000 square feet (186 m²).~~

3.4 Large Rooms or Open ~~Areas~~ 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 m²) of the room or open area and for any remaining portion of the area that is less than 2,000 square feet (186 m²).

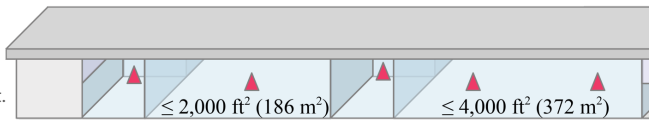


Figure 3 E
2,000 Sq. Ft.

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.

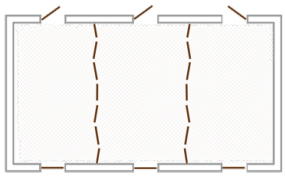


Figure 3 F Moveable walls

~~**3.5 Additional Protocols for Complex Heating, Cooling and Ventilation Systems**~~ ~~See Section 4.4.~~

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.

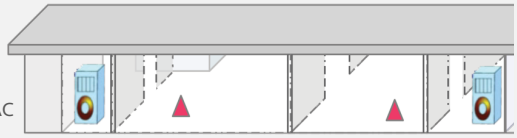


Figure 3 G
Multi-zone HVAC

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.

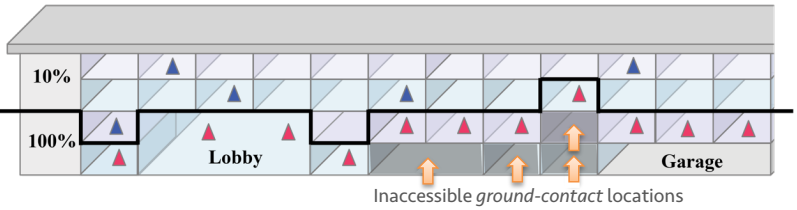


Figure 3 H
Inaccessible

Commented [GH15]: Harmonized with MALB

Commented [GH16]: Harmonized with MALB and more specific on large room sizing calculations.

Commented [GH17]: Harmonized with MALB (Informative)

Commented [GH18]: Addresses mixed-use buildings and harmonized with MALB

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.

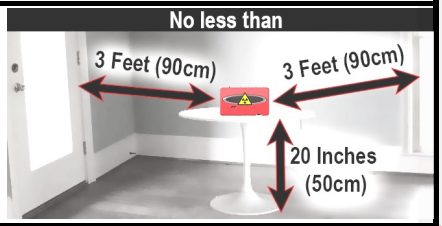
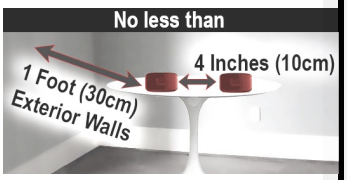
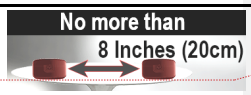
Commented [GH19]: Harmonized informational content deemed important for inclusion.

3.8 Choosing A ~~Test~~ 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

~~Place detectors within the general breathing zone and locate detectors no less than~~ **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	~~Select a position where the detectors will not be disturbed during the measurement period. Occupied areas are preferred, but choose a location where the detectors are not likely to be moved or have their performance altered during the test.~~ *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.
~~Place detectors where they are not influenced by other factors:~~	▪ ~~Do not place detectors~~ inside closets, cabinets, drawers, sumps, crawl spaces or nooks in the building foundation. ▪ ~~Do not place detectors near~~ heat sources, such as on appliances, radiators, fireplaces or in direct sunlight.

Commented [GH20]: Previous "instructive" style text is now rendered as minimum requirement statements to ensure clarity.

Commented [GH21]: Consolidated into one location: Clarity relative to both QA control measurements and when implementing time sensitive testing (passive devices side-by-side)

Detectors shall NOT be located:	▪ ~~Do not place detectors~~ near drafts caused by fans or heating and air conditioning vents or within enclosed areas of high air velocity such as mechanical/furnace closets.
	▪ ~~Do not place detectors~~ 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.

~~**6.0 CONDITIONS REQUIRED BEFORE AND DURING THE TEST**~~

~~**6.1 Closed-building Protocol**~~

4.0 TEST CONDITIONS REQUIRED

~~6.2.2 ***Closed-building conditions when initiating the test***~~

~~If, at the initiation of the test, the radon measurement professional discovers or observes that closed-building conditions have not been maintained, one of the following options is required:~~

~~a) The radon test can be postponed until at least 12 hours of closed-building conditions have been maintained prior to the test;~~

~~b) The radon test period can be extended to 4 days or more with an appropriate detector after closed-building conditions are initiated;~~

~~c) For continuous monitors, detector features or methods may be used to obtain an average reading that represents at least 48 hours of contiguous data collected after at least 12 hours of closed-building conditions have been maintained (e.g. a test may be run for 60 hours, the first 12 hours discarded and the last 48 averaged manually).~~

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.

Commented [GH22]: Because QC on test conditions must also be considered for test scheduling, it was moved from Section 6 to Section 4.

A significant change was harmonized across measurement standards. Example: The radon test period can be extended to not less than 72 hours ~~4 days or more~~ after closed-building conditions are initiated;

~~Table 6.0-A~~ 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)

~~**Window Air Conditioners and Unit Ventilators**~~ ~~**Window fans, whole building ventilation fans or systems**~~ ~~that temporarily bring air into or out of the building for seasonal energy savings or comfort.~~ Systems that temporarily ventilate with outdoor air for seasonal comfort or energy savings	~~**Operate in recirculation mode only**~~ ~~*with outside air dampers closed.*~~ ~~**Do not operate**~~ 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,** including those that burn solid, liquid or gas fuels, unless they are the primary/normal sources of heat for the building~~ Fireplaces (that burn solid, liquid or gas fuels unless a primary/normal source of heat for the building)	Do not operate

Commented [GH23]: Harmonized with MALB

~~**4.4 Additional Protocols for Complex HVAC Systems**~~

~~**Table 4.4 Additional Protocols for Complex HVAC**~~

~~4.4.7 *Group 3 HVAC – Alternate Option 2*~~

4.2 HVAC Ventilation

Commented [GH24]: Harmonized from Table 4.4 and MALB. Previous "instructive" style text is now rendered as minimum requirement statements.

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 6.0-C~~ 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 6.0-C~~ 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

~~4.0~~ 5.0 TESTING PROCEDURES AND OPTIONS

~~**4.1 Detector Deployment Periods**~~

5.1 Test Deployment Periods

~~4.1.1 ***Test all areas*** during the same time period (days or phase)~~

~~7.1.8.1 **Elevated Radon**~~

~~when initial testing strategy did not include all ground-contact dwellings and/or upper floors as prescribed in Section 3. … F) Repeat testing procedures to include all ground-contact areas and dwellings, and not less than 10% of the dwellings on each upper floor in all buildings associated with the testing survey. When mitigation actions need to begin quickly, conduct this testing no later than during the initial post-mitigation testing.~~

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.

~~4.1.2 ***Short-term testing***~~

~~For short-term tests, detectors shall be deployed for two to 90 days under closed-building protocol conditions in accordance with Section 6. Deployment periods should optimally collect at least 48 hours of valid sampling time. Deployment periods shall not be less than 46 hours.~~

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.

Commented [GH25]: Harmonized with MALB with consideration of mixed-use buildings.

~~4.1.3 ***Long-term testing***~~

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.

Commented [GH26]: Previous "instructive" style text is now rendered as minimum requirement statements. Clarity added relative to seasonal evaluations and that longer test periods do not always provide a better idea of annual average exposure.

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.

Commented [GH27]: Harmonized with MALB with consideration of mixed-use buildings.

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:*

~~**4.3 Time-Sensitive Testing Protocol**~~

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 4.3~~ 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.	

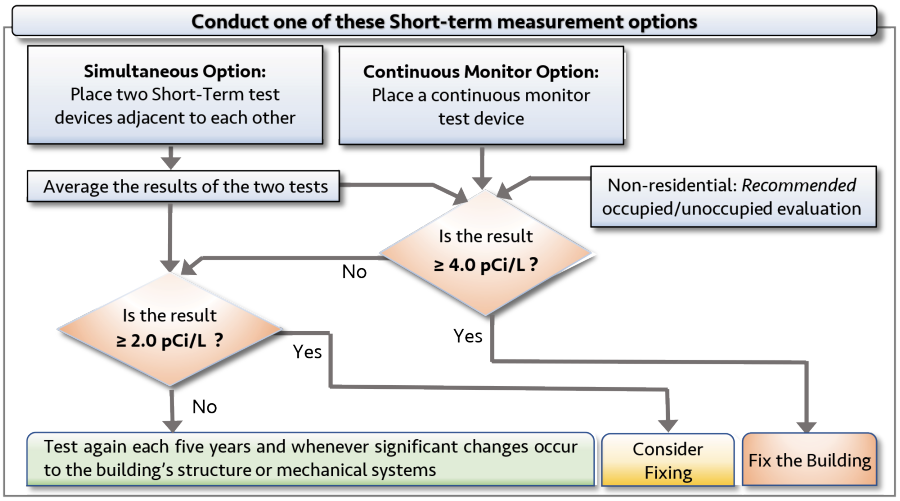
[1] Where evaluations of occupied versus unoccupied concentrations have been conducted in accordance with Section 5.2, report recommendations shall account for radon exposures indicated by the evaluation.

[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.

Commented [GH28]: Harmonized with MALB with consideration of mixed-use buildings.

Commented [GH29]: Relative MALB where occupied hourly measurements may have been a reason to fix or not fix the building

~~Figure 4.3~~ Figure 5.3 **Time-Sensitive Testing Option Flowchart**



~~4.2 Extended Testing Protocol~~

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 4.2~~ 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.

~~2.2.3 *Advise the client about choices and limitations*~~

~~If the Extended Test Protocol is chosen for use under a Time-Sensitive situation, clients shall be informed in writing prior to testing that when test results from the first phase of testing (i.e., Step 1) indicate occupants may be exposed to elevated concentrations:~~

~~a) The test result from Steps 1 and 2 of this testing protocol are to be used for mitigation decisions and the nature of time-sensitive situations will often not permit long-term testing as an option for Step 2; and~~

~~b) Any untested ground-contact dwellings in the building shall be included in the second phase (Step 2) of testing. See Section 3.0 and Section 7.1.8.1 f.~~

Commented [GH30]: While sentence phrasing is improved, changes harmonize with MALB.

Commented [GH31]: Relative MALB where occupied hourly measurements may have been a reason to fix or not fix the building

Commented [GH32]: Adds a limit for time period between initial tests and completing the entire procedure.

Commented [GH33]: Relative MALB where occupied hourly measurements may have been a reason to fix or not fix the building

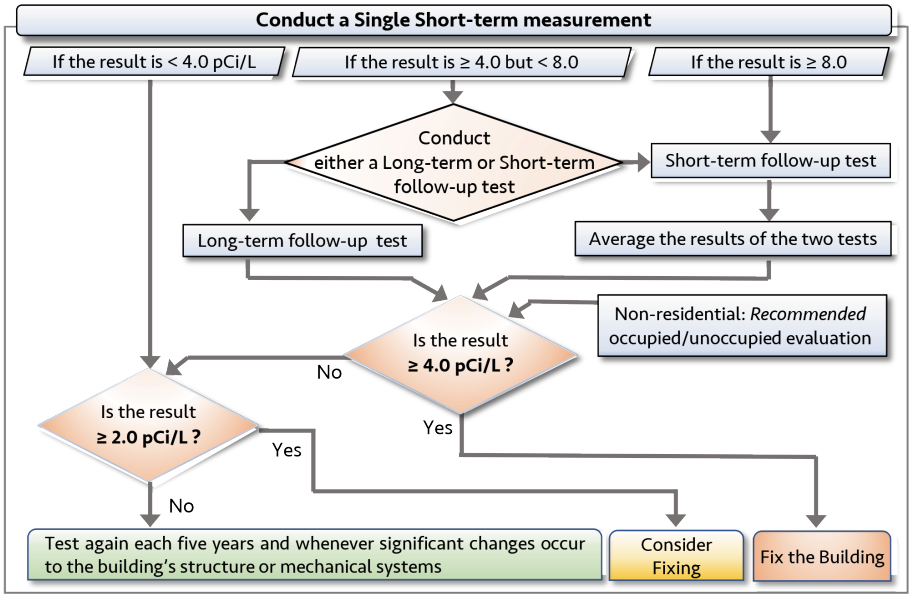
5.4.1 *Client Advisory required*

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 4.2~~ Figure 5.4 **Extended Testing Option Flowchart**



~~**4.4 Additional Protocols for Complex HVAC Systems**~~

~~4.4.7 *Group 3 HVAC – Alternate Option 2*~~

~~Place both a short-term detector and a long-term detector simultaneously in each test location for initial testing. Conduct QC for each detector type in accordance with Section 4.2.1.1. Deploy long-term test devices for the following time periods and use only the results from long-term detectors for decisions to mitigate:~~

~~a) If the highest short-term test result is 8 pCi/L (296 Bq/m³) or greater, leave long-term detectors in place for at least 91 days;~~

~~b) If the highest short-term test result is 4.0 pCi/L (148 Bq/m³) or greater but less than 8 pCi/L (296 Bq/m³), leave long-term detectors in place for at least 180 days; and~~

~~c) If the highest short-term test result is less than 4.0 pCi/L (148 Bq/m³), leave long-term detectors in place for one year.~~

Commented [GH34]: Test Alternative Option 2 with simultaneous placement of both long-and short-term devices was removed because it was determined not practical and never used.

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

Commented [GH35]: Allowance added for starting with long-term testing.

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.

~~4.6.3 *Testing single dwellings*~~

5.5 Testing A Single Room or Dwelling

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

~~4.5.1 *New construction*~~

~~Buildings constructed with radon resistant new construction or rough-in systems that have not been activated with a fan shall be tested in accordance with Sections 4.2, 4.3 or 4.4.~~

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

~~**6.2 Test Condition Verification**~~

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.

~~6.2.3~~ 6.1.1 *Where closed-building conditions cannot be maintained*

~~Do not conduct short-term tests~~ Tests shall not be conducted if closed building conditions, as required in Section ~~6~~ 4, cannot be ~~reasonably~~ maintained across the test period for tests lasting up to 90 days.

Commented [GH36]: Previous "instructive" style text is now rendered as minimum requirement statements.

~~6.2.3.1~~ 6.1.2 *Where closed-building conditions did not occur prior to the test*

~~If, at the initiation of the test, the radon measurement professional discovers or observes that closed-building conditions have not been maintained, one of the following options is required~~

Where closed-building conditions were not maintained for twelve hours prior to deployment, as required in Section ~~6~~ 4, the radon testing shall be conducted with one of the following options:

a) The ~~radon test can be~~ testing is postponed until at least 12 hours of closed-building conditions have been maintained prior to initiating the test; or

b) The ~~radon~~ test period ~~can be extended to 4 days or more with an appropriate detector~~ extends not less than 72 hours after closed-building conditions are initiated; or

Commented [GH37]: Amended in 2022

c) ~~For continuous monitors, detector features or methods may be used to obtain an average reading that represents at least 48 hours of contiguous data collected after at least 12 hours of closed-building conditions have been maintained (e.g. a test may be run for 60 hours, the first 12 hours discarded and the last 48 averaged manually~~

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.

~~4.6.3 ***Testing single dwellings***~~

~~Tests conducted in only one or a portion of individual dwellings that are above or below adjoining units require closed-building conditions for all portions of the building. Such tests conducted without closed-building compliance in all adjoined dwellings unit(s), including those directly above and below the tested dwellings(s), shall not be considered valid measurements.~~

~~Exception: When testing a single dwelling in a multifamily building that is not above or below another attached dwelling, it shall be permitted to conduct the test in accordance with the most current version of ANSI/AARST **MAH** "Protocols for Conducting Measurements of Radon and Radon Decay Products in Homes" in addition to, or as otherwise required by, local statutes.~~

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.

~~6.2.3.1 Occupant health and safety~~

6.1.5 *Where closed conditions pose a health hazard*

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

~~a) The client should be informed and provided with a recommendation to test at a time when closed-building conditions can be reasonably achieved; and~~

~~b) Summary reports shall prominently identify any short-term test location conducted in absence of closed-building conditions as invalid and include a recommendation to test at a time when closed-building conditions can be reasonably achieved.~~

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*

~~6.2 A test company's minimum requirements for verifying test conditions shall be fulfilled by the following:~~

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~~ing~~ the person responsible for building operation ~~and~~ of the required test conditions;

b) ~~c) Posting a *Radon Test in Progress* notification form. (See examples in Section Exhibit 7);~~ 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) ~~b)~~ Obtain~~ing~~ or attempt~~ing~~ to obtain a signed ~~noninterference agreement (See Exhibits 8 and 9)~~ 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.

Commented [GH38]: Revised to provide new and clear minimums on closed building conditions relative to testing upper floors.

Commented [GH39]: Newly added in consideration of retesting only where one or more locations did not have closed building conditions.

Commented [GH40]: Previous "instructive" style text is now rendered as minimum requirement statements.

Commented [GH41]: Previous "instructive" style text is now rendered as minimum requirement statements.

~~d) Conducting a visual inspection of the dwelling upon placement to assure all closed-building conditions are intact;~~

~~e) Conducting a visual inspection of the dwelling upon retrieval of the detector including:~~

~~i Maintenance of closed-building conditions,~~

~~ii Changes in the detector placement, and~~

~~iii The condition of all tamper seals.~~

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 ~~radon~~ measurement professional is not ~~responsible for~~ required to inspect~~ing~~ for closed-building conditions during the 12-hour period before the start of the test or between placement and retrieval of the detectors.

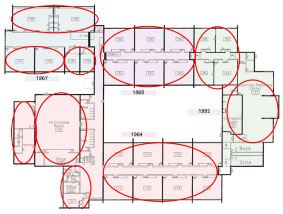
6.1.7 *Visual Inspections*

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.

Commented [GH42]: Elaborations with additional clarity from MALB involving complex HVAC configurations.

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

~~7.1.9 ***Observance of extenuating factors***~~

~~The summary of measurement results shall describe locations that were intended to be tested but did not result in valid measurements or temporary conditions were observed that may affect mitigation decisions.~~

~~Informative notes – It is not uncommon when testing multiple dwellings that test efforts will encounter a small number of locations with missing detectors upon retrieval, denied access or inappropriate test conditions. Such incidences do not invalidate other measurements when considering the needs of mitigation. However, the narrative should recommend retesting a building:~~

~~a) if the number of valid test measurements in the building is inadequate to reasonably characterize radon concentrations for the building; or~~

~~b) if the number of locations in a building where required closed-building conditions were compromised is sufficient to cast doubt on the validity of all measurements in that building.~~

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%

Commented [GH43]: New clarity was provided on an adequate number of test devices required to characterize radon concentrations in a building.

Criteria for measurements observed for both the property being tested and the building were used to set limits. Limits published for MAMF 2017 Rev. 1/21 used the Earth study where if all tests in the building were < 2 pCi/L, missing 25% of valid test locations still provided 90-95% confidence of properly characterizing the building.

Commented [GH44]: Subsequent to MAMF 2017 Rev. 1/21, committee members experienced push-back that this was too strict.

Using concepts in the footnoted[6] document, attributes were introduced into calculations.
Based on criteria cited in 6.2 a), for both existing measurements at the property being tested and the building being tested, missing <33% of valid test locations was deemed to have similar confidence of properly characterizing the building.

Based on criteria cited in 6.2 b), missing <25% of valid test locations was deemed to have similar confidence of properly characterizing the building.

[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).

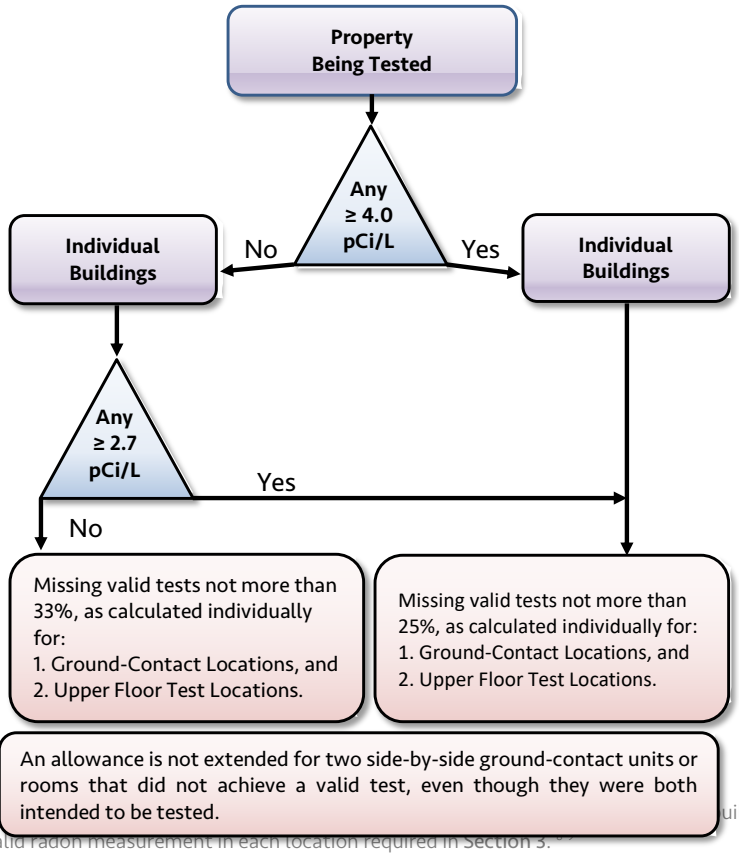
Note—This allowance observes that the parcel of land where buildings reside has been shown to produce radon in soil sufficient to lead to elevated indoor radon concentrations.

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.

Figure 6.2

Quality Control Flowchart for Number of Valid Tests

Commented [GH45]: Restating 6.2 limits



Informative a uilding 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.

Commented [GH46]: Restating field activities for test device QC

Commented [GH47]: Restating field activities documenting test locations

Commented [GH48]: Clarifying field activities for test device tracking

Commented [GH49]: Clarifying field activities relative to lab report logistics and data needed

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.

~~4.6.1 ***Limits on disagreement between collocated or duplicate test results***~~

~~Some variation between the results of collocated or duplicate detectors is expected. If test results from two collocated detectors are either both above the action level or both below the action level, use the average of the test results to determine if this location needs mitigation.~~

~~**Special consideration is required** when one test result is above the action level (e.g., 4.0 pCi/L or greater) and the other test result is below the action level:~~

~~a) If the higher result for collocated (or duplicate) detectors is less than twice the lower result, use the average of the test results to determine if this location needs mitigation.~~

~~b) If the higher result is twice or more the lower result, **a repeat test for this location is required** in order to obtain a valid measurement.~~

7.2 When Two Test Results Disagree

Commented [GH50]: Harmonized with MAH) with clarity on what is acceptable and what is not acceptable, including for results from tests that are taken at different times.

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.

~~**4.5 Post-Mitigation Testing Protocols**~~

7.3 Post-Mitigation Testing Protocol

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

~~4.5.2 ***Systems operational (active radon reduction systems,*** 4.5.3 ***Initial post-mitigation testing (active systems),*** 4.5.4 ***Subsequent post-mitigation testing.*** 4.5.5 ***QC***~~

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*

~~7.1.8.2 **Initial Post-Mitigation**~~

~~a) ***Test locations after mitigation:***~~

~~In all buildings that demonstrated elevated radon concentrations in ground-contact areas during the initial testing phase(s) and evaluations, post-mitigation testing is required to include all ground-contact areas and dwellings, and not less than 10% of the dwellings on each upper floor.~~

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

Commented [GH51]: Added is the 12 hr closed building protocol prior to valid test data.

QC is now inherent to all testing per MS-QA required.

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.

~~4.5.6 ***Diagnostic radon testing***~~

~~Diagnostic testing is not sufficient to verify mitigation effectiveness~~

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.

~~7.0 DOCUMENTATION, PROTOCOLS AND GUIDANCE~~ **8.0 TEST REPORTS**

8.1 Conventions

~~7.1.6 *Conventions*~~

~~Radon gas results reported in picocuries per liter (pCi/L) shall be reported to only one figure after the decimal (e.g., 3.2 pCi/L). If, for example, the average of two measurements produces a result of 3.95 pCi/L, standard mathematical rules should be followed and such average shall be reported as 4.0 pCi/L.~~

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.

~~7.1.7 *Duplicate and collocated detector reporting*~~

~~When duplicate or collocated tests were conducted at a location, the average of those results shall be reported as the location's test result for that phase (e.g., Step 1 or Step 2) of testing. See Section 4.6.1 for special considerations.~~

~~Measurements made in separate locations shall NOT be averaged. Detectors located more than 8 inches from each other shall be considered in a separate location. They shall be reported individually.~~

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.

~~7.1 A Summary Report~~

~~The following information shall be provided in a prominent location on a summary report~~

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 and contact information for the organization providing services to conduct the test.~~

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 address of the building(s) tested, including zip code.~~

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 licens~~ing~~ number(s) of the service or organization(s) used to analyze detectors shall be provided;

e) Radon Information Sources

~~7.1.5 ***Radon information sources*:~~

~~a) Include contact information of the State Radon Office where the test is conducted or other local authority; and~~
~~b) Include information for obtaining federal or state guidance documents.~~

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)

~~7.1.3 ***The Measurement Professional's identification and certification of quality practices*:~~

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*

~~*7.1.8 A summary of: Test results, Recommended actions and Additional protocols*~~

~~Identify locations where test results meet or exceed the action level in accordance with health information and action-level information established in federal guidance or as required by the state or other jurisdiction of authority where the test is being conducted.~~

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

~~7.1.8.1 **Elevated Radon**~~

~~e) The test results indicate needs for an evaluation of radon sources other than soil, such as building materials or water supplies. Diagnostic radon testing and evaluation of soil gas transport mechanisms are commonly employed when making this evaluation.~~

~~7.1.8.2 **Initial Post-Mitigation Testing**~~

~~b) ***Test locations after mitigating sources other than soil gas:***~~

~~Conduct post-mitigation testing sufficient to characterize the initial status of mitigation effectiveness for all affected dwellings or areas.~~

~~d) In addition, conduct testing in all dwellings on the floor where elevated concentrations were found and in all vertically adjoining dwellings.~~

Commented [GH52]: Previous "instructive" style text is now rendered as minimum requirement statements.

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

~~7.3.3 ***Quality Assurance summary statement***~~

~~A summary statement regarding QC measurements directly associated with the testing project shall be provided that summarizes:~~

~~a) the overall degree of agreement for the quality control measurements observed as compared to control tolerances established in national standards (e.g., EPA Guidance on Quality Assurance [402-R-95-012, October 1997]); and~~

~~b) a description, if deemed needed, for QC measurements that fell outside of control perimeters established in national standards.~~

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).

Commented [GH53]: Citing newer MS-QA standard.

b) Temporary conditions

~~**7.7 Report Temporary Conditions**~~

~~Include a description of observed building conditions or other factors that are temporary in nature and may affect the measurement results. The report shall also document for the client that the test may not reflect the client's risk from radon if such conditions are altered from the condition existing during the test period.~~

~~7.7.1 ***Temporary conditions to report include:***~~

~~a) units that were tested but were vacant during the test period;~~

~~b) the condition of any temporary radon mitigation methods that are not permanent installations;~~

~~c) the condition (i.e., open/closed) of any permanent vents such as crawlspace vents;~~

~~d) HVAC operations that are inconsistent with normal operating conditions;~~

~~e) the condition of active or passive air supplies to the building or to combustive appliances; and~~

~~f) if a permanently installed ventilation system, such as a heat recovery ventilator or air-to-air heat exchanger, is active during the test but ready access exists for deactivation, or it functions intermittently.~~

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;

Commented [GH54]: Previous "instructive" style text is now rendered as minimum requirement statements.

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

~~**7.5 Report Noninterference Controls**~~

~~**7.6 Report Protocol Deviations**~~

~~Include a description of any observed deviations from appropriate measurement procedures that may affect the measurement results including:~~

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)

~~7.1.10 *Mitigation system status*~~

~~If applicable, a statement shall be provided in the summary report to identify:~~

~~a) if a mitigation system was observed in a building; and~~

~~b) additional observations, if any.~~

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

Commented [GH55]: Previous "instructive" style text is now rendered as minimum requirement statements.

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*

~~The summary report shall include statements from the following tables, or their equivalent, for each of the directives that apply to each test location as well as the entire building.~~

~~These tables include:~~

~~a) additional protocols for minimum practices required by this standard; and~~

~~b) appropriate guidance related to radon testing and mitigation.~~

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.

~~7.1.8.4 Low Concentrations~~ 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

~~7.1.8.2 **Initial Post-Mitigation Testing**~~

~~c) ***Seasonal verification:***~~

~~It is recommended to repeat testing of mitigated buildings under heating season conditions no later than within the first year after mitigation.~~

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.

~~7.1.8.1 Elevated Radon~~

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.

~~7.1.8.1 Elevated Radon~~ 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.

~~7.1.8.2 Initial Post-Mitigation Testing~~

~~b) *Test locations after mitigation:*~~

~~In all buildings that demonstrated elevated radon concentrations in ground-contact areas during the initial testing phase(s) and evaluations, post-mitigation testing is required to include all ground-contact areas and dwellings, and not less than 10% of the dwellings on each upper floor.~~

— 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.

~~7.1.8.1 Elevated Radon~~

~~d) If testing at any time indicates concentrations above the action level, it is recommended to conduct evaluations of the mitigation systems(s), corrections and further testing until testing indicates radon concentrations have been mitigated to below the action level.~~

— 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

Commented [GH56]: For large buildings, the following text was removed due to uncontrollable time constraints.
7.1.8.1 → **Elevated Radon**
a) Initiate short-term radon testing no sooner than 24 hours after a mitigation system is operational and within 30 days after installation of the system(s).

Commented [GH57]: Provides validation criteria for recommending mitigation prior to completing all testing steps.

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.

~~4.5.6 ***Diagnostic radon testing***~~

~~Diagnostic testing is not sufficient to verify mitigation effectiveness~~

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

~~7.1.8.2 **Initial Post-Mitigation**~~

~~d) ***Passive, pressurization or dilution mitigation methods:***~~

~~• Mitigation is not complete for mitigation systems that rely on passive methods or active pressurization or dilution of indoor building air until post-mitigation testing procedures are repeated to verify that effectiveness is retained for both the heating season and the cooling season.~~

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.

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

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

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

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

~~1. recommend retesting every 2 years to verify continued *mitigation* system effectiveness, and~~

~~2. include guidance required in Section 8.2.5 whenever reporting low test results.~~

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.

Commented [GH58]: As radon in upper floors have been known to sometimes result in from building materials rather than soil, it is recognized that mitigation methods required may be unique and expensive.

This Section and Normative Appendix C were created in response to this concern.

~~7.1.8.3 **Subsequent Post-Mitigation Retests**~~
~~Include these advisories on frequency of retesting~~

- ~~Conduct post-mitigation tests every 2 years in all previously tested locations for mitigated areas to ensure that the system remains effective.~~
- ~~Retest all building(s) at least every 5 years and in conjunction with any sale of a building. Conduct this testing with procedures to include testing of all ground-contact areas and dwellings, and not less than 10% of the dwellings on each upper floor.~~

And portions of ~~7.1.8.4 **Low Concentrations (e.g., < 4 pCi/L)**~~

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;

Commented [GH59]: This section resulted from harmonizing with MALB

- ✓ 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.

Commented [GH60]: Harmonized with MAH relative to requirements in ISO 17025 for reports.

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.

Commented [GH61]: Harmonized with MAH and other standards

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.

Commented [GH62]: Harmonized with content and guidance herein

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.

Commented [GH63]: Harmonized with content herein

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.

Commented [GH64]: Harmonized with content herein

8.3 Summary Report Attachments

~~**7.2 In Addition to the Summary Report**~~

~~The report shall contain sufficient information to allow clients to evaluate the data, interpretations and also make comparisons to any previous or future tests in accordance with Sections 7.3 through 7.7~~

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*

~~7.4.3 *Locations*~~

~~Include documentation of the locations of all detectors deployed. It is advisable to diagram the test area noting the location of the detector and measurement results. Specific details are recommended for greater clarity during review of test data that may also include supplemental photographic records. (See Exhibit 2 for an example *floor-plan log*.)~~

~~7.4.3.1 In addition, include documentation regarding:~~

~~a) locations that should have been tested but were not tested and include an explanation of the reasons why tests were not conducted;~~
~~b) missing, lost, non-retrievable or otherwise invalidated detectors;~~
~~c) identification of locations tested that are not expected to be occupiable (e.g., furnace or laundry rooms); and~~
~~d) identification of units tested that could be occupied with minor renovation.~~

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*

~~7.1.9 ***Observance of extenuating factors***~~

~~7.1.9.1 When tests are conducted in a location or building after the initial test phase, test conditions that affect building operation such as outdoor seasonal weather should reflect average building operating conditions across the year or be similar to the previous testing. If different weather and/or building operating conditions occur, such conditions shall be reported for consideration and comparison with previous test reports for the property.~~

~~7.7.2 ***Report weather conditions***~~

~~To allow clients to evaluate test data and also make comparisons to any previous or future tests, sufficient information regarding weather conditions as they existed 12 hours prior to and during the test period shall be provided, including:~~

~~a) outdoor conditions:~~
~~– minimum, maximum and average outdoor temperature~~
~~– precipitation, humidity, wind~~
~~– ground cover such as snow, ice or saturated soil; and~~
~~b) conditions of unusually severe storms or periods of unusually high winds.~~

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*

~~7.3.5 ***Existing tests***~~
~~Include observation of any other reports or test data acquired from residents who have independently tested. Observations regarding placement locations and test conditions should be included for comparison.~~

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

~~**7.2 In Addition to the Summary Report**~~

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*

~~**7.3 Report All Individual Valid Measurement Results**~~

~~7.3.1 ***Report QC measurements***~~
~~All individual QC measurements directly associated with the testing project shall also be reported and should be annotated as such (e.g., "B" for blanks, "D" for duplicates, "S" for spikes).~~

~~7.4.1 ***Dates/Times***~~
~~Include the appropriate start and stop dates and times of the measurement exposure period for each detector.~~

~~7.4.2 ***Detector description and identification***~~
~~include a description of the devices and detectors used including identification/serial numbers.~~

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*

~~7.3.2 ***When using continuous radon monitors:***~~

~~a) Hourly readings shall be included.~~

~~b) The calibration date of continuous monitor(s) shall be included on the test reports. Proof of calibration shall be made available upon request.~~

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.

Commented [GH65]: Latitude for providing hourly data only upon client request and consolidating other related CRM requirements into one location.

Commented [GH66]: Reporting certain communications to disclose that the communications were sent.

Commented [GH67]: Clarifying reporting and disclosures required by various authorities having jurisdiction.

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

~~**7.8 Retention of Records**~~

~~The detector placement log and supporting documentation shall be maintained for at least 6 years after testing. Sufficient information about each measurement shall be recorded in this log to allow for future comparisons, interpretations and reporting to residence managers.~~

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**	A unit of concentration of radioactivity corresponding to 0.037 decays per second

	(pCi/L)	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.

NORMATIVE APPENDIX A

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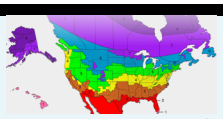
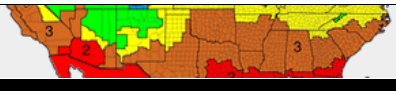
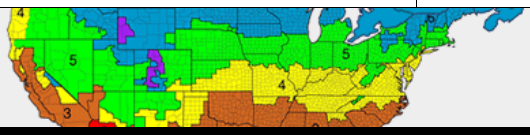
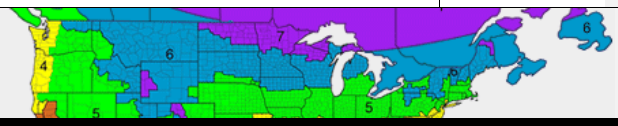
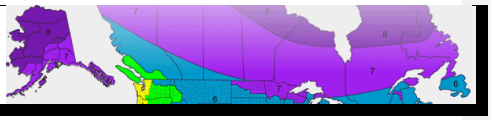
REPORTING REQUIREMENTS FOR BUILDING OPERATING CONDITIONS

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
n	1 Very Hot	Southern Florida and Hawaii	Miami 76˚ F (24 C)
n	2 Hot	Florida, New Orleans, Houston, Mexico	New Orleans 68˚ F (20 C)
			
n	3 Warm	North Carolina to Southern California	Atlanta 61˚ F (16 C)
			
n	4 Mixed	NYC, PA, NJ, VA, KT, TN KS, MO, Seattle WA, and Portland OR.	Kansas City 54˚ F (12 C)
n	5 Cool	MA, NY, OH, MI, IN, IL, IA, NE, CO, UT and NV.	Chicago 49˚ F (9 C)
			
n	6 Cold	ME, NH, VT, WI, MN, ND, WY, SD and ND.	Montreal 43˚ F (6 C)
			
n	7 Very Cold	Minot, ND; Anchorage, AK; Winnipeg, Canada	Winnipeg 36˚ F (2 C)
n	8 Subarctic	Fairbanks Alaska; Cambridge Bay, Canada	Fairbanks 26 ˚ F (-3 C)



A-1.0 Reporting Operating Condition Comparisons

Commented [GH69]: Elaborated upon to require disclosure of test conditions that may influence test results compared to annual average test conditions.

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 * Required data
Comparison of building operating conditions

		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.

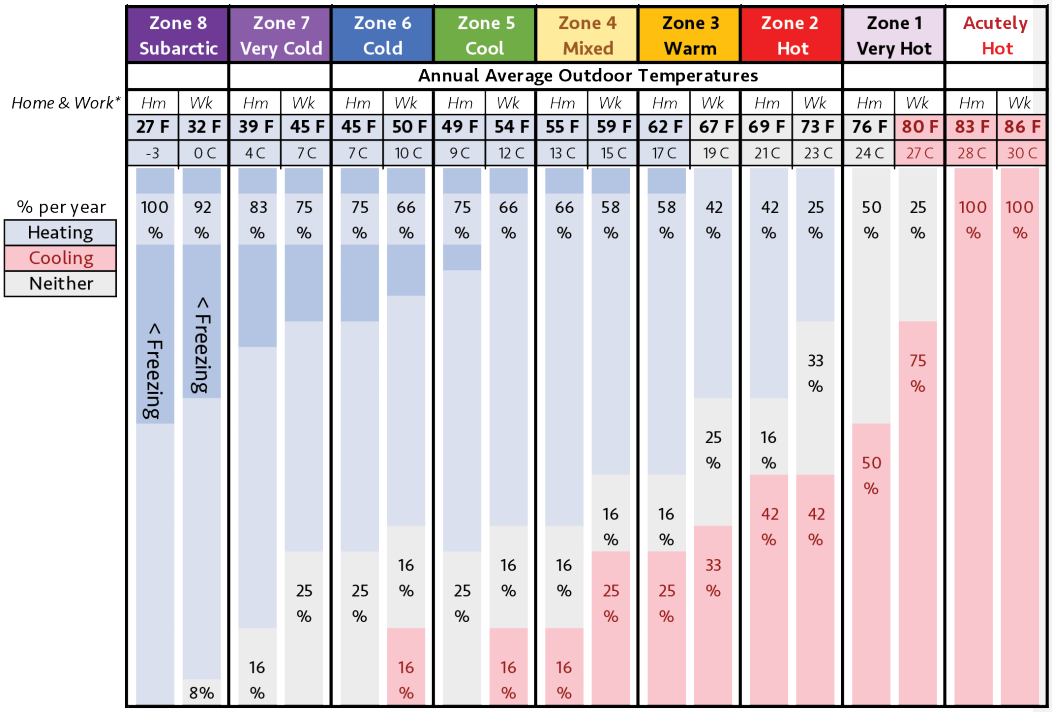
a) Simulation of conditions requires both:

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.

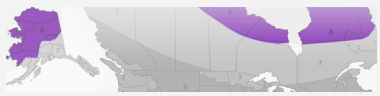
Each operating condition influences test results. The measured concentration in each building or unique sector within a building across any span of time is the product of dynamic interactions between factors that include: building capacity for stack effect strength; soil permeability that relates to 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)	

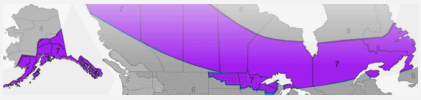
Table A-7

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

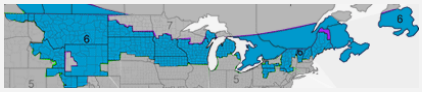
Table A-6

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

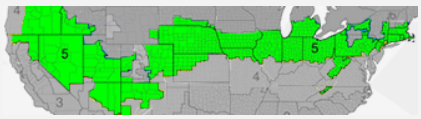
Table A-5

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

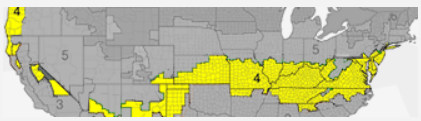
Table A-4

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

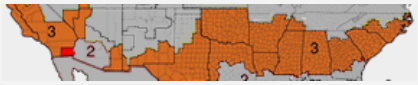
Table A-3

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

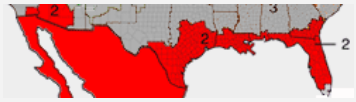
Table A-2

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

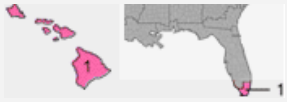
Table A-1

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.

Commented [GH70]: Relative to MALB, elaborated upon test methods and reporting where evaluation day to night radon concentrations may be warrented.

NORMATIVE APPENDIX C

ELEVATED RADON CONCENTRATIONS IN UPPER FLOORS

Commented [GH71]: Elaborate on test methods and guidance relative to radon concentrations found on upper floors. Mitigation methods may be more elaborate and expensive when radon source is not from soil gas entry.

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.

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[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

Commented [GH72]: Criteria developed for meeting ANSI requirements published in 2021 relative to certification and 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

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